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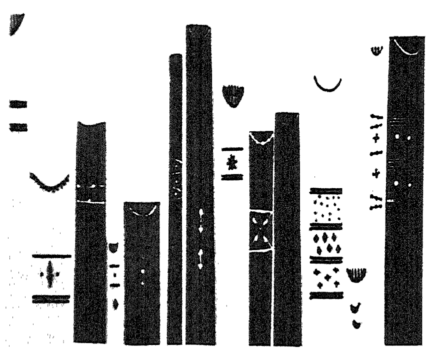


HANDBOOK

OF

NATURE-STUDY

ANNA BOTSFORD COMSTOCK

SEPTEMBER 1, 1854 – AUGUST 24, 1930

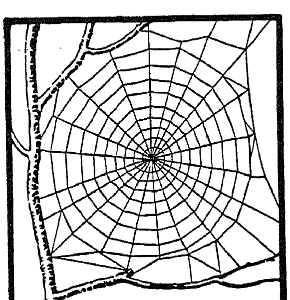
HANDBOOK OF NATURE-STUDY

BY

ANNA BOTSFORD COMSTOCK, B.S., L.H.D.

LATE PROFESSOR OF NATURE-STUDY IN
CORNELL UNIVERSITY

TWENTY-FOURTH EDITION



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TO

LIBERTY HYDE BAILEY

UNDER WHOSE WISE, STAUNCH, AND INSPIRING LEADERSHIP
THE NATURE-STUDY WORK AT CORNELL UNIVERSITY
HAS BEEN ACCOMPLISHED

AND TO MY CO-WORKER

JOHN WALTON SPENCER

WHOSE COURAGE, RESOURCEFULNESS, AND UNTIRING ZEAL
WERE POTENT FACTORS IN THE SUCCESS OF THE CAUSE

THIS BOOK IS DEDICATED

PUBLISHER'S FOREWORD

The publication of the twenty-fourth edition of the *Handbook of Nature-Study* seemed an appropriate time to make certain revisions which had become pressingly necessary, to replace and improve the illustrations, and to incorporate suggestions which had been received from many interested friends. Accordingly, the entire text has been carefully scrutinized, and has been corrected or elaborated in the light of the most recent knowledge. Where the earlier treatment seemed inadequate new material has been added, and Part IV in particular has been much expanded. New subjects, such as soil conservation, have been introduced. We think it is safe to say that the *Handbook* has been well modernized.

But by far the greater part of Mrs. Comstock's work proved to be as accurate and timely in 1939 as in 1911, a striking tribute to the scientific genius of the author. In such cases the language of the earlier text has been preserved, for no improvement could be made on the charming style that has won friends in the tens of thousands. And a careful attempt has been made throughout to preserve the method of treatment adopted by Mrs. Comstock. Perhaps some justification of this policy is needed. Some readers of the *Handbook* have suggested that the new edition be oriented away from the nature-study approach, and be made instead to serve as an introduction to the natural sciences. For the convenience of readers who wish preparation for the academic studies, some scientific classifications and terminology have been introduced. But the nature-study approach has been preserved. The kernel of that method of treatment is the study of the organism in its environment, its relation to the world about it, and the features which enable it to function in its surroundings. This study takes the individual organism, rather than an abstract phylum or genus, as the point of departure. Mrs. Comstock believed that the student found in such a study a fresh, spontaneous interest which was lacking in formal textbook science, and the phenomenal success of her work seems to prove that she was right. Moreover, nature-study as Mrs. Comstock conceived it was an aesthetic experience as well as a discipline. It was an opening of the eyes to the individuality, the ingenuity, the personality of each of the unnoticed life-forms about us. It meant a broadening of intellectual outlook, an expansion of sympathy, a fuller life. Much of this Mrs. Comstock succeeded in conveying into her work; and perhaps it is this informing spirit that is the chief virtue of the book.

But it should not be thought that nature-study is not a science. The promising science of ecology is merely formalized nature-study; indeed it might be said that nature-study is natural science from an ecological rather than an anatomical point of view. The truth is that nature-study is a science, and is more than a science; it is not merely a study of life, but an experience of life. One realizes, as he reads these pages, that with Mrs. Comstock it even contributed to a philosophy of life.

Only the generous efforts of many specialists made possible the thoroughgoing revision of the book. Dr. Marjorie Ruth Ross assumed in large part the responsibility for editorial supervision and co-ordination, and performed most of the labor of revision and replacement of illustrations. Professor A. H. Wright and Mrs. Wright made valuable suggestions and criticisms of the book in general, provided hitherto unpublished photographs for the sections on reptiles and amphibians, and read proof on those sections.

Professor Glenn W. Herrick, Professor J. G. Needham, and Dr. Grace H. Griswold made suggestions for the revision of the material on insects, and supplied illustrations for that section. Professor E. F. Phillips contributed criticism for the lesson on bees. Professor A. A. Allen kindly made suggestions and provided illustrations for the material on birds. Professor B. P. Young gave assistance in the treatment of aquatic life; Dr. W. J. Koster made suggestions for improving the section on fish; and Dr. Emmeline Moore selected photographs of fish, and on behalf of the New York State Department of Conservation gave permission to use them.

Thanks are due to Professor W. J. Hamilton, Jr., for criticism of the section on mammals and for supplying several photographs; to Professor E. S. Harrison for aid in revising the lesson on cattle and supplying illustrations. Mrs. C. N. Stark made helpful suggestions for the revision of the lesson on bacteria. Miss Ethel Belk suggested many revisions in the part on plants. Professor W. C. Muenscher made useful criticisms of the section on weeds, and supplied illustrations. Professor C. H. Guise revised the portion dealing with the chestnut tree and Professor Ralph W. Curtis gave valuable assistance in the revision of the whole section on trees, and furnished pictures. Professor Joseph Oskamp suggested several improvements in the text on the apple tree. Mr. William Marcus Ingram, Jr. prepared the captions for the illustrations of shells.

Professor H. Ries made extensive revisions and additions in the lessons relating to geology. Professor H. O. Buckman revised the lesson on soil. Professor A. F. Gustafson revised the lesson on the brook, and added material on soil conservation. Professor S. L. Boothroyd not only revised the old text on the sky, but he also provided new material and supplied maps and photographs to illustrate it. Dr. H. O. Geren made valuable suggestions for the revision of the text on weather. Miss Theodosia Hadley supplied material for the new bibliography; Dr. Eva L. Gordon revised the bibliography, made numerous suggestions for revision of other parts of the text, and provided some of the illustrations.

Dr. F. D. Wormuth acted as literary editor of the manuscript. Dr. John M. Raines composed many of the captions for the new illustrations, and, with Mrs. Raines, read proof of the entire book.

Many teachers throughout the country offered constructive criticisms; an attempt has been made to put them into effect. To all of these persons the publishers wish to express most cordial and sincere thanks.

THE PUBLISHERS

ITHACA, NEW YORK
January 1, 1939

PREFACE

The Cornell University Nature-Study propaganda was essentially an agricultural movement in its inception and its aims; it was inaugurated as a direct aid to better methods of agriculture in New York State. During the years of agricultural depression 1891–1893, the Charities of New York City found it necessary to help many people who had come from the rural districts — a condition hitherto unknown. The philanthropists managing the Association for Improving the Condition of the Poor asked, "What is the matter with the land of New York State that it cannot support its own population?" A conference was called to consider the situation to which many people from different parts of the State were invited; among them was the author of this book, who little realized that in attending that meeting the whole trend of her activities would be thereby changed. Mr. George T. Powell, who had been a most efficient Director of Farmers' Institutes of New York State, was invited to the conference as an expert to explain conditions and give advice as to remedies. The situation seemed so serious that a Committee for the Promotion of Agriculture in New York State was appointed. Of this committee the Honorable Abram S. Hewitt was Chairman, Mr. R. Fulton Cutting, Treasurer, Mr. Wm. H. Tolman, Secretary. The other members were Walter L. Suydam, Wm. E. Dodge, Jacob H. Schiff, George T. Powell, G. Howard Davidson, Howard Townsend, Professor I. P. Roberts, C. McNamee, Mrs. J. R. Lowell, and Mrs. A. B. Comstock. Mr. George T. Powell was made Director of the Department of Agricultural Education.

At the first meeting of this committee Mr. Powell made a strong plea for interesting the children of the country in farming as a remedial measure, and maintained that the first step toward agriculture was nature-study. It had been Mr. Powell's custom to give simple agricultural and nature-study instruction to the school children of every town where he was conducting a farmers' institute, and his opinion was, therefore, based upon experience. The committee desired to see for itself the value of this idea, and experimental work was suggested, using the schools of Westchester County as a laboratory. Mr. R. Fulton Cutting generously furnished the funds for this experiment, and work was done that year in the Westchester schools which satisfied the committee of the soundness of the project.

The committee naturally concluded that such a fundamental movement must be a public rather than a private enterprise; and Mr. Frederick Nixon, then Chairman of the Ways and Means Committee of the Assembly, was invited to meet with the committee at Mr. Hewitt's home. Mr. Nixon had been from the beginning of his public career deeply interested in improving the farming conditions of the State. In 1894, it was through his influence and the support given him by the Chautauqua Horticultural Society under the leadership of Mr. John W. Spencer, that an appropriation had been given to Cornell University for promoting the horticultural interests of the western counties of the State. In addition to other work done through this appropriation, horticultural schools were conducted under the direction of Professor L. H. Bailey with the aid of other Cornell instructors and especially of Mr. E. G. Lodeman; these schools had proved to be most useful and were well attended. Therefore, Mr. Nixon was open-minded toward an educational movement. He listened to the plan of the committee and after due consideration declared that if this new measure would surely help the farmers of the State, the money would be forthcoming. The committee unanimously decided that if an appropriation were made for this purpose it should be given to the Cornell College of Agriculture; and that year eight thousand dollars were added to the Cornell University Fund, for Extension Teaching and inaugurating this work. The work was begun under Professor I. P. Roberts; after one year Professor Roberts placed it under the supervision of Professor L. H. Bailey, who for the fifteen years since has been the inspiring leader of the movement, as well as the official head.

In 1896, Mr. John W. Spencer, a fruit grower in Chautauqua County, became identified with the enterprise; he had lived in rural communities and he knew their needs. He it was who first saw clearly that the first step in the great work was to help the teacher through simply written leaflets; and later he originated the great plan of organizing the children in the schools of the State into Junior Naturalists Clubs, which developed a remarkable phase of the movement. The members of these clubs paid their dues by writing letters about their nature observations to Mr. Spencer, who speedily became their beloved "Uncle John"; a button and charter were given for continued and earnest work. Some years, 30,000 children were thus brought into direct communication with Cornell University through Mr. Spencer. A monthly leaflet for Junior Naturalists followed; and it was to help in this enterprise that Miss Alice G. McCloskey, the able Editor of the present *Rural School Leaflet*, was brought into the work. Later, Mr. Spencer organized the children's garden movement by forming the children of the State into junior gardeners; at one time he had 25,000 school pupils working in gardens and reporting to him.

In 1899, Mrs. Mary Rogers Miller, who had proven a most efficient teacher when representing Cornell nature-study in the State Teachers' Institutes, planned and started the Home Nature-Study Course Leaflets for the purpose of helping the teachers by correspondence, a work which fell to the author in 1903 when Mrs. Miller was called to other fields.

For the many years during which New York State has intrusted this important work to Cornell University, the teaching of nature-study has gone steadily on in the University, in teachers' institutes, in State summer schools, through various publications and in correspondence courses. Many have assisted in this work, notably Dr. W. C. Thro, Dr. A. A. Allen, and Miss Ada Georgia. The New York Education Department with Charles R. Skinner as Commissioner of Education and Dr. Isaac Stout as the Director of Teachers' Institutes co-operated heartily with the movement from the first. Later with the co-operation of Dr. Andrew Draper, as Commissioner of Education, many of the Cornell leaflets have been written with the special purpose of aiding in carrying out the New York State Syllabus in Nature-Study and Agriculture.

The leaflets upon which this volume is based were published in the Home Nature-Study Course during the years 1903–1911, in limited editions and were soon out of print. It is to make these lessons available to the general public that this volume has been compiled. While the subject matter of the lessons herein given is essentially the same as in the leaflets, the lessons have all been rewritten for the sake of consistency, and many new lessons have been added to bridge gaps and make a coherent whole.

Because the lessons were written during a period of so many years, each lesson has been prepared as if it were the only one, and without reference to others. If there is any uniformity of plan in the lessons, it is due to the inherent qualities of the subjects, and not to a type plan in the mind of the writer; for, in her opinion, each subject should be treated individually in nature-study; and in her long experience as a nature-study teacher she has never been able to give a lesson twice alike on a certain topic or secure exactly the same results twice in succession. It should also be stated that it is not because the author undervalues physics nature-study that it has been left out of these lessons, but because her own work has been always along biological lines.

The reason why nature-study has not yet accomplished its mission, as thought-core for much of the required work in our public schools, is that the teachers are as a whole untrained in the subject. The children are eager for it, unless it is spoiled in the teaching; and whenever we find a teacher with an understanding of out-of-door life and a love for it, there we find nature-study in the school is an inspiration and a joy to pupils and teacher. It is because of the author's sympathy with the untrained teacher and her full comprehension of her difficulties and helplessness that this book has been written. These difficulties are chiefly three-fold: The teacher does not know what there is to see in studying a planet or animal; she knows little of the literature that might help her; and because she knows so little of the subject, she has no interest in giving a lesson about it. As a matter of fact, the literature concerning our common animals and plants is so scattered that a teacher would need a large library and almost unlimited time to prepare lessons for an extended nature-study course.

The writer's special work for fifteen years in Extension teaching has been the helping of the untrained teacher through personal instruction and through leaflets. Many methods were tried and finally there was evolved the method followed in this volume: All the facts available and pertinent concerning each topic have been assembled in the "Teacher's story" to make her acquainted with the subject; this is followed by an outline for observation on the part of the pupils while studying the object. It would seem that with the teacher's story before the eyes of the teacher, and the subject of the lesson before the eyes of the pupils with a number of questions leading them to see the essential characteristics of the object, there should result a wider knowledge of nature than is given in this or any other book.

That the lessons are given in a very informal manner, and that the style of writing is often colloquial, results from the fact that the leaflets upon which the book is based were written for a correspondence course in which the communications were naturally informal and chatty. That the book is meant for those untrained in science accounts for the rather loose terminology employed; as, for instance, the use of the word *seed* in the popular sense whether it be a drupe, an akene, or other form of fruit; or the use of the word *pod* for almost any seed envelope, and many like instances. Also, it is very likely, that in teaching quite incidentally the rudiments of the principles of evolution, the results may often seem to be confused with an idea of purpose, which is quite unscientific. But let the critic labor for fifteen years to interest the untrained adult mind in nature's ways, before he casts any stones! And it should be always borne in mind that if the author has not dipped deep in the wells of science, she has used only a child's cup.

For many years requests have been frequent from parents who have wished to give their children nature interests during vacations in the country. They have been borne in mind in planning this volume; the lessons are especially fitted for field work, even though schoolroom methods are so often suggested.

The author feels apologetic that the book is so large. However, it does not contain more than any intelligent country child of twelve should know of his environment; things that he should know naturally and without effort, although it might take him half his life-time to learn so much if he should not begin before the age of twenty. That there are inconsistencies, inaccuracies, and even blunders in the volume is quite inevitable. The only excuse to be offered is that, if through its use, the children of our land learn early to read nature's truths with their own eyes, it will matter little to them what is written in books.

The author wishes to make grateful acknowledgment to the following people: To Professor Wilford M. Wilson for his

chapter on the weather; to Miss Mary E. Hill for the lessons on mould, bacteria, the minerals, and reading the weather maps; to Miss Catherine Straith for the lessons on the earthworm and the soil; to Miss Ada Georgia for much valuable assistance in preparing the original leaflets on which these lessons are based; to Dean L. H. Bailey and to Dr. David S. Jordan for permission to quote their writings; to Mr. John W. Spencer for the use of his story on the movements of the sun; to Dr. Grove Karl Gilbert, Dr. A. C. Gill, Dr. Benjamin Duggar, Professor S. H. Gage and Dr. J. G. Needham for reading and criticizing parts of the manuscript; to Miss Eliza Tonks for reading the proof; to the Director of the College of Agriculture for the use of the engravings made for the original leaflets; to Miss Martha Van Rensselaer for the use of many pictures from *Boys and Girls*; to Professor Cyrus Crosby, and to Messrs. J. T. Lloyd, A. A. Allen and R. Matheson for the use of their personal photographs; to the U. S. Geological Survey and the U. S. Forest Service for the use of photographs; to Louis A. Fuertes for drawings of birds; to Houghton Mifflin & Company for the use of the poems of Lowell, Harte and Larcom, and various extracts from Burroughs and Thoreau; to Small, Maynard & Company and to John Lane & Company for the use of poems of John T. Babb; to Doubleday, Page & Company for the use of pictures of birds and flowers; and to the American Book Company for the use of electrotypes of dragon-flies and astronomy. Especially thanks are extended to Miss Anna C. Stryke for numerous drawings, including most of the initials.

ANNA BOTSFORD COMSTOCK

ITHACA, NEW YORK

July, 1911

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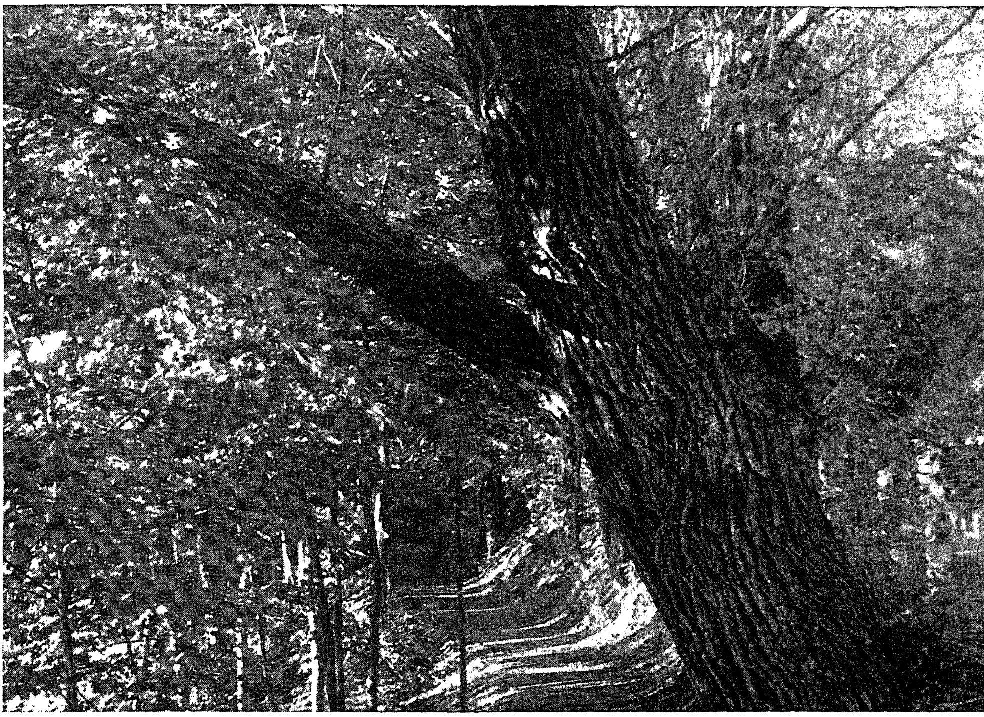
PART I
THE TEACHING OF NATURE-STUDY

THE TEACHING OF NATURE-STUDY



Ralph W. Curtis

What Nature-Study Is

Nature-study is, despite all discussions and perversions, a study of nature; it consists of simple, truthful observations that may, like beads on a string, finally be threaded upon the understanding and thus held together as a logical and harmonious whole. Therefore, the object of the nature-study teacher should be to cultivate in the children powers of accurate observation and to build up within them understanding.

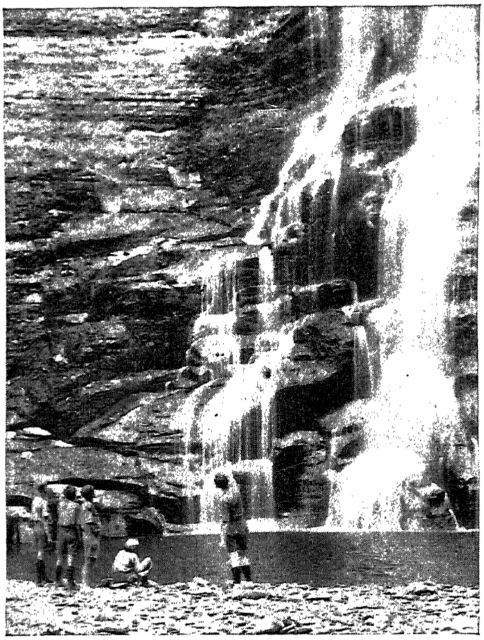
What Nature-Study Should Do for the Child

First, but not most important, nature-study gives the child practical and helpful knowledge. It makes him familiar with nature's ways and forces, so that he is not so helpless in the presence of natural misfortune and disasters.

Nature-study cultivates the child's imagination, since there are so many wonderful and true stories that he may read with his own eyes, which affect his imagination as much as does fairy lore; at the same time nature-study cultivates in him a perception and a regard for what *is* true, and the power to express it. All things seem possible in nature; yet this seeming is always guarded by the eager quest of what is true. Perhaps half the falsehood in the world is due to lack of power to detect the truth and to express it. Nature-study aids both in discernment and in expression of things as they are.

Nature-study cultivates in the child a

love of the beautiful; it brings to him early a perception of color, form, and music. He sees whatever there is in his environment, whether it be the thunder-head piled up in the western sky, or the golden flash of the oriole in the elm; whether it be the purple of the shadows on the snow, or the azure glint on the wing of the little butterfly. Also, what there is of sound, he hears; he reads the music score of the bird orchestra, separating each part and knowing which bird sings it. And the patter of the rain, the gurgle of the brook, the sighing of the wind in the pine, he notes and loves and becomes enriched thereby.



Louis Agassiz Fuertes Council, Boy Scouts of America

A nature hike

But, more than all, nature-study gives the child a sense of companionship with life out-of-doors and an abiding love of nature. Let this latter be the teacher's criterion for judging his or her work. If nature-study as taught does not make the child love nature and the out-of-doors, then it should cease. Let us not inflict permanent injury on the child by turning him away from nature instead of toward it. However, if the love of nature is in the teacher's heart, there is no danger; such a teacher, no matter by what method, takes the child gently by the hand and walks with him in paths that lead to the seeing and comprehending of what he may find beneath his feet or above his head. And these paths, whether they lead among the lowliest plants, or whether to the stars, finally converge and bring the wanderer to that serene peace and hopeful faith that is the sure inheritance of all those who realize fully that they are working units of this wonderful universe.

Nature-Study as a Help to Health

Perhaps the most valuable practical lesson the child gets from nature-study is a personal knowledge that nature's laws are not to be evaded. Wherever he looks, he discovers that attempts at such evasion result in suffering and death. A knowledge thus naturally attained of the immutability of nature's " must " and " shall not " is in itself a moral education. The realization that the fool as well as the transgressor fares ill in breaking natural laws makes for wisdom in morals as well as in hygiene.

Out-of-door life takes the child afield and keeps him in the open air, which not only helps him physically and occupies his mind with sane subjects, but keeps him out of mischief. It is not only during childhood that this is true, for love of nature counts much for sanity in later life. This is an age of nerve tension, and the relaxation which comes from the comforting companionship found in woods and fields is, without doubt, the best remedy for this condition. Too many men who seek the out-of-doors for rest at the present time, can only find it with a gun in hand. To rest and heal their nerves they must go out and try to kill some unfortunate creature — the old, old story of sacrificial blood. Far better will it be when, through properly training the child, the man shall be enabled to enjoy nature through seeing how creatures live rather than watching them die. It is the sacred privilege of nature-study to do this for future generations and for him thus trained, shall the words of Longfellow's poem to Agassiz apply:

And he wandered away and away, with
Nature the dear old nurse,
Who sang to him night and day, the
rhymes of the universe.
And when the way seemed long, and his
heart began to fail,
She sang a more wonderful song, or told
a more wonderful tale.

What Nature-Study Should Do for the Teacher

During many years, I have been watching teachers in our public schools in their conscientious and ceaseless work; and so far as I can foretell, the fate that awaits them finally is either nerve exhaustion or nerve atrophy. The teacher must become either a neurasthenic or a "clam."

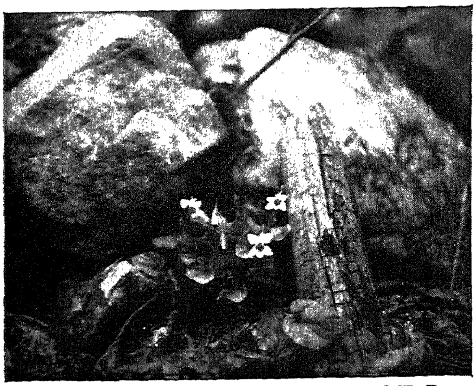
I have had conversations with hundreds of teachers in the public schools of New York State concerning the introduction of nature-study into the curriculum, and most of them declared, "Oh, we have not time for it. Every moment is full now!" Their nerves were at such a tension that with one more thing to do they must fall apart. The question in my own mind during these conversations was always, how long can she stand it! I asked some of them, "Did you ever try a vigorous walk in the open air in the open country every Saturday or every Sunday of your teaching year?" "Oh no!" they exclaimed in despair of making me understand. "On Sunday we must go to church or see our friends and on Saturday we must do our shopping or our sewing. We must go to the dressmaker's lest we go unclad, we must mend, and darn stockings; we need Saturday to catch up."

Yes, catch up with more cares, more worries, more fatigue, but not with more growth, more strength, more vigor, and more courage for work. In my belief, there are two and only two occupations for Saturday afternoon or forenoon for a teacher. One is to be out-of-doors and the other is to lie in bed, and the first is best. Out in this, God's beautiful world, there is everything waiting to heal lacerated nerves, to strengthen tired muscles, to please and content the soul that is torn to shreds with duty and care. To the teacher who turns to nature's healing, nature-study in the schoolroom is not a trouble; it is a sweet, fresh breath of air blown across the heat of radiators and the noisome odor of overcrowded small humanity. She who opens her eyes and her heart nature-ward even once a week finds nature-study in the schoolroom a delight and an abiding joy. What does such a one find in her schoolroom instead of the terrors of discipline, the eternal watching and eternal nagging to keep the pupils quiet and at work? She finds, first of all, companionship with her children; and second, she finds that without planning or going on a far voyage, she has found health and strength.

When and Why the Teacher Should Say "I Do Not Know"

No science professor in any university, if he be a man of high attainment, hesitates to say to his pupils, "I do not know," if they ask for information beyond his knowledge. The greater his scientific reputation and erudition, the more readily, simply, and without apology he says this. He, better than others, comprehends how vast is the region that lies beyond man's present knowledge. It is only the teacher in the elementary schools who has never received enough scientific training to reveal to her how little she does know, who feels that she must appear to know everything or her pupils will lose confidence in her. But how useless is this pretense, in nature-study! The pupils, whose younger eyes are much keener for details than hers, will soon discover her limitations and then their distrust of her will be real.

In nature-study any teacher can with honor say, "I do not know"; for perhaps the question asked is as yet unanswered by the great scientists. But she should not let lack of knowledge be a wet blanket thrown over her pupils' interest. She should say frankly, "I do not know; let us see if we cannot together find out this mysterious thing. Maybe no one knows it as yet, and I wonder if you will discover it before I do." She thus conveys the right impression, that only a little about the intricate life of plants and animals is yet known; and at the same time she makes her pupils feel the thrill and zest of investigation. Nor will she lose their respect by doing this, if she does it in the right spirit. For three years, I had for comrades in my walks afield two little children and they kept me busy saying, "I do not know." But they never lost confidence in me or in my knowledge; they simply gained respect for the vastness of the unknown.



Leonard K. Beyer

Long-spurred violet

The chief charm of nature-study would be taken away if it did not lead us through the border-land of knowledge into the realm of the undiscovered. Moreover, the teacher, in confessing her ignorance and at the same time her interest in a subject, establishes between herself and her pupils a sense of companionship which relieves the strain of discipline, and gives her a new and intimate relation with her pupils which will surely prove a potent element in her success. The best teacher is always one who is the good comrade of her pupils.

Nature-Study, the Elixir of Youth

The old teacher is too likely to become didactic, dogmatic, and "bossy" if she does not constantly strive with herself. Why? She has to be thus five days in the week and, therefore, she is likely to be so seven. She knows arithmetic, grammar, and geography to their uttermost, she is never allowed to forget that she knows them, and finally her interests become limited to what she knows.

After all, what is the chief sign of growing old? Is it not the feeling that we know all there is to be known? It is not years which make people old; it is ruts, and a limitation of interests. When we no longer care about anything except our own interests, we are then old, it matters not whether our years be twenty or eighty. It is rejuvenation for the teacher, thus growing old, to stand ignorant as a child in the presence of one of the simplest of nature's miracles — the formation of a crystal, the evolution of the butterfly from the caterpillar, the exquisite adjustment of the silken lines in the spider's orb web. I know how to "make magic" for the teacher who is growing old. Let her go out with her youngest pupil and reverently watch with him the miracle of the blossoming violet and say: "Dear Nature, I know naught of the wondrous life of these, your smallest creatures. Teach me!" and she will suddenly find herself young.

Nature-Study as a Help in School Discipline

Much of the naughtiness in school is a result of the child's lack of interest in his work, augmented by the physical inaction that results from an attempt to sit quietly. The best teachers try to obviate both of these causes of misbehaviour rather than to punish the naughtiness that results from them. Nature-study is an aid in both respects, since it keeps the child interested and also gives him something to do.

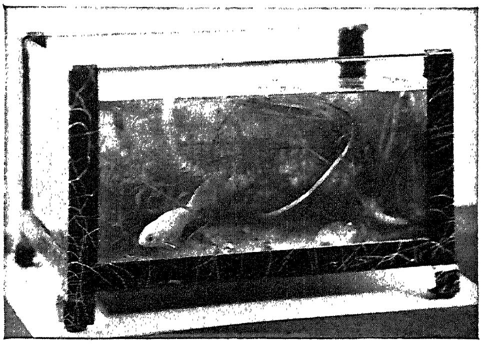
In the nearest approach to an ideal school that I have ever seen, for children of second grade, the pupils were allowed, as a reward of merit, to visit the aquaria or the terrarium for periods of five minutes, which time was given to the blissful observation of the fascinating prisoners. The teacher also allowed the reading of stories about the plants and animals under observation to be regarded as a reward of merit. As I entered the schoolroom, eight or ten of the children were at the windows watching eagerly what was happening to the creatures confined there in the various cages. There was a mud aquarium for the frogs and salamanders, an aquarium for fish, many small aquaria for insects, and each had one or two absorbedly interested spectators who were quiet, well-behaved, and were getting their nature-study lessons in an ideal manner. The teacher told me that the problem of discipline was solved by this method, and that she was rarely obliged to rebuke or punish. In many other schools, watching the living creatures in the aquaria or terraria has been used as a reward for other work well done.

The Relation of Nature-Study to Science

Nature-study is not elementary science as so taught, because its point of attack is not the same; error in this respect has caused many a teacher to abandon nature-study and many a pupil to hate it. In elementary science the work begins with the simplest animals and plants and progresses logically through to the highest forms; at least this is the method pursued in most universities and schools. The object of the study is to give the pupils an outlook over all the forms of life and their relation one to another. In nature-study the work begins with any plant or creature which chances to interest the pupil. It begins with the robin when it comes back to us in March, promising spring; or it begins with the maple leaf which flutters to the ground in all the beauty of its autumnal tints. A course in biological science leads to the comprehension of all kinds of life upon our globe. Nature-study is for the comprehension of the individual life of the bird, insect, or plant that is nearest at hand.

Nature-study is perfectly good science within its limits, but it is not meant to be more profound or comprehensive than the capabilities of the child's mind. More than all, nature-study is not science belittled as if it were to be looked at through the reversed opera glass in order to bring it down small enough for the child to play with. Nature-study, as far as it goes, is just as large as is science for "grown-ups." It may deal with the same subject matter and should be characterized by the same accuracy. It simply does not go so far.

To illustrate: If we are teaching the science of ornithology, we take first the Archæopteryx, then the swimming and scratching birds, and finally reach the song birds, studying each as a part of the whole. Nature-study begins with the robin because the child sees it and is interested in it, and notes the things about the habits and appearance of the robin that may be perceived by intimate observa-



Hugh Spencer

An aquarium

tion. In fact, he discovers for himself all that the most advanced book of ornithology would give concerning the ordinary habits of this one bird; the next bird studied may be the turkey in the barnyard, or the duck on the pond, or the screech owl in the spruces, if any of these happen to impinge upon his notice and interest. However, such nature-study makes for the best of scientific ornithology, because by studying the individual birds thus thoroughly, the pupil finally studies a sufficient number of forms so that his knowledge, thus assembled, gives him a better comprehension of birds as a whole than could be obtained by the routine study of them. Nature-study does not start out with the classification given in books, but in the end it builds up in the child's mind a classification which is based on fundamental knowledge; it is a classification like that evolved by the first naturalists, because it is built on careful personal observations of both form and life.

Nature-Study Not for Drill

If nature-study is made a drill, its pedagogic value is lost. When it is properly taught, the child is unconscious of mental effort or that he is suffering the act of teaching. As soon as nature-study becomes a task, it should be dropped; but how could it ever be a task to see that the sky is blue, or the dandelion golden, or to listen to the oriole in the elm!

Stanley Mulaik

A young entomologist

The Child Not Interested in Nature-Study

What to do with the pupil not interested in nature-study subjects is a problem that confronts many earnest teachers. Usually the reason for this lack of interest is the limited range of subjects used for nature-study lessons. Often the teacher insists upon flowers as the lesson subject, when toads or snakes would prove the key to the door of the child's interest. But whatever the cause may be, there is only one right way out of this difficulty: The child not interested should be kept at his regular school work and not admitted as a member of the nature-study class, where his influence is always demoralizing. He had much better be learning his spelling lesson than learning to hate nature through being obliged to study subjects in which he is not interested. In general, it is safe to assume that the pupil's lack of interest in nature-study is owing to a fault in the teacher's method. She may be trying to fill the child's mind with facts when she should be leading him to observe these for himself, which is a most entertaining occupation for the child. It should always be borne in mind that mere curiosity is always impertinent, and that it is never more so than when exercised in the realm of nature. A genuine interest should be the basis of the study of the lives of plants and lower animals. Curiosity may elicit facts, but only real interest may mold these facts into wisdom.

When to Give the Lesson

There are two theories concerning the time when a nature-study lesson should be given. Some teachers believe that it should be a part of the regular routine; others have found it of greatest value if reserved for that period of the school day when the pupils are weary and restless, and the teacher's nerves strained to the snapping point. The lesson on a tree, insect, or flower at such a moment affords immediate relief to everyone; it is a mental excursion, from which all return refreshed and ready to finish the duties of the day.

While I am convinced that the use of the nature-study lesson for mental refreshment makes it of greatest value, yet I realize fully that if it is relegated to such periods, it may not be given at all. It might be better to give it a regular period late in the day, for there is strength and sureness in regularity. The teacher is much more likely to prepare herself for the lesson, if she knows that it is required at a certain time.

The Length of the Lesson

The nature-study lesson should be short and sharp and may vary from ten minutes to a half hour in length. There should be no dawdling; if it is an observation lesson, only a few points should be noted and the meaning for the observations made clear. If an outline be suggested for field observation, it should be given in an inspiring manner which shall make each pupil anxious to see and read the truth for himself. The nature story when properly read is never finished; it is always at an interesting point, "continued in our next."

The teacher may judge as to her own progress in nature-study by the length of time she is glad to spend in reading from nature's book what is therein written. As she progresses, she finds those hours spent in studying nature speed faster, until a day thus spent seems but an hour. The author can think of nothing she would so gladly do as to spend days and months with the birds, bees, and flowers with no obligation to tell what she should see. There is more than mere information in hours thus spent. Lowell describes them well when he says:

Those old days when the balancing of a
yellow butterfly o'er a thistle bloom
Was spiritual food and lodging for the
whole afternoon.

The Nature-Study Lesson Always New

A nature-study lesson should not be repeated unless the pupils demand it. It should be done so well the first time that there is no need of repetition, because it has thus become a part of the child's consciousness. The repetition of the same lesson in different grades was, to begin with, a hopeless incubus upon nature-study. One disgusted boy declared, "Darn germination! I had it in the primary and last year and now I am having it again. I know *all about germination.*" The boy's attitude was a just one; but if there had been revealed to him the meaning of germination, instead of the mere process, he would have realized that until he had planted and observed every plant in the world he would not know all about germination, because each seedling has its own interesting story. The only excuse for repeating a nature-study lesson is in recalling it for comparison and contrast with other lessons. The study of the violet will naturally bring about a review of the pansy; the dandelion, of the sunflower; the horse, of the donkey; the butterfly, of the moth.

Nature-Study and Object Lessons

The object lesson method was introduced to drill the child to see a thing accurately, not only as a whole but in detail, and to describe accurately what he saw. A book or a vase or some other object was held up before the class for a moment and then removed; afterwards the pupils described it as perfectly as possible. This is an excellent exercise and the children usually enjoy it as if it were a game. But if the teacher has in mind the same thought when she is giving the nature-study lesson, she has little comprehension of the meaning of the latter and the pupils will have less. In nature-study, it is not desirable that the child see all the details, but rather those details that have something to do with the life of the creature studied; if he sees that the grasshopper has the hind legs much longer than the others, he will inevitably note that there are two other pairs of legs and he

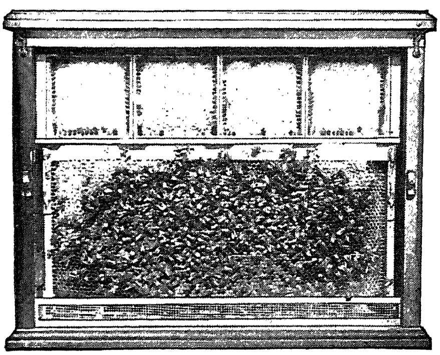
Leonard K. Beyer

A mountain brook

will in the meantime have come into an illuminating comprehension of the reason the insect is called "grasshopper." The child should see definitely and accurately all that is necessary for the recognition of a plant or animal; but in nature-study, the observation of form is for the purpose of better understanding life. In fact, it is form linked with life, the relation of "being" to "doing."

Nature-Study in the Schoolroom

Many subjects for nature-study lessons may be brought into the schoolroom. Whenever it is possible, the pupils should themselves bring the material, as the collecting of it is an important part of the lesson. There should be in the schoolroom conveniences for caring for the little prisoners brought in from the field. A terrarium and breeding cages of different kinds should be provided for the insects, toads, and little mammals. Here they may live in comfort, when given their natural food, while the children observe their interesting ways. The ants' nest and the observation hive yield fascinating views of the marvelous lives of the insect socialists, while the cheerful prisoner in the bird cage may be made a constant illustration of the adaptations and habits of all birds. The aquaria for fishes, tadpoles, and insects afford the opportunity for continuous study of these water creatures and are a never-failing source of interest to the pupils, while the window garden may be made not only an ornament and an æsthetic delight, but a basis for interesting study of plant growth and development.



A. I. Root Co.

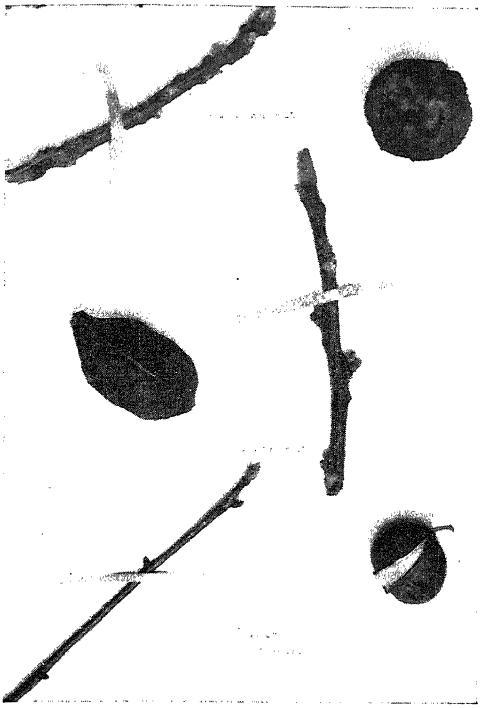
An observation beehive

A schoolroom thus equipped is a place of delight as well as enlightenment to the children. Once, a boy whose luxurious home was filled with all that money could buy and educated tastes select, said of a little nature-study laboratory which was in the unfinished attic of a school building, but which was teeming with life, "I think this is the most beautiful room in the world."

Nature-Study and Museum Specimens

The matter of museum specimens is another question for the nature-study teacher to solve, and has a direct bearing on an attitude toward taking life. There are many who believe the stuffed bird or the case of pinned insects have no place in nature-study; and certainly these should not be the chief material. But let us use our common sense; the boy sees a bird in the woods or field and does not know its name; he seeks the bird in the museum and thus is able to place it and read about it and is stimulated to make other observations concerning it. Wherever the museum is a help to the study of life in the field, it is well and good. Some teachers may give a live lesson from a stuffed specimen, and other teachers may stuff their pupils with facts about a live specimen; of the two, the former is preferable.

There is no question that making a collection of insects is an efficient way of developing the child's powers of close observation, as well as of giving him manual dexterity in handling fragile things. Also it is a false sentiment which attributes to an insect the same agony at being impaled on a pin that we might suffer at being thrust through by a stake. The insect nervous system is far more conveniently arranged for such an ordeal than ours; and, too, the cyanide bottle brings immediate and painless death to the insects placed within it; moreover, the insects usually collected have short lives anyway. So far as the child is concerned,



Mounted twigs and nuts. These may be put in the bottom of a shallow box with a sheet of cellophane pasted over the top

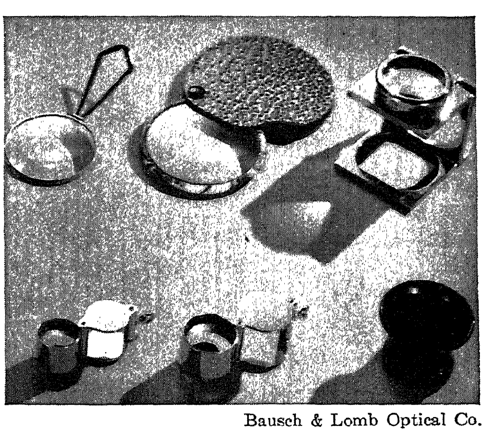
he is thinking of his collection of moths or butterflies and not at all of taking life; so it is not teaching him to wantonly destroy living creatures. However, an indiscriminate encouragement of the making of insect collections cannot be advised. There are some children who will profit by it and some who will not, and unquestionably the best kind of study of insects is watching their interesting ways while they live.

To kill a creature in order to prepare it for a nature-study lesson is not only wrong but absurd, for nature-study has to do with life rather than death, and the form of any creature is interesting only when its adaptations for life are studied. But again, a nature-study teacher may be an opportunist; if without any volition on her part or the pupils', a freshly killed specimen comes to hand, she should make the most of it. The writer remembers most illuminating lessons from a partridge that broke a window and its neck simultaneously during its flight one winter night, a yellow hammer that killed itself against an electric wire, and a muskrat that turned its toes to the skies for no understandable reason. In each of these cases the creature's special physical adaptations for living its own peculiar life were studied, and the effect was not the study of a dead thing, but of a successful and wonderful life.

The Lens, Microscope, and Field Glass as Helps in Nature-Study

In elementary grades, nature-study deals with objects which the children can see with the naked eye. However, a lens is a help in almost all of this work because it is such a joy to the child to gaze at the wonders it reveals. There is no lesson given in this book which requires more than a simple lens for seeing the most minute parts discussed. An excellent lens may be bought for a dollar, and a fairly good one for fifty cents or even twenty-five cents. The lens should be chained to a table or desk where it may be used by the pupils at recess. This gives each an opportunity for using it and obviates the danger of losing it. If the pupils themselves own lenses, they should be fastened by a string or chain to the pocket.

A microscope has no legitimate part in nature-study. But if there is one available, it reveals so many wonders in the commonest objects that it can ofttimes be



Bausch & Lomb Optical Co.

Hand lenses

Bausch & Lomb Optical Co.

A field glass

made a source of added interest. For instance, thus to see the scales on the butterfly's wing affords the child pleasure as well as edification. Field or opera glasses, while indispensable for bird study, are by no means necessary in nature-study. However, the pupils will show greater interest in noting the birds' colors if they are allowed to make the observations with the help of a glass.

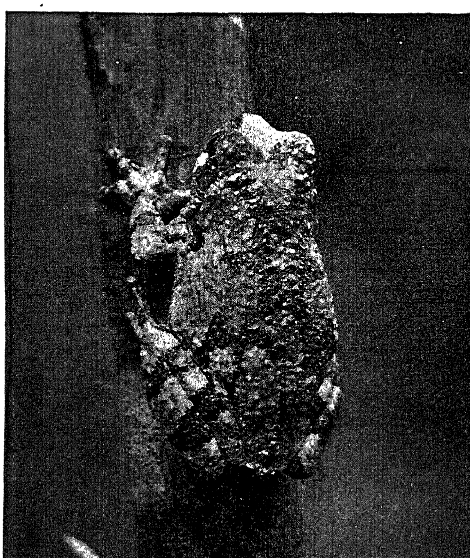
Uses of Pictures, Charts, and Blackboard Drawings

Pictures alone should never be used as the subjects for nature-study lessons, but they may be of great use in illustrating and illuminating a lesson. Books well illustrated are more readily comprehended by the child and are often very helpful to him, especially after his interest in the subject is thoroughly aroused. If charts are used to illustrate the lesson, the child is likely to be misled by the size of the drawing, which is also the case in blackboard pictures. However, this error may be avoided by fixing the attention of the pupil on the object first. If the pupils are studying the ladybird and have it in their hands, the teacher may use a diagram representing the beetle as a foot long and it will still convey the idea accurately; but if she begins with the picture, she probably can never convince the children that the picture has anything to do with the insect.

In making blackboard drawings illustrative of the lesson, it is best, if possible, to have one of the pupils do the drawing in the presence of the class; or, if the teacher does the drawing, she should hold the object in her hand while doing it and look at it often so that the children may see that she is trying to represent it accurately. Taking everything into consideration, however, nature-study charts and blackboard drawings are of little use to the nature-study teacher.

The Uses of Scientific Names

Disquieting problems relative to scientific nomenclature always confront the teacher of nature-study. My own practice has been to use the popular names of species, except in cases where confusion might ensue, and to use the scientific names for anatomical parts. However, this matter is of little importance if the teacher bears in mind that the purpose of nature-study is to know the subject under observation and to learn the name incidentally.



Common tree frog or tree toad, Hyla versicolor versicolor. *Another species,* Hyla crucifer, *is also often called the tree frog and tree toad. Common names, then, will not distinguish these amphibians one from another; the scientific names must be applied*

If the teacher says, "I have a pink hepatica. Can anyone find me a blue one?" the children, who naturally like grownup words, will soon be calling these flowers hepaticas. But if the teacher says, "These flowers are called hepaticas. Now please everyone remember the name. Write it in your books as I write it on the blackboard, and in half an hour I shall ask you again what it is," the pupils naturally look upon the exercise as a word lesson and its real significance is lost. This sort of nature-study is dust and ashes and there has been too much of it. The child should never be *required* to learn the name of anything in the nature-study work; but the name should be used so often and so naturally in his presence that he will learn it without being conscious of the process.

The Story as a Supplement to the Nature-Study Lesson

Many of the subjects for nature lessons can be studied only in part, since but one phase may be available at the time. Often, especially if there is little probability that the pupils will find opportunity to complete the study, it is best to round out their knowledge by reading or telling the story to supplement the facts which they have discovered for themselves. This story should not be told as a finality or as a complete picture but as a guide and inspiration for further study. Always leave at the end of the story an interrogation mark that will remain aggressive and insistent in the child's mind. To illustrate: Once a club of junior naturalists brought me rose leaves injured by the leaf-cutter bee and asked me why the leaves were cut out so regularly. I told them the story of the use made by the mother bee of these oval and circular bits of leaves and made the account as vital as I was able; but at the end I said, "I do not know which species of bee cut these leaves. She is living here among us and building her nest with your rose leaves, which she is cutting every day almost under your very eyes. Is she then so much more clever than you that you cannot see her or find her nest?" For two years following this lesson I received letters from members of this club. Two carpenter bees and their nests were discovered by them and studied before the mysterious leaf-cutter was finally ferreted out. My story had left something interesting for the young naturalists to discover. The children should be impressed with the fact that the nature story is never finished. There is not a weed or an insect or a tree so common that the child, by observing carefully, may not see things never yet recorded in scientific books; therefore the supplementary story should be made an inspiration for keener interest and further investigation on the part of the pupil. The supplementary story simply thrusts aside some of the obscuring underbrush, thus revealing more plainly the path to further knowledge.

The leaf-cutter bee

The Nature-Study Attitude toward Life and Death

Perhaps no greater danger besets the pathway of the nature-study teacher than the question involved in her pupils' attitude toward life and death. To inculcate in the child a reverence for life and yet to keep him from becoming mawkish and morbid is truly a problem. It is almost inevitable that the child should become sympathetic with the life of the animal or plant studied, since a true understanding of the life of any creature creates an interest which stimulates a desire to protect this particular creature and make its life less hard. Many times, within my own experience, have I known boys, who began by robbing birds' nests for egg collections, to end by becoming most zealous protectors of the birds. The humane qualities within these boys budded and blossomed in the growing knowledge of the lives of the birds. At Cornell University, it is a well-known fact that those students who turn aside so as not to crush the ant, caterpillar, or cricket on the pavement are almost invariably those that are studying entomology; and in America it is the botanists themselves who are leading the crusade for flower protection.

Thus, the nature-study teacher, if she does her work well, is a sure aid in inculcating a respect for the rights of all living beings to their own lives; and she needs only to lend her influence gently in this direction to change carelessness to thoughtfulness and cruelty to kindness. But with this impetus toward a reverence for life, the teacher soon finds herself in a dilemma from which there is no logical way out, so long as she lives in a world where lamb chop, beefsteak, and roast chicken are articles of ordinary diet; a world in fact, where every meal is based upon the death of some creature. For if she places much emphasis upon the sacredness of life, the children soon begin to question whether it be right to slay the lamb or the chicken for their own food. It would seem that there is nothing for the consistent nature-study teacher to do but become a vegetarian, and even then there might arise refinements in this question of taking life; she might have to consider the cruelty to asparagus in cutting it off in plump infancy, or the ethics of devouring in the turnip the food laid up by the mother plant to perfect her seed. In fact, a most rigorous diet would be forced upon the teacher who should refuse to sustain her own existence at the cost of life; and if she should attempt to teach the righteousness of such a diet she would undoubtedly forfeit her position; and yet what is she to do! She will soon find herself in the position of a certain lady who placed sheets of sticky fly-paper around her kitchen to rid her house of flies, and then in mental anguish picked off the buzzing, struggling victims and sought to clean their too adhesive wings and legs.

In fact, drawing the line between what to kill and what to let live requires the use of common sense rather than logic. First of all, the nature-study teacher, while exemplifying and encouraging the humane attitude toward the lower creatures, and repressing cruelty which wantonly causes suffering, should never magnify the terrors of death. Death is as natural as life and is the inevitable end of physical life on our globe. Therefore, every story and every sentiment expressed which makes the child feel that death is terrible is wholly wrong. The one right way to teach about death is not to emphasize it one way or another, but to deal with it as a circumstance common to all; it should be no more emphasized than the fact that creatures eat or fall asleep.

Another thing for the nature-study teacher to do is to direct the interest of the child so that it shall center upon the hungry creature rather than upon the one which is made into the meal. It is well to emphasize that one of the conditions imposed upon every living being in the woods and fields is that if it is clever enough to get a meal it is entitled to one when it is hungry. The child naturally takes this view of it. I remember well that as a child I never thought particularly about the mouse which my cat was eating; in fact, the process of transmuting mouse into cat seemed altogether proper, but when the cat played with the mouse, that was quite another thing, and was never permitted. Although no one appreciates more deeply than I the debt which we owe to Thompson Seton and writers of his kind, who have placed before the public the animal story from the animal point of view and thus set us all to thinking, yet it is certainly wrong to impress this view too strongly upon the young and sensitive child. In fact, this process should not begin until the judgment and the understanding are well developed, for we all know that although seeing the other fellow's standpoint is a source of strength and breadth of mind, yet living the other fellow's life is, at best, an enfeebling process and a futile waste of energy.

Should the Nature-Study Teacher Teach How to Destroy Life?

It is probably within the proper scope of the nature-study teacher to place emphasis upon the domain of man, who, being the most powerful of all animals, asserts his will as to which ones shall live in his midst. From a standpoint of abstract justice, the stray cat has just as much right to kill and eat the robin which builds in the vine of my porch as the robin has to pull and eat the earthworms from my lawn; but the place is mine, and I choose to kill the cat and preserve the robin.

When emphasizing the domain of man, we may have to deal with the killing of creatures which are injurious to his interests. Nature-study may be tributary to this, in a measure and indirectly, but the study of this question is surely *not* nature-study. For example, the child studies the cabbage butterfly in all its stages, the exquisitely sculptured yellow egg, the velvety green caterpillar, the chrysalis with its protecting colors, the white-winged butterfly, and becomes interested in the life of the insect. Not under any consideration, when the attention of the child is focused on the insect, should we suggest a remedy for it when it becomes a pest. Let the life story of the butterfly stand as a fascinating page of nature's book. But later, when the child enters on his career as a gardener, when he sets out his row of cabbage plants and waters and cultivates them, and does his best to bring them to maturity, along comes the butterfly, now an arch enemy, and begins to rear her progeny on the product of his toil. Now the child's interest is focused on the cabbage, and the question is not one of killing insects so much as of saving plants. In fact, there is nothing in spraying the plants with Paris green which suggests cruelty to innocent caterpillars, nor is the process likely to harden the child's sensibilities.

To gain knowledge of the life story of insects or other creatures is nature-study. To destroy them as pests is a part of agriculture or horticulture. The one may be of fundamental assistance to the other, but the two are quite separate and should never be confused.

The Field Notebook

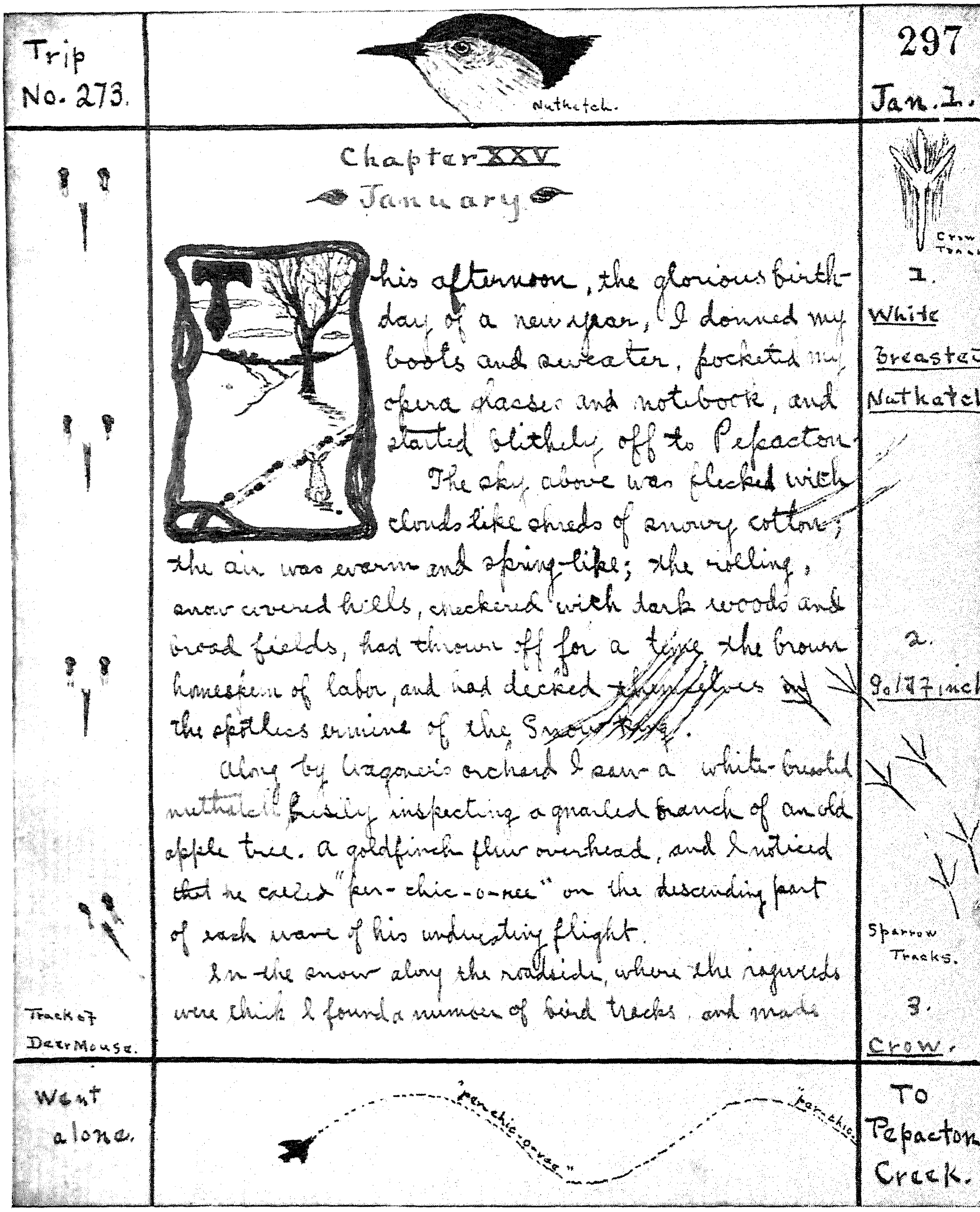
A field notebook may be made a joy to the pupil and a help to the teacher. Any kind of blank book will do for this, except that it should not be too large to be carried in the pocket, and it should always have the pencil attached. To make the notebook a success the following rules should be observed:

(a) The book should be considered the personal property of the child and should never be criticized by the teacher except as a matter of encouragement; for the spirit in which the notes are made is more important than the information they cover.

(b) The making of drawings to illustrate what is observed should be encouraged. A graphic drawing is far better than a long description of a natural object.

(c) The notebook should not be regarded as a part of the work in English. The spelling, language, and writing of the notes should all be exempt from criticism.

(d) As occasion offers, outlines for ob-



A page from the field notebook of a boy of fourteen who read Thoreau and admired the books of Ernest Thompson Seton

serving certain plants or animals may be placed in the notebook previous to the field excursion so as to give definite points for the work.

(e) No child should be compelled to have a notebook.

The field notebook is a veritable gold mine for the nature-study teacher to work in securing voluntary and happy observations from the pupils concerning their out-of-door interests. It is a friendly gate which admits the teacher to a knowledge of what the child sees and cares for. Through it she may discover where the child's attention impinges upon the realm of nature and thus may know

A brook in winter

where to find the starting point for cultivating larger intelligence and wider interest.

I have examined many field notebooks kept by pupils in the intermediate grades and have been surprised at their plenitude of accurate observation and graphic illustration. These books ranged from blank account books furnished by the family grocer up to a quarto, the pages of which were adorned with many marginal illustrations made in passionate admiration of Thompson Seton's books and filled with carefully transcribed text that showed the direct influence of Thoreau. These books, of whatever quality, are precious beyond price to their owners. And why not? For they represent what cannot be bought or sold, personal experience in the happy world of out-of-doors.

The Field Excursion

Many teachers look upon the field excursion as a precarious voyage, steered between the Scylla of hilarious seeing too much and the Charybdis of seeing nothing at all because of the zest which comes from freedom in the fields and wood. This danger can be obviated if the teacher plans the work definitely before starting, and demands certain results.

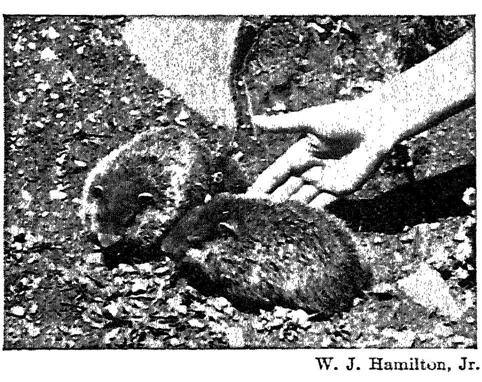
It is a mistake to think that a half day is necessary for a field lesson, since a very efficient field trip may be made during the ten or fifteen minutes at recess, if it is well planned. Certain questions and lines of investigation should be given the pupils before starting and given in such a manner as to make them thoroughly interested in discovering the facts. A certain teacher in New York State has studied all the common plants and trees in the vicinity of her school by means of these recess excursions and the pupils have been enthusiastic about the work.

The half-hour excursion should be preceded by a talk concerning the purposes of the outing and the pupils must know that certain observations are to be made or they will not be permitted to go again. This should not be emphasized as a punishment; but they should be made to understand that a field excursion is only, naturally enough, for those who wish to see and understand outdoor life. For all field work, the teacher should make use of the field notebook which should be a part of the pupils' equipment.

Pets as Nature-Study Subjects

Little attention has been given to making the child understand what would be the lives of his pets if they were in their native environment, or to relating their habits and lives as wild animals. Almost any pet, if properly observed, affords an admirable opportunity for understanding the reasons why its structure and peculiar habits may have made it successful among other creatures and in other lands.

Moreover, the actions and the daily



W. J. Hamilton, Jr.

Young woodchucks

life of the pet make interesting subject matter for a notebook. The lessons on the dog, rabbit, and horse as given in this volume may suggest methods for such study, and with apologies that it is not better and more interesting, I have placed with the story of the squirrel a few pages from one of my own notebooks regarding my experiences with "Furry." I include this record as a suggestion for the children that they should keep notebooks of their pets. It will lead them to closer observation and to a better and more natural expression of their experiences.

The Correlation of Nature-Study with Language Work

Nature-study should be so much a part of the child's thought and interest that it will naturally form a thought core for other subjects quite unconsciously on his part. In fact, there is one safe rule for correlation in this case — it is legitimate and excellent training as long as the pupil does not discover that he is correlating. But there is something in human nature which revolts against doing one thing to accomplish quite another. A boy once said to me, "I'd rather never go on a field excursion than to have to write it up for English," a sentiment I sympathized with keenly; ulterior motive is sickening to the honest spirit. But if that same boy had been a member of a field class and had enjoyed all the new experiences and had witnessed the interesting things discovered on this excursion, and if later his teacher had asked him to write for her an account of some part of it, because *she wished to know what he had discovered*, the chances are that he would have written his story joyfully and with a certain pride that would have counted much for achievement in word expression.

When Mr. John Spencer, known to so many children in New York State as "Uncle John," was conducting the Junior Naturalist Clubs, the teachers allowed letters to him to count for language exercises; and the eagerness with which these letters were written should have given the teachers the key to the proper method of teaching English. Mr. Spencer requested the teachers not to correct the letters, because he wished the children to be thinking about the subject matter rather than the form of expression. But so anxious were many of the pupils to make their letters perfect that they earnestly requested their teachers to help them write correctly, which was an ideal condition for teaching them English. Writing letters to Uncle John was such a joy to the pupils that it was used as a privilege and a reward of merit in many schools. One rural teacher reduced the percentage of tardiness to a minimum by giving the first period in the morning to the work in English which consisted of letters to Uncle John.

Why do pupils dislike writing English exercises? Simply because they are not interested in the subject they are asked to write about, and they know that the teacher is not interested in the information contained in the essay. But when they are interested in the subject and write about it to a person who is interested, the conditions are entirely changed. If the teacher, overwhelmed as she is by work and perplexities, could only keep in mind that the purpose of a language is, after all, merely to convey ideas, some of her perplexities would fade away. A conveyance naturally should be fitted for the load it is to carry, and if the pupil acquires the load first he is very likely to construct a conveyance that will be adequate. How often the conveyance is made perfect through much effort and polished through agony of spirit and the load entirely forgotten!

Nature-study lessons give much excellent subject matter for stories and essays, but these essays should never be criticized or defaced with the blue pencil. They should be read with interest by the teacher; the mistakes made in them, so transformed as to be unrecognizable, may be used for drill exercises in grammatical construction. After all, grammar and spelling are only gained by practice and there is no royal road leading to their acquirement.

The Correlation of Nature-Study and Drawing

The correlation of nature-study and drawing is so natural and inevitable that it needs never be revealed to the pupil. When the child is interested in studying any object, he enjoys illustrating his observations with drawings; the happy absorption of children thus engaged is a delight to witness. At its best, drawing is a perfectly natural method of self-expression. The savage and the young child, both untutored, seek to express themselves and their experiences by this means. It is only when the object to be drawn is foreign to the interest of the child that drawing is a task.

A mounted fern. A pressed dry fern placed on a layer of cotton batting backed by cardboard is covered with a sheet of cellophane and is slipped into an envelope from which a panel has been cut

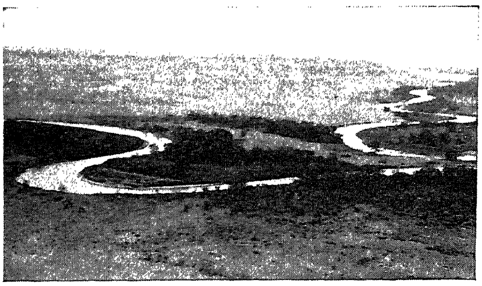
Nature-study offers the best means for bridging the gap that lies between the kindergarten child who makes drawings because he loves to and is impelled to from within, and the pupil in the grades who is obliged to draw what the teacher places before him. From making crude and often meaningless pencil strokes, which is the entertainment of the young child, to the outlining of a leaf or some other simple and interesting natural object, is a normal step full of interest for the child because it is still self-expression.

Miss Mary E. Hill, formerly of the Goodyear School of Syracuse, gave each year an exhibition of the drawings made by the children in the nature-study classes; and these were universally so excellent that most people regarded them as an exhibition from the art department; and yet many of these pupils never had had lessons in drawing. They had learned to draw because they liked to make pictures of the living objects which they had studied. One year there were in this exhibit many pictures of toads in various stages, and although their anatomy was sometimes awry in the pictures, yet there was a certain vivid expression of life in their representation; one felt that the toads could jump. Miss Hill allowed the pupils to choose their own medium, pencil, crayon, or water color, and said that they seemed to feel which was best. For instance, when drawing the outline of trees in winter they chose pencil, but when representing the trillium or iris they preferred the water color, while for bittersweet and crocuses they chose the colored crayons.

It is through this method of drawing that which interests him that the child retains and keeps as his own what should be an inalienable right, a graphic method of expressing his own impressions. Too much have we emphasized drawing as an art; it may be an art, if the one who draws is an artist; but if he is not an artist, he still has a right to draw if it pleases him to do so. We might as well declare that a child should not speak unless he put his words into poetry, as to declare that he should not draw because his drawings are not artistic.

The Correlation of Nature-Study with Geography

Life depends upon its environment. Geographical conditions and limitations have shaped the mold into which plastic life has been poured and by which its form has been modified. It may be easy for the untrained mind to see how the deserts and oceans affect life. Cattle may not roam in the former because there is



U. S. Geological Survey — Photo by W. G. Pierce
A meandering stream

nothing there for them to eat, nor may they occupy the latter because they are not fitted for breathing air in the water. And yet the camel can endure thirst and live on the scant food of the desert; and the whale is a mammal fitted to live in the sea. The question is, how are we to impress the child with the "have to" which lies behind all these geographical facts? If animals live in the desert they *have to* subsist on scant and peculiar food which grows there; they *have to* get along with little water; they *have to* endure heat and sand storms; they *have to* have eyes that will not become blinded by the vivid reflection of the sunlight on the sand; they *have to* be of sand color so that they may escape the eyes of their enemies or creep upon their prey unperceived.

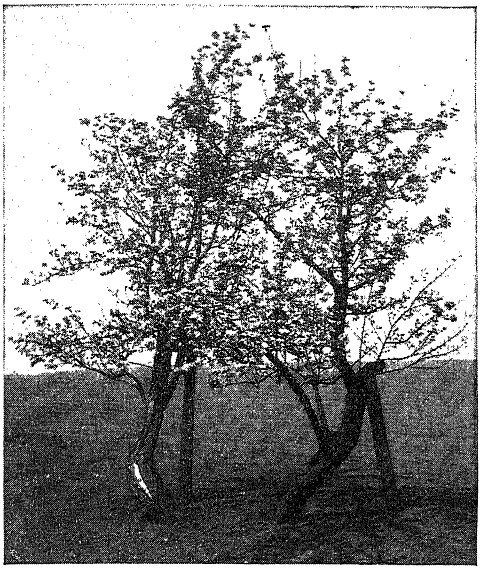
All these "have to's" are not mere chance, but they have existed so long that the animal, by constantly coming in contact with them, has attained its present form and habits.

There are just as many "have to's" in the stream or the pond back of the schoolhouse, on the dry hillside behind it, or in the woods beyond the creek as there are in desert or ocean; and when the child gets an inkling of this fact, he has made a great step into the realm of geography. When he realizes why water lilies can grow only in still water that is not too deep and which has a silt bottom, and why the cattails grow in swamps where there is not too much water, and why the mullein grows in the dry pasture, and why the hepatica thrives in the rich, damp woods, and why the daisies grow in the meadows, he will understand that this partnership of nature and geography illustrates the laws which govern life. Many phases of physical geography belong to the realm of nature-study: the brook, its course, its work of erosion and sedimentation; the rocks of many kinds, the soil, the climate, the weather, are all legitimate subjects for nature-study lessons.

The Correlation of Nature-Study with History

There are many points where nature-study impinges upon history in a way that may prove the basis for an inspiring lesson. Many of our weeds, cultivated plants, and domestic animals have been introduced from Europe and are a part of our colonial history; while many of the most commonly seen creatures have played their part in the history of ancient times. For instance, the bees which gave to man the only means available to him for sweetening his food until the 17th century, were closely allied to the home life of ancient peoples. The buffalo which ranged our western plains had much to do with the life of the red man. The study of the grasshopper brings to the child's attention stories of the locusts' invasion mentioned in the Bible, and the stars which witnessed our creation and of which Job sang and the ancients wrote, shine over our heads every night.

But the trees, through the lengthy span of their lives, cover more history individually than do other organisms. In glancing across the wood-covered hills of New York one often sees there, far above the other trees, the gaunt crowns of old white pines. Such trees belonged to the forest primeval and may have attained the age of two centuries; they stand there looking out over the world, relics of another age when America belonged to the red man, and the bear and the panther played or fought beneath them. The cedars live longer than do the pines, and the great scarlet oak may have attained the age of four centuries before it yields to fate.



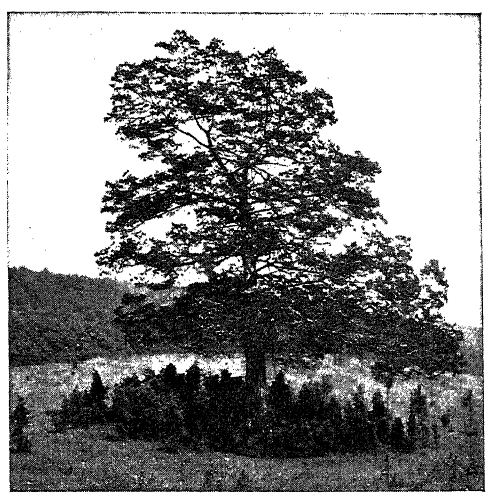
The Arnold Arboretum

The Endicott pear tree. This tree was planted by Governor John Endicott in his garden in Salem, Massachusetts, in 1630. George Washington, Abraham Lincoln, and Daniel Webster enjoyed the fruit of this patriarchal tree. Sprouts, shown above, from the old tree still bear

Perhaps in no other way can the attention of the pupil be turned so naturally to past events as through the thought that the life of such a tree has spanned so much of human history. The life history of one of these ancient trees should be made the center of local history; let the pupils find when the town was first settled by the whites and where they came from, and how large the tree was then; what Indian tribes roamed the woods before that and what animals were common in the forest when this tree was a sapling. Thus may be brought out the chief events in the history of the county and township, when they were established and for whom or what they were named; and a comparison of the present industries may be made with those of a hundred years ago.

The Correlation of Nature-Study with Arithmetic

The arithmetical problems presented by nature-study are many; some of them are simple and some of them are complicated, and all of them are illuminating. Seed distribution especially lends itself to computation; a milkweed pod contains 140 seeds; there are five such pods on one plant; each milkweed plant requires at least one square foot of ground to grow on; how much ground would be required to grow all of the seeds from this one plant? Or, count the seeds in one dandelion head, multiply by the number of flower heads on the plant and estimate how many plants can grow on a square foot, then ask a boy how long it would take for one dandelion plant to cover his father's farm with its progeny; or count the blossoms on one branch of an apple tree, later count the ripened fruit; what percentage of blossoms matured into fruit? Measuring trees, their height and thickness and computing the lumber they will make combines arithmetic and geometry, and so on *ad infinitum.*



W. C. Muenscher

A red cedar and its seedlings

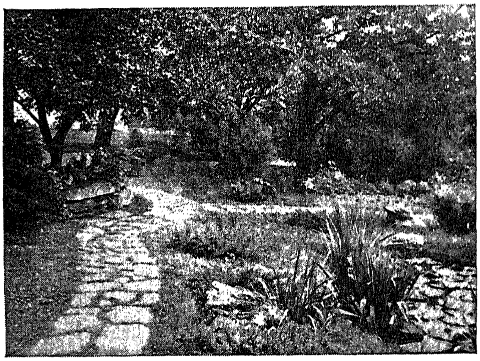
As a matter of fact, the teacher will find in almost every nature lesson an arithmetic lesson; and when arithmetic is used in this work, it should be vital and inherent and not " tacked on "; the pupils should be really interested in the answers to their problems; and as with all correlation, the success of it depends upon the genius of the teacher.

Gardening and Nature-Study

Erroneously, some people maintain that gardening is nature-study; this is not so necessarily nor ordinarily. Gardening may be a basis for nature-study, but it is rarely made so to any great extent. Even the work in children's gardens is so conducted that the pupils know little or nothing of the flowers or vegetables which they grow except their names, their uses to man, and how to cultivate them. They are taught how to prepare the soil, but the reason for this from the plant's standpoint is never revealed; and if the child becomes acquainted with the plants in his garden, he makes the discovery by himself. All this is nothing against gardening! It is a wholesome and valuable experience for a child to learn how to make a garden even if he remains ignorant of the interesting facts concerning the plants which he there cultivates. But if the teachers are so inclined, they may find in the garden and its products the most interesting material for the best of nature lessons. Every plant the child grows is an individual with its own peculiarities as well as those of its species in manner of growth. Its roots, stems, and leaves are of certain form and structure; and often the special uses to the plant of its own kind of leaves, stems, and roots are obvious. Each plant has its own form of flower and even its own tricks for securing pollination; and its own manner of developing and scattering its seeds. Every weed of the garden has developed some special method of winning and holding its place among the cultivated plants; and in no other way can the child so fully and naturally come into a comprehension of that term " the survival of the fittest " as by studying the ways of the fit as exemplified in the triumphant weeds of his garden.

Every earthworm working below the soil is doing something for the garden. Every bee that visits the flowers there is on an errand for the garden as well as for herself. Every insect feeding on leaf or root is doing something to the garden. Every bird that nests near by or that ever visits it, is doing something which affects the life and the growth of the garden. What all of these uninvited guests are doing is one field of garden nature-study. Aside from all this study of individual life in the garden, which even the youngest child may take part in, there are the more advanced lessons on the soil. What kind of soil is it? From what sort of rock was it formed? What renders it mellow and fit for the growing of plants? Moreover, what do the plants get from it? How do they get it? What do they do with what they get?

This leads to the subject of plant physiology, the elements of which may be taught simply by experiments carried on by the children themselves, experiments which should demonstrate the sap currents in the plant; the use of water to



carry food and to make the plant rigid; the use of sunshine in making the plant food in the leaf laboratories; the nourishment provided for the seed and its germination, and many other similar lessons.

A child who makes a garden, and thus becomes intimate with the plants he cultivates, and comes to understand the interrelation of the various forms of life which he finds in his garden, has progressed far in the fundamental knowledge of nature's ways as well as in a practical knowledge of agriculture.

Nature-Study and Agriculture

Luckily, thumb-rule agriculture is being pushed to the wall in these enlightened days. Thumb rules would work much better if nature did not vary her performances in such a confusing way. Government experiment stations were established because thumb rules for farming were unreliable and disappointing; and all the work of all the experiment stations has been simply advanced nature-study and its application to the practice of agriculture. Both nature-study and agriculture are based upon the study of life and the physical conditions which encourage or limit life; this is known to the world as the study of the natural sciences; and if we see clearly the relation of nature-study to science, we may understand better the relation of nature-study to agriculture, which is based upon the sciences.

Nature-study is science brought home. It is a knowledge of botany, zoology, and geology as illustrated in the dooryard, the cornfield or the woods back of the house. Some people have an idea that to know these sciences one must go to college; they do not understand that nature has furnished the material and laboratories on every farm in the land. Thus, by beginning with the child in nature-study we take him to the laboratory of the wood or garden, the roadside or the field, and his materials are the wild flowers or the

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A wheat shock

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A meadow at harvest time

weeds, or the insects that visit the goldenrod or the bird that sings in the maple tree, or the woodchuck whistling in the pasture. The child begins to study living things anywhere or everywhere, and his progress is always along the various tracks laid down by the laws of life, along which his work as an agriculturist must always progress if it is to be successful.

The child through nature-study learns the way a plant grows, whether it be an oak, a turnip, or a pigweed; he learns how the roots of each are adapted to its needs; how the leaves place themselves to get the sunshine and why they need it; and how the flowers get their pollen carried by the bee or the wind; and how the seeds are finally scattered and planted. Or he learns about the life of the bird, whether it be a chicken, an owl, or a bobolink; he knows how each bird gets its food and what its food is, where it lives, where it nests, and its relation to other living things. He studies the bumblebee and discovers its great mission of pollen-carrying for many flowers, and in the end would no sooner strike it dead than he would voluntarily destroy his clover patch. This is the kind of learning we call nature-study and not science or agriculture. But the country child can never learn anything in nature-study that has not something to do with science, and that has not its own practical lesson for him, when he shall become a farmer.

Some have argued, "Why not make nature-study solely along the lines of agriculture? Why should not the child begin nature-study with the cabbage rather than with the wild flowers?" This argument carried out logically provides recreation for a boy in hoeing corn rather than in playing ball. Many parents in the past have argued thus and have, in consequence, driven thousands of splendid boys from the country to the city with a loathing in their souls for the drudgery which seemed all there was to farm life. The reason the wild flowers may be selected for beginning the nature-study of plants is that every child loves these woodland posies, and his happiest hours are spent in gathering them. Never yet have we known of a case where a child, having gained his knowledge of the way a plant lives through studying the plants he loves, has failed to be interested and delighted to find that the wonderful things he discovered about his wild flower may be true of the vegetable in the garden, or the purslane which fights with it for ground to stand upon.

Some have said, "We, as farmers, care only to know what concerns our pocketbooks; we wish only to study those things which we must, as farmers, cultivate or destroy. We do not care for the butterfly, but we wish to know the plum weevil; we do not care for the trillium, but we are interested in the onion; we do not care for the meadowlark, but we cherish the gosling." This is an absurd argument since it is a mental impossibility for any human being to discriminate between two things when he knows or sees only one. In order to understand the important economic relations to the world of one plant or animal, it is absolutely necessary to have a wide knowledge of other plants and animals. One might as well say, "I will see the approaching cyclone, but never look at the sky; I will look at the clover, but not see the dandelion; I will look for the sheriff when he comes over the hill, but will not see any other team on the road."

Nature-study is an effort to make the individual use his senses instead of losing them; to train him to keep his eyes open to all things so that his powers of discrimination shall be based on wisdom. The ideal farmer is not the man who by hazard and chance succeeds; he is the man who loves his farm and all that surrounds it because he is awake to the beauty as well as to the wonders which are there; he is the man who understands as far as may be the great forces of nature which are at work around him, and therefore he is able to make them work for him. For what is agriculture save a diversion of natural forces for the benefit of man! The farmer who knows these forces only when restricted to his paltry crops, and has no idea of their larger application, is no more efficient as a farmer than a man who knew only how to start and stop an engine would be as an engineer.

In order to appreciate truly his farm, the farmer must needs begin as a child with nature-study; in order to be successful and make the farm pay, he must needs continue in nature-study; and to make his declining years happy, content, full of wide sympathies and profitable thought, he must needs conclude with nature-study; for nature-study is the alphabet of agriculture and no word in that great vocation may be spelled without it.

Nature-Study Clubs

The organizing by the pupils of a club for studying out-of-door life is a great help and inspiration to the work in nature-study in the classroom. The essays and the talks before the club prove efficient aid in English composition; and the varied interests of the members of the club furnish new and vital material for study. A button or a badge may be designed for the club and, of course, it must have a constitution and bylaws. The proceedings of the club meetings should be conducted according to parliamentary rules; but the field excursions should be entirely informal.

The meetings of the Junior Naturalists Clubs, as organized in the schools of New York State by Mr. John W. Spencer, were most impressive. The school session would be brought to a close, the teacher stepping down and taking a seat with the pupils. The president of the club, some bashful boy or slender slip of a girl, would take the chair and conduct the meeting with a dignity and efficiency worthy of a statesman. The order was perfect, the discussion much to the point. I confess to a feeling of awe when I attended these meetings, conducted so seriously and so formally, by such youngsters. Undoubtedly, the parliamentary training and experience in speaking impromptu are among the chief benefits of such a club.

These clubs may be organized for special study. In one bird club of which I know there have been contests. Sides were chosen and the number of birds seen from May 1 to 31 inclusive was the test of supremacy. Notes on the birds were taken in the field with such care that, when at the end of the month each member handed in his notes, they could be used as evidence of accurate identification. An umpire decided the doubtful points with the help of bird manuals. The contest was always close and exciting.

The programs of the nature club should be varied so as to be continually interesting. Poems and stories concerning the objects studied help make the program attractive. Observing nature, however, should be the central theme of all meetings.

HOW TO USE THIS BOOK

First and indispensably, the teacher should have at hand the subject of the lesson. She should make herself familiar with the points covered by the questions and read the story before giving the lesson. If she does not have the time to go over the observations suggested before giving the lesson, she should take up the questions with the pupils as a joint investigation, and be boon companion in discovering the story.

The story should not be read to the pupils. It is given as an assistance to the teacher, and is not meant for direct information to the pupils. If the teacher knows a fact in nature's realm, she is then in a position to lead her pupils to discover this fact for themselves.

Make the lesson an investigation and make the pupils feel that they are investigators. To tell the story to begin with inevitably spoils this attitude and quenches interest.

The "leading thought" embodies some of the points which should be in the teacher's mind while giving the lesson; it should not be read or declared to the pupils.

The outlines for observations herein given by no means cover all of the observations possible; they are meant to suggest to the teacher observations of her own, rather than to be followed slavishly.

The suggestions for observations have been given in the form of questions, merely for the sake of saving space. The direct questioning method, if not employed with discretion, becomes tiresome

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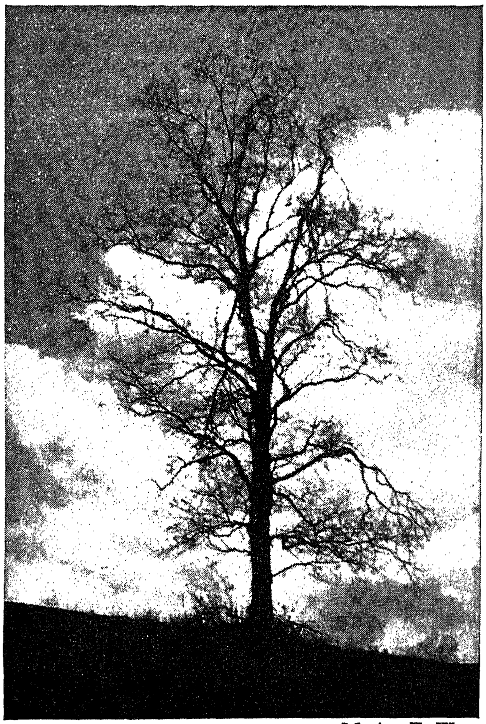
to both pupil and teacher. If the questions do not inspire the child to investigate, they are useless. To grind out answers to questions about any natural object is not nature-study, it is simply "grind," a form of mental activity which is of much greater use when applied to spelling or the multiplication table than to the study of nature. The best teacher will cover the points suggested for observations with few direct questions. To those who find the questions inadequate I will say that, although I have used these outlines once, I am sure I should never be able to use them again without making changes.



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A hickory tree

The topics chosen for these lessons may not be the most practical or the most interesting or the most enlightening that are to be found; they are simply those subjects which I have used in my classes, because we happened to find them at hand the mornings the lessons were given.

While an earnest attempt has been made to make the information in this book accurate, it is to be expected and to be hoped that many discrepancies will be found by those who follow the lessons. No two animals or plants are just alike, and no two people see things exactly the same way. *The chief aim of this volume is to encourage investigation rather than to give information.* Therefore, if mistakes are found, the object of the book will have been accomplished, and the author will feel deeply gratified. If the teacher finds that the observations made by her and her pupils do not agree with the statements in the book, I earnestly enjoin upon her to trust to her own eyes rather than to any book.

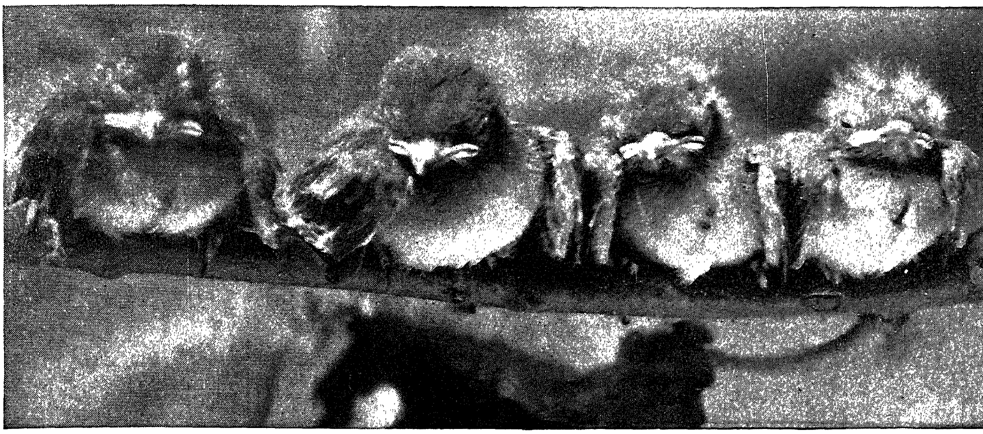
No teacher is expected to teach all the lessons in this book. A wide range of subjects is given, so that congenial choice may be made.

PART II
ANIMALS

ANIMAL GROUPS

For some inexplicable reason, the word *animal*, in common parlance, is restricted to the mammals. As a matter of fact, the bird, the fish, the insect, and the snake have as much right to be called animals as the squirrel or the deer. And while I believe that much freedom in the matter of scientific nomenclature is permissible in nature-study, I also believe that it is well for the child to have a clearly defined idea of the classes into which the animal kingdom is divided; I would have him gain this knowledge by noting how one animal differs from another rather than by studying the classification of animals in books. He sees that the fish differs in many ways from the bird and that the toad differs from the snake; and it will be easy for him to grasp the fact that the mammals differ from all other animals in that their young are nourished by milk from the breasts of the mother; when he appreciates this, he will understand that such diverse forms as the whale, the cow, the bat, and man are members of one great class of animals.

BIRDS



Young phoebes that have just left the nest

The reason for studying any bird is to ascertain what it does; in order to accomplish this, it is necessary to know what the bird is, learning what it is being simply a step that leads to a knowledge of what it does. But, to hear some of our bird devotees talk, one would think that to be able to identify a bird is all of bird study. On the contrary, the identification of birds is simply the alphabet to the real study, the alphabet by means of which we may spell out the life habits of the bird. To know these habits is the ambition of the true ornithologist, and should likewise be the ambition of the beginner, even though the beginner be a young child.

Several of the most common birds have been selected as subjects for lessons in this book; other common birds, like the phœbe and the wrens, have been purposely omitted; after the children have studied the birds, as indicated in the lessons, they will enjoy working out lessons for themselves with other birds. Naturally, the sequence of these lessons does not follow scientific classification; in the first lessons, an attempt has been made to lead the child gradually into a knowledge of bird life. Beginning with the chicken there follow naturally the lessons with pigeons and the canary; then there follow the careful and detailed study of the robins and constant comparison of them with the bluebirds. This is enough for the first year in the primary grades. The next year the work begins with the birds that remain in the North during the winter, the

Leonard K. Beyer

A family of cedar waxwings

chickadee, nuthatch, and downy woodpecker. After these have been studied carefully, the teacher may be an opportunist when spring comes and select any of the lessons when the bird subjects are at hand. The classification suggested for the woodpeckers and the swallows is for more advanced pupils, as are the lessons on the geese and turkeys. It is to be hoped that these lessons will lead the child directly to the use of the bird books, of which there are many excellent ones; for these, see the bibliography.

Beginning Bird Study in the Primary Grades

The hen is especially adapted as an object lesson for the young beginner of bird study. First of all, she is a bird, notwithstanding the adverse opinions of two of my small pupils who stoutly maintained that " a robin is a bird, but a hen is a hen." Moreover, the hen is a bird always available for nature-study; she looks askance at us from the crates of the world's marts; she comes to meet us in the country barnyard, stepping toward us sedately; looking at us earnestly with one eye, then

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A redstart at her nest

turning her head so as to check up her observations with the other; meantime she asks us a little question in a wheedling, soft tone, which we understand perfectly to mean, " Have you perchance brought me something to eat? " Not only is the hen an interesting bird in herself, but she is a bird with problems; and by studying her carefully we may be introduced into the very heart and center of bird life.

This lesson may be presented in two ways: First, if the pupils live in the country, where they have poultry at home, the whole series of lessons may best be accomplished through talks by the teacher, followed on the part of the children by observations to be made at home. The results of these observations should be given in school in oral or written lessons. Second, if the pupils are not familiar with fowls, a hen and a chick, if possible, should be kept in a cage in the schoolroom for a few days, and a duck or gosling should be brought in one day for observation. The crates in which fowls are sent to market make very good cages. One of the teachers of the Elmira, N. Y. schools introduced into the basement of the schoolhouse a hen, which there hatched her brood of chicks, much to the children's delight and edification. After the pupils have become thoroughly interested in the hen and are familiar with her ways, after they have fed her and watched her, and have for her a sense of ownership, the following lessons may be given in an informal manner, as if they were naturally suggested to the teacher's mind through watching the fowl.

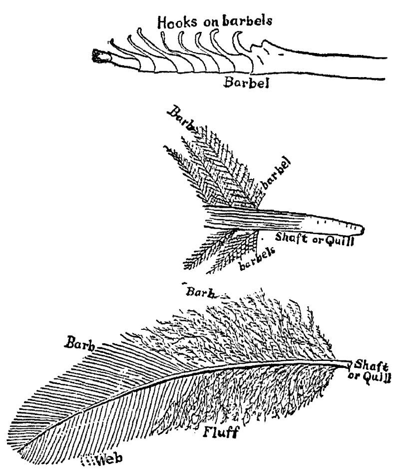
Suggested Reading — *Audubon Bird Cards*, by Allan Brooks, with text by Alden H. Hadley; *Audubon Bird Leaflets*, published by the National Association of Audubon Societies; *The Bird Book*, by Neltje Blanchan; *Bird Guide: Land Birds East of the Rockies*, by Chester A. Reed; *Bird Guide: Water Birds, Game Birds and Birds of Prey East of the Rockies*, by Chester A. Reed; *Bird Life*, by Frank M. Chapman; *Birds of America*, edited by T. Gilbert Pearson; *Birds of Massachusetts and Other New England States*, by *Edward H. Forbush*; *Birds of Minnesota, Bird Portraits in Color, A Manual for the Identification of the Birds of Minnesota and Neighboring States, 295 American Birds* (pictures in spiral binding or loose in portfolio), all by Thomas S. Roberts; *Birds of New York*, by E. H. Eaton; *The*

Book of Bird Life, by A. A. Allen; *The Book of Birds*, edited by Gilbert Grosvenor and Alexander Wetmore; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *A Field Guide to the Birds*, by Roger Tory Peterson; *Handbook of the Birds of Eastern North America*, by Frank M. Chapman; *Ornithology Laboratory Notebook*, by A. A. Allen; *Red Book of Birds of America, Blue Book of Birds of America, Green Book of Birds of America*, by Frank G. Ashbrook; *What Bird is That?* by Frank M. Chapman.

(These books contain descriptions and accounts of all the wild birds considered in this section of the Handbook. Additional references are to be found in the bibliography in the back of the book, under various headings: Birds, Animals in General, Nature Study in General, Textbooks and Readers, Nature Poetry, Magazines and Periodicals, Books for Parents and Teachers.)

FEATHERS AS CLOTHING

The bird's clothing affords a natural beginning for bird study because the wearing of feathers is a most striking characteristic distinguishing birds from other creatures; also, feathers and flying are the first things the young child notices about birds.

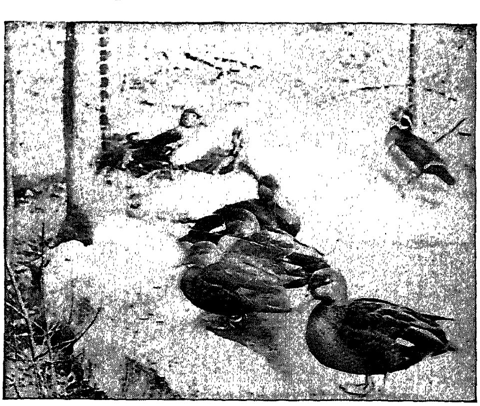


A feather

The purpose of all these lessons on the hen are: (a) To induce the child to make continued and sympathetic observations on the habits of the domestic birds. (b) To cause him involuntarily to compare the domestic with the wild birds. (c) To induce him to think for himself how the shape of the body, wings, head, beak, feet, legs, and feathers are adapted in each species to protect the bird and assist it in getting its living.

The overlapping of the feathers on a hen's back and breast is a pretty illustration of nature's method of shingling, so that the rain, finding no place to enter, drips off, leaving the bird's underclothing quite dry. It is interesting to note how a hen behaves in the rain; she droops her tail and holds herself so that the water finds upon her no resting place, but simply a steep surface down which to flow to the ground.

Each feather consists of three parts, the shaft or quill, which is the central stiff stem of the feather, giving it strength. From this quill come off the barbs which, toward the outer end, join together in a smooth web, making the thin, fanlike portion of the feather; at the base is the fluff, which is soft and downy and near to the body of the fowl. The teacher


Feathers help birds to endure the cold

should put on the blackboard this figure so that incidentally the pupils may learn the parts of a feather and their structure. If a microscope is available, show both the web and the fluff of a feather under a three-fourths objective.

The feathers on the back of a hen are longer and narrower in proportion than those on the breast and are especially fitted to protect the back from rain; the breast feathers are shorter and have more of the fluff, thus protecting the breast from the cold as well as the rain. It is plain to any child that the soft fluff is comparable to our underclothing while the smooth, overlapping web forms a rain- and wind-proof outer coat. Down is a feather with no quill; young chicks are covered with down. A pin-feather is simply a young feather rolled up in a sheath, which bursts later and is shed, leaving the feather free to assume its form. Take a large pin-feather and cut the sheath open and show the pupils the young feather lying within.

When a hen oils her feathers it is a process well worth observing. The oil gland is on her back just at the base of the tail feathers; she squeezes the gland with her beak to get the oil and then rubs the beak over the surface of her

Young pelicans are born naked, but are soon covered with white down

feathers and passes them through it; she spends more time oiling the feathers on her back and breast than those on the other parts, so that they will surely shed water. Country people say that when the hen oils her feathers it is a sure sign of rain. The hen sheds her feathers once a year and is a most untidy looking bird meanwhile, a fact that she seems to realize, for she is as shy and cross as a young lady caught in company with her hair in curlers; but she seems very pleased with

J. E. Rice

Feathers of a rooster, showing their relative size, shape, and position

1, neck hackle; 2, breast; 3, wing shoulder covert; 4, wing flight covert; 5, wing primary; 6, wing secondary; 7, wing covert; 8, back; 9, tail covert; 10, main tail; 11, fluff; 12, thigh; 13, saddle hackle; 14, the sickle or feather of beauty; 15, lesser sickle

herself when she finally gains her new feathers.

Suggested Reading — *The Bird Book*, by Fannie H. Eckstorm; *Bird Friends*, by Gilbert H. Trafton; *Bird Life*, by Frank M. Chapman; *Birds and Their Attributes*, by Glover M. Allen; *The Book of Bird Life*, by A. A. Allen; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*.

LESSON 1

Feathers as Clothing

Leading Thought — Feathers grow from the skin of a bird and protect the bird from rain, snow, wind, and cold. Some of the feathers act as cloaks or mackintoshes and others as underclothing.

METHOD — The hen should be at close range for this lesson where the children may observe how and where the different kinds of feathers grow. The pupils should also study separately the form of a feather from the back, from the breast, from the under side of the body, and a pin-feather.

OBSERVATIONS FOR PUPILS — 1. How are the feathers arranged on the back of the hen? Are they like shingles on the roof?

2. How does a hen look when standing in the rain?

3. How are the feathers arranged on the breast?

4. Compare a feather from the back and one from the breast and note the difference.

5. Are both ends of these feathers alike? If not, what is the difference?

6. Is the fluffy part of the feather on the outside or next to the bird's skin? What is its use?

7. Why is the smooth part of the feather (the web) on the outside?

8. Some feathers are all fluff and are called "down." At what age was the fowl all covered with down?

9. What is a pin-feather? Why do you think it is so called?

10. How do hens keep their feathers oily and glossy so they will shed water?

11. Where does the hen get the oil? Describe how she oils her feathers; which ones does she oil most? Does she oil her feathers before a rain?

"How beautiful your feathers be!"
The Redbird sang to the Tulip-tree
New garbed in autumn gold.
"Alas!" the bending branches sighed,
"They cannot like your leaves abide
To keep us from the cold!"

— JOHN B. TABB.

FEATHERS AS ORNAMENT

The ornamental plumage of birds is one of the principal illustrations of a great principle of evolution. The theory is that the male birds win their mates because of their beauty, those that are not beautiful being doomed to live single and leave no progeny to inherit their dullness. On the other hand, the successful wooer hands down his beauty to his sons. However, another quite different principle acts upon the coloring of the plumage of the mother birds; for if they should develop bright colors themselves, they would attract the eyes of the enemy to their precious hidden nests; only by being inconspicuous are they able to protect their eggs and nestlings from discovery and death. The mother partridge, for instance, is so nearly the color of the dead leaves on the ground about her that we may almost step upon her before we discover her; if she were the color of the male oriole or tanager she would very soon be the center of attraction to every prowler. Thus it has come about that among the birds the male has developed gorgeous colors which attract the female, while the female has kept modest, unnoticeable plumage.

Olin Sewall Pettingill, Jr.

Not a candidate for a beauty contest. A young belted kingfisher clothed in pin feathers

The curved feathers of the rooster's tail are weak and mobile and could not possibly be of any use as a rudder; but they give grace and beauty to the fowl and cover the useful rudder feathers underneath by a feather fountain of iridescence. The neck plumage of the cock

Peacock feathers. Is beauty useful?

is also often luxurious and beautiful in color and quite different from that of the hen. Among the Rouen ducks the brilliant blue-green iridescent head of the drake and his wing bars are beautiful, and make his wife seem Quaker-like in contrast.

As an object lesson to instill the idea that the male bird is proud of his beautiful feathers, I know of none better than that presented by the turkey gobbler, for he is a living expression of self-conscious vanity. He spreads his tail to the fullest extent and shifts it this way and that to show the exquisite play of colors over the feathers in the sunlight, meanwhile throwing out his chest to call particular attention to his blue and red wattles; and to keep from bursting with pride he bubbles over in vainglorious " gobbles."

The hen with her chicks and the turkey hen with her brood, if they follow their own natures, must wandei in the fields for food. If they were bright in color, the hawks would soon detect them and their chances of escape would be small; this is an instance of the advantage to the young of adopting the colors of the mother rather than of the father; a fact equally true of the song birds in cases where the males are brilliant in color at maturity. The male Baltimore oriole does not assist his mate in brooding, but he sits somewhere on the home tree and cheers her by his glorious song and by glimpses of his gleaming orange coat. Some have accused him of being lazy; on the contrary, he is a wise householder, for, instead of attracting the attention of crow or squirrel to his nest, he distracts their attention from it by both color and song.

A peacock's feather should really be a lesson by itself, it is so much a thing of beauty. The brilliant color of the purple eye-spot, and the graceful flowing barbs that form the setting to the central gem, are all a training in æsthetics as well as in nature-study. After the children have studied such a feather let them see the peacock, either in reality or in picture, and give them stories about this bird of Juno — a bird so inconspicuous, except for his great spread of tail, that a child seeing him for the first time cried, " Oh, oh, see this old hen all in bloom! "

The whole question of sexual selection may be made as plain as need be for the little folks, by simply telling them that the mother bird chooses for her mate the one which is most brightly and beautifully dressed; make much of the comb and wattles of the rooster and gobbler as additions to the brilliancy of their appearance.

Suggested Reading — See suggested reading for " Feathers as Clothing."

LESSON 2

Feathers as Ornament

Leading Thought — The color of feathers and often their shape make some birds more beautiful; while in others, the color of the feathers serves to protect them from the observation of their enemies.

Method — While parts of this lesson relating to fowls may be given in primary grades, it is equally fitted for pupils who have a wider knowledge of birds. Begin with a comparison of the plumage of the hen and the rooster. Then, if possible, study the turkey gobbler and a peacock in life or in pictures. Also the plumage of a Rouen duck and drake, and if possible, the Baltimore oriole, the goldfinch, the scarlet tanager, and the cardinal.

Observations — 1. Note the difference in shape and color of the tail feathers of hen and rooster.

2. Do the graceful curved tail feathers of the rooster help him in flying? Are they stiff enough to act as a rudder?

3. If not of use in flying what are they for? Which do you think the more beautiful, the hen or the rooster?

4. In what respects is the rooster a more beautiful fowl?

5. What other parts of the rooster's plumage are more beautiful than that of the hen?

6. If a turkey gobbler sees you looking at him he begins to strut. Do you think he does this to show off his tail feathers? Note how he turns his spread tail this way and that so the sunshine will bring out the beautiful changeable colors. Do you think he does this so you can see and admire him?

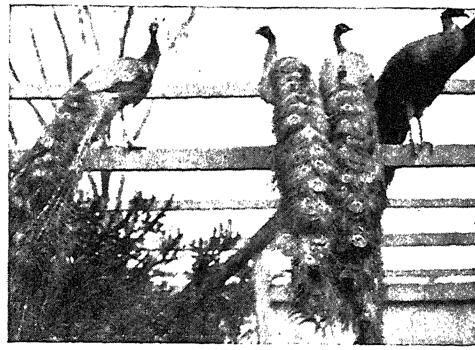
7. Describe the difference in plumage between the hen turkey and the gobbler. Does the hen turkey strut?

8. Note the beautiful blue-green iridescent head and wing patches on the wings of the Rouen ducks. Is the drake more beautiful than the duck?

9. What advantage is it for these fowls to have the father bird more beautiful and bright in color than the mother bird?

10. In the case of the Baltimore oriole, is the mother bird as bright in color as the father bird?

11. Study a peacock's feather. What color is the eye-spot? What color around that? What color around that? What color and shape are the outside barbs of the feather? Do you blame a peacock for being proud when he can spread a tail of a hundred eyes? Does the peahen have such beautiful tail feathers as the peacock?



Peacocks

The bird of Juno glories in his plumes;
Pride makes the fowl to preene his feathers so.
His spotted train fetched from old Argus' head,
With golden rays like to the brightest sun,
Inserteth self-love in the silly bird;
Till midst its hot and glorious fumes
He spies his feet and then lets fall his plumes.

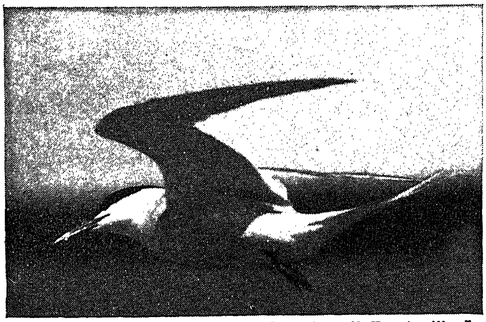
— "The Peacock,"
Robert Greene (1560)

HOW BIRDS FLY

To convince the children that a bird's wings correspond to our arms, they should see a fowl with its feathers off, prepared for market or oven, and they will infer the fact at once.

The bird flies by lifting itself through pressing down upon the air with its wings. There are several experiments which are needed to make the child understand this. It is difficult for children to conceive that the air is really anything, because they cannot see it; so the first experiment should be to show that the air is something we can push against or that pushes against us. Strike the air with a fan and we feel there is something which the fan pushes; we feel the wind when it is blowing and it is very difficult for us to walk against a hard wind. If we hold an open umbrella in the hand while we jump from a step, we feel buoyed up because the air presses up against the umbrella. The air presses up against the wings of the birds just as it does against the open umbrella. The bird flies by pressing down upon the air with its wings just as a boy jumps high by pressing down with his hands on his vaulting pole.

Study wing and note: (a) That the wings open and close at the will of the bird. (b) That the feathers open and shut on each other like a fan. (c) When the wing is open the wing quills overlap, so



Olin Sewall Pettingill, Jr.

Common tern. While we are having winter this bird spends the summer in South America. It will return to spend our summer with us

that the air cannot pass through them. (d) When the wing is open it is curved so that it is more efficient, for the same reason that an umbrella presses harder against the atmosphere when it is open than when it is broken by the wind and turned wrong side out.

A wing feather has the barbs on the front edge lying almost parallel to the quill, while those on the hind edge come off at a wide angle. The reason for this is easy to see, for this feather has to cut the air as the bird flies; and if the barbs on the front side were like those of the other side, they would be torn apart by the wind. The barbs on the hind side of the feather form a strong, close web so as to press down on the air and not let it through. The wing quill is curved; the convex side is up and the concave side below during flight. The concave side, like the umbrella, catches more air than the upper side; the down stroke of the wings is forward and down; while on the up stroke, as the wing is lifted, it bends at the joint like a fan turned sidewise, and offers less surface to resist the air. Thus, the up stroke does not push the bird down.

Observations should be made on the use of the bird's tail in flight. The hen spreads her tail like a fan when she flies to the top of the fence; the robin does likewise when in flight. The fact that the tail is used as a rudder to guide the bird in flight, as well as to give more surface for pressing down upon the air, is hard for the younger pupils to understand, and perhaps can be best taught by watching the erratic unbalanced flight of young birds whose tail feathers are not yet grown.

The tail feather differs from the wing feather in that the quill is not curved, and the barbs on each side are of about equal length and lie at about the same angle on each side of the quill. See Fig. p. 30.

Suggested Reading — *The Bird Book,* by Fannie H. Eckstorm; *Bird Flight,* by Gordon C. Aymar; *Bird Life,* by Frank M. Chapman; *Birds and Their Attributes,* by Glover M. Allen; *The Book of Bird Life,* by A. A. Allen; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Nature — by Seaside and Wayside,* by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals.*

LESSON 3

How Birds Fly

Leading Thought — A bird flies by pressing down upon the air with its wings, which are made especially for this purpose. The bird's tail acts as a rudder during flight.

Method — The hen, it is hoped, will by this time be tame enough so that the teacher may spread open her wings for the children to see. In addition, have a detached wing of a fowl such as is used in farmhouses instead of a whisk-broom.

Observations — 1. Do you think a bird's wings correspond to our arms? If so why?

2. Why do birds flap their wings when they start to fly?

3. Can you press against the air with a fan?

4. Why do you jump so high with a vaulting pole? Do you think the bird uses the air as you use the pole?

5. How are the feathers arranged on the wing so that the bird can use it to press on the air?

6. If you carry an umbrella on a windy morning, which catches more wind, the under or the top side? Why is this? Does the curved surface of the wing act in the same way?

7. Take a wing feather. Are the barbs as long on one side of the quill as on the other? Do they lie at the same angle from the quill on both sides? If not why?

8. Which side of the quill lies on the outer side and which on the inner side of the wing?

9. Is the quill of the feather curved?

10. Which side is uppermost in the wing, the convex or the concave side? Take a quill in one hand and press the tip against the other hand. Which way does it bend more easily, toward the convex or the concave side? What has this to do with the flight of the bird?

11. If the bird flies by pressing the wings against the air on the down stroke, why does it not push itself downward with its wings on the up stroke?

12. What is the shape and arrangement of the feathers which prevent pushing the bird back to earth when it lifts its wings?

13. Why do you have a rudder to a boat?

14. Do you think a bird could sail through the air without something to steer with? What is the bird's rudder?

15. Have you ever seen a young bird whose tail is not yet grown, try to fly? If so, how did it act?

16. Does the hen when she flies keep the tail closed or open like a fan?

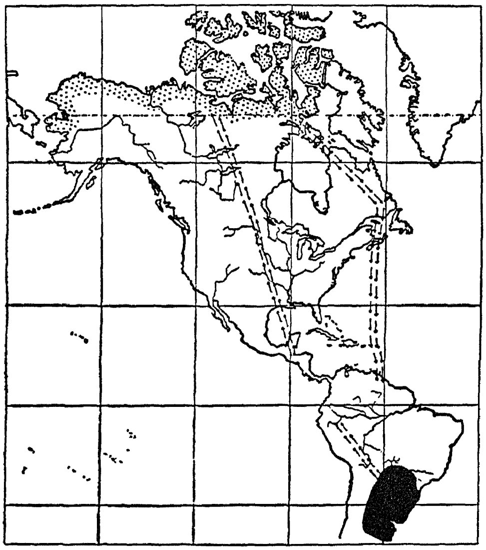
17. Compare a tail feather with a wing feather and describe the difference.

MIGRATION OF BIRDS

The travelogues of birds are as fascinating as our favorite stories of fairies, adventure, and fiction. If we could accompany certain birds, such as the Arctic terns, on their spring and autumn trips, the logs of the trips would be far more exciting than some recorded by famous aviators. The Arctic tern seems to hold the record for long-distance flight. Its nest is made within the bounds of the Arctic circle and its winter home is in the region of the Antarctic circle. The round-trip mileage for this bird during a year is about 22,000 miles. Wells W. Cooke, a pioneer student of bird migration, has called attention to the interesting fact that the Arctic tern "has more hours of daylight than any other animal on the globe. At the northern nesting-site the midnight sun has already appeared before the birds' arrival, and it never sets during their entire stay at the breeding grounds. During two months of their sojourn in the Antarctic the birds do not see a sunset, and for the rest of the time the sun dips only a little way below the horizon and broad daylight is continuous. The birds, therefore, have twenty-four hours of daylight for at least eight months in the year, and during the other four months have considerably more daylight than darkness." It is true that few of our birds take such long trips as does the Arctic tern; but most birds do travel for some distance each spring and fall.

Each season brings to our attention certain changes in the bird population. During late summer, we see great flocks of swallows; they are on telephone or telegraph wires, wire fences, clothes lines, or aerial wires. They twitter and flutter and seem all excited. For a few days, as they prepare for their southern journey, they are seen in such groups, and then are seen no more until the following spring. Some birds do not gather in flocks before leaving for the winter; they just disappear and we scarcely know when they go. We may hear their call notes far over our heads as they wing their way to their winter homes. Some birds migrate only during the day, others go only during the night, and others may travel by either day or night.

Those birds that do not migrate are called permanent residents. In the eastern United States chickadees, jays, downy woodpeckers, nuthatches, grouse, and pheasants are typical examples of the permanent resident group. These birds must be able to secure food under even the most adverse conditions. Much of their food is insect life found in or about trees; some fruits and buds of trees, shrubs, and vines are also included in their diet.



After Cooke

The migration routes of the golden plover. The dotted area is the summer home and nesting place; the black area is the winter home. Migration routes are indicated by arrows. On the southern route the plover makes a flight of 2,400 miles from Labrador to South America

Birds that travel are called migratory birds. If the spring migrants remain with us for the summer, we call them our summer residents. Fall migrants that remain with us for the winter are called winter residents. The migrants that do not remain with us but pass on to spend the summer or winter in some other area are called our transients or visitors. Of course, we must remember that the birds which visit us only for a short time are summer residents and winter residents in other parts of the country. Our summer residents are the winter residents of some other area.

In spring we await with interest the arrival of the first migrants. These birds are, in general, those which have spent the winter only a comparatively short distance away. In the eastern United States, we expect robins, red-winged blackbirds, song sparrows, and bluebirds among the earliest migrants. In many species the males arrive first; they may come as much as two weeks ahead of the females. The immature birds are usually the last to arrive. The time of arrival of the first migrants is determined somewhat by weather conditions; their dates cannot be predicted with as much accuracy as can those of birds which, having spent the winter at a greater distance from us, arrive later when the weather is more favorable. In some places, for example at Ithaca, New York, bird records have been kept each season for more than thirty years. With the information from these records, it is possible to indicate almost to a day when certain birds, such as barn swallows, orioles, or hummingbirds, may be expected to arrive. Usually the very first birds of a kind to arrive are those individuals which will within a few days continue their northward journey. The later arrivals are usually those that remain to become summer residents. In some species all individuals are migrants; for southern New York the white-throated sparrow is representative of such a group. It winters farther south and nests farther north than southern New York.

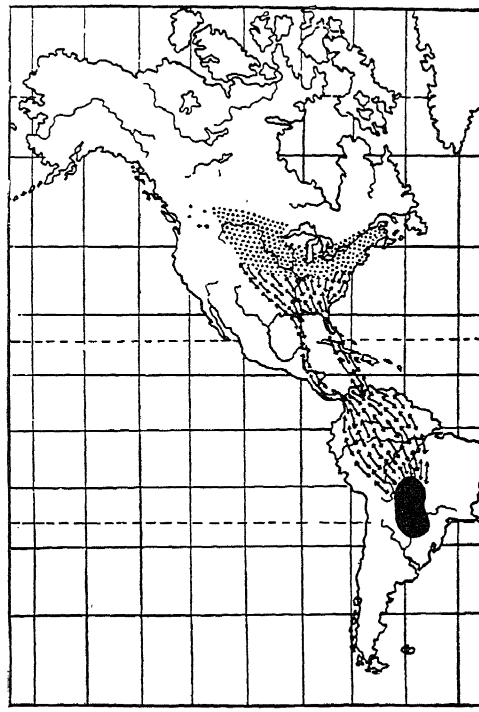
Why do birds migrate? This question has often been asked; but in answer to it we must say that while we know much about where birds go and how fast they travel, we still know actually very little about the reasons for their regular seasonal journeys.

As the airplane pilot has man-made instruments to aid him in reaching a certain airport, so the birds have a well-developed sense of direction which guides them to their destination. Each kind of bird seems, in general, to take the route followed by its ancestors; but this route may be varied if for any reason food should become scarce along the way. Such routes are so exactly followed year after year that they are known as lanes of migration. Persons desiring to study a certain species of bird can have excellent opportunities to do so by being at some good vantage point along this lane. Sometimes undue advantage has been taken of certain birds, especially hawks. Persons desiring to kill these birds have collected at strategic points along the lanes and wantonly killed many of them. As a result of such activities sanctuaries have been established at certain places along the lanes to give added protection to birds.

The routes north and south followed by a given species of bird may lead over entirely different parts of the country; these are called double migration routes. They may vary so much that one route may lead chiefly over land while the other may lead over the ocean. The golden plover is an example of such a case. See the migration map.

Much valuable information as well as pleasure can be gained from keeping a calendar of migration and other activities of birds. It is especially interesting during the spring months when first arrivals are recorded if daily lists are made of all species observed. In summer, nesting activities and special studies of an individual species provide something of interest for each day. More pleasure can be derived from the hobby if several people take it up and compare their findings. Interests in photography, sketching, or nature-story writing are natural companions of such bird study.

Suggested Reading — *Bird Friends*, by Gilbert H. Trafton; *Bird Life*, by Frank M. Chapman; *Birds and Their Attributes*, by Glover M. Allen; *Birds of America*, edited by T. Gilbert Pearson; *Birds of New York*, by E. H. Eaton; *The Book of Bird Life*, by A. A. Allen; *The Book of Birds*, edited by Gilbert Grosvenor and Alexander Wetmore; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Flight Speed of Birds*, by May Thacher Cooke (U. S. Department of Agriculture,



The travels of the bobolink. The migration routes of the bobolink are shorter than those of the plover and follow land more closely

Circular 428); *The Migration of North American Birds*, by Frederick C. Lincoln (U. S. Department of Agriculture, Circular 363); *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*; *Our Winter Birds*, by Frank M. Chapman; *Pathways in Science*, by Gerald S. Craig and Co-authors, Book 2, Out-of-doors, Book 5, *Learning about Our World*; *The Stir of Nature*, by William H. Carr; *Traveling with the Birds*, by Rudyerd Boulton; *The Travels of Birds*, by Frank M. Chapman.

EYES AND EARS OF BIRDS

The hen's eyes are placed at the side of the head so that she cannot see the same object with both eyes at the same time, and thus she has the habit of looking at us first with one eye and then the other to be sure she sees correctly. The position of the hen's eyes gives her a command of her entire environment. All birds have much keener eyes than we have; and they can adjust their eyes for either near or far vision much more effectively than we can; some hawks, flying high in the air, can see mice on the ground.

A wide range of colors is found in the eyes of birds: white, red, blue, yellow, brown, gray, pink, purple, and green are found in the iris of different species. The hen's eye consists of a black pupil at the center, which must always be black in any eye, since it is a hole through which enters the image of the object. The iris of the hen's eye is yellow; there is apparently no upper lid, but the lower lid comes up during the process of sleeping. When the bird is drowsy the little film lid comes out from the corner of the eye and spreads over it like a veil; just at the corner of our own eye, next the nose, is the remains of this film lid, although we cannot move it as the hen does.

Olin Sewall Pettingill, Jr.

A duck hawk. Notice the strong hooked beak, the keen eye, and the prominent nostril

The hearing of birds is very acute, although in most cases the ear is simply a hole in the side of the head, and is more or less covered with feathers. The hen's ear is like this in many varieties of chickens; but in others and in the roosters there are ornamental ear lobes.

SUGGESTED READING — *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller.

LESSON 4

EYES AND EARS OF BIRDS

LEADING THOUGHT — The eyes and ears of birds are peculiar and very efficient.

METHOD — The hen or chicken and the rooster should be observed for this lesson; notes may be made in the poultry yard or in the schoolroom when the birds are brought there for study.

OBSERVATIONS — 1. Why does the hen turn her head first this side and then that as she looks at you? Can she see an object with both eyes at once? Can she see well?

2. How many colors are there in a hen's eye? Describe the pupil and the iris.

3. Does the hen wink as we do? Has she any eyelids?

4. Can you see the film lid? Does it come from above or below or the inner or outer corner? When do you see this film lid?

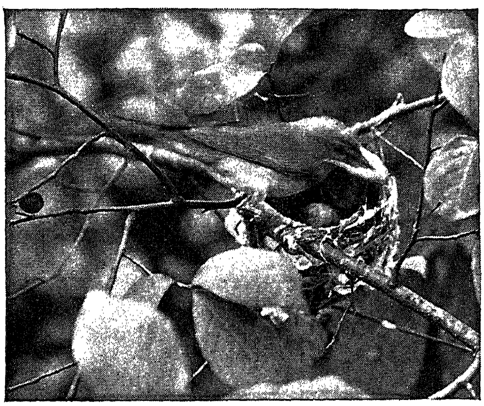
5. Where are the hen's ears? How do they look? How can you tell where the rooster's ears are?

6. Do you think the hen can see and hear well?

THE FORM AND USE OF BEAKS

Since the bird uses its arms and hands for flying, it has been obliged to develop other organs to take their place, and of their work the beak does its full share. It is well to emphasize this point by letting the children at recess play the game of trying to eat an apple or to put up their books and pencils with their arms tied behind them; such an experiment will show how naturally the teeth and feet come to the aid when the hands are useless.

The hen feeds upon seeds and insects which she finds on or in the ground; her beak is horny and sharp and acts not only as a pair of nippers, but also as a pick as she strikes it into the soil to get the seed



A. A. Allen

A red-eyed vireo repairing her nest

or insect. She has already made the place bare by scratching away the grass or surface of the soil with her strong, stubby toes. The hen does not have any teeth, nor does she need any, for her sharp beak enables her to seize her food; and she does not need to chew it, since her gizzard does this for her after the food is swallowed.

The duck's bill is broad, flat, and much softer than the hen's beak. The duck feeds upon water insects and plants; it obtains these by thrusting its head down into the water, seizing the food, and holding it fast while the water is strained out through the sieve at the edges of the beak; for this use, a wide, flat beak is necessary. It would be quite as impossible for a duck to pick up hard seeds with its broad, soft bill as it would for the hen to get the duck's food

Leonard K. Beyer

These holes were made by a pileated woodpecker in search of insects

out of the water with her narrow, horny bill.

Both the duck and hen use their bills for cleaning and oiling their feathers and for fighting also; the hen strikes a sharp blow with her beak, making a wound like a dagger, while the duck seizes the enemy and simply pinches hard. Both fowls also use their beaks for turning over the eggs when incubating, and also as an aid to the feet when they make nests for themselves.

The nostrils are very noticeable and are situated in the beak near the base. However, we do not believe that birds have a keen sense of smell, since their nostrils are not surrounded by a damp, sensitive, soft surface as are the nostrils of the deer and dog. This arrangement aids these animals to detect odor in a marvelous manner.

Suggested Reading — *The Bird Book*, by Fannie H. Eckstorm; *Bird Life*, by

Frank M. Chapman; *The Book of Bird Life*, by A. A. Allen; *The Book of Birds*, edited by Gilbert Grosvenor and Alexander Wetmore; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*.

LESSON 5

The Beak of a Bird

Leading Thought — Each kind of bird has a beak especially adapted for getting its food. The beak and feet of a bird are its chief weapons and implements.

Method — Study first the beak of the hen or chick and then that of the duckling or gosling.

Observations — 1. What kind of food does the hen eat and where and how does she find it in the field or garden? How is her beak adapted to get this food? If her beak were soft like that of a duck could she peck so hard for seeds and worms? Has the hen any teeth? Does she need any?

2. Compare the bill of the hen with that of the duck. What are the differences in shape? Which is the harder?

3. Note the saw teeth along the edge of the duck's bill. Are these for chewing? Do they act as a strainer? Why does the duck need to strain its food?

4. Could a duck pick up a hen's food from the earth or the hen strain out a duck's food from the water? For what other things than getting food do these fowls use their bills?

5. Can you see the nostrils in the bill of a hen? Do they show plainer in the duck? Do you think the hen can smell as keenly as the duck?

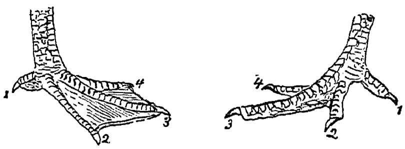
It is said that nature-study teaching should be accurate, a statement that every good teacher will admit without debate; but accuracy is often interpreted to mean completeness, and then the statement cannot pass unchallenged. To study " the dandelion," " the robin," with emphasis on the particle " the," working out the complete structure, may be good laboratory work in botany or zoology for advanced pupils, but it is not an elementary educational process. It contributes nothing more to accuracy than does the natural order of leaving untouched all those phases of the subject that are out of the child's reach; while it may take out the life and spirit of the work, and the spiritual quality may be the very part that is most worth the while. Other work may provide the formal " drill "; this should supply the quality and vivacity. Teachers often say to me that their children have done excellent work with these complete methods, and they show me the essays and drawings; but this is no proof that the work is commendable. Children can be made to do many things that they ought not to do and that lie beyond them. We all need to go to school to children. — " The Outlook to Nature," L. H. Bailey

Weather and wind and waning moon,
Plain and hilltop under the sky,
Ev'ning, morning and blazing noon,
Brother of all the world am I.
The pine-tree, linden and the maize,
The insect, squirrel and the kine,
All — natively they live their days —
As they live theirs, so I live mine,
I know not where, I know not what: —
Believing none and doubting none
Whate'er befalls it counteth not, —
Nature and Time and I are one.

— L. H. Bailey

THE FEET OF BIRDS

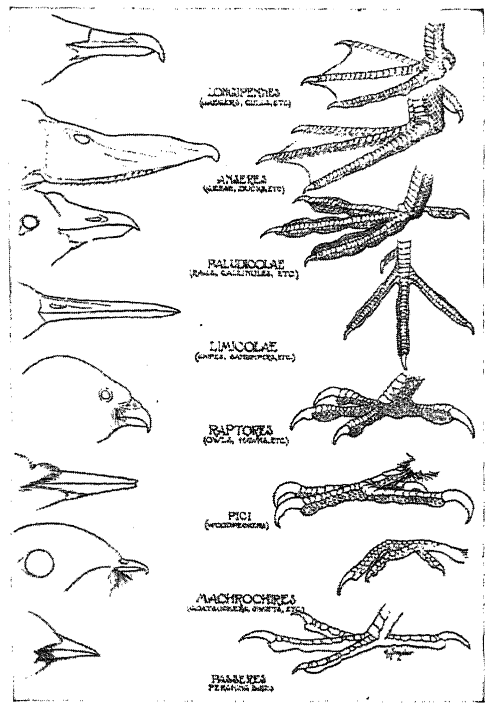
Obviously, the hen is a digger of the soil; her claws are long, strong, and slightly hooked, and her feet and legs are covered with horny scales. These scales protect her feet from injury when they are used in scratching the hard earth to lay bare the seeds and insects hiding there. The hen is a very good runner indeed. She lifts her wings a little to help, much as an athletic runner uses his arms, and so can cover ground with amazing rapidity, her strong toes giving her a firm foothold. The track she makes is very characteristic; it consists of three toe-marks projecting forward and one backward. A bird's toes are numbered thus: the hind toe is number one, the inner toe number two, the middle toe three, and the outer toe four.



Duck's foot and hen's foot with toes numbered

A duck has the same number of toes as the hen, but there is a membrane, called the web, which joins the second, third, and fourth toes, making a fan-shaped foot; the first or hind toe has a little web of its own. A webbed foot is first of all a paddle for propelling its owner through the water; it is also a very useful foot on the shores of ponds and streams, since its breadth and flatness prevent it from sinking into the soft mud.

The duck's legs are shorter than those of the hen and are placed farther back and wider apart. They are essentially swimming organs and are not fitted for scratching or for running. They are placed at the sides of the bird's body so that they may act as paddles, and are farther back so that they may act like the wheel of a propeller in pushing the bird along. We often laugh at a duck on land, since its short legs are so far apart and so far back that its walk is necessarily an awkward waddle; but we must always remember that the duck is naturally a water bird, and on the water its movements are graceful. Think how a hen would appear if she attempted to swim! The duck's body is so poorly balanced on its short legs that it cannot run rapidly; and if chased even a short distance it will fall dead from the effort, as many a country child has discovered to his sorrow when he tried to drive the ducks home from the creek or pond to coop. The long hind claw of the hen enables her to clasp a roost firmly during the night; a duck's foot could not do this and the duck sleeps squatting on



Types of bills and feet

the ground. However, the Muscovy ducks, which are not good swimmers, have been known to perch.

Suggested Reading — *The Bird Book*, by Fannie H. Eckstorm; *Bird Life*, by Frank M. Chapman; *Birds and Their Attributes*, by Glover M. Allen; *The Book of Bird Life*, by A. A. Allen; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*.

LESSON 6

The Feet of Birds

Leading Thought — The feet of birds are shaped so as to assist the bird in getting its food as well as for locomotion.

Method — The pupils should have opportunity to observe the chicken or hen and a duck as they move about; they should also observe the duck swimming.

Observations — 1. Are the toes of the hen long and strong? Have they long, sharp claws at their tips?

2. How are the legs and feet of the hen covered and protected?

3. How are the hen's feet and legs fitted for scratching the earth, and why does she wish to scratch the earth?

4. Can a hen run rapidly? What sort of track does she make?

5. You number your fingers with the thumb as number one and the little finger as five. How do you think the hen's toes are numbered?

6. Has the duck as many toes as the hen? What is the chief difference between the feet of the duck and of the hen?

7. Which of the duck's toes are connected by a web? Does the web extend to the tips of the toes? How does the web help the duck?

8. Are the duck's legs as long as the hen's? Are they placed farther forward or farther back than those of the hen? Are they farther apart?

9. Can a duck run as well as a hen? Can the hen swim at all?

10. Where does the hen sleep and how does she hold on to her perch? Could the duck hold on to a perch? Does the duck need to perch while sleeping?

SONGS OF BIRDS

Anyone who attempts to recognize birds by sight alone misses much of the pleasure that comes to those who have

taken the time and pains to learn bird songs and use them as a means of bird recognition. It is true that not all people have a talent for music; but anyone interested in birds can learn to identify the songs and most of the call notes of common birds.

The observer will notice that in most cases only the male bird sings, but a few exceptions are recorded, notably the female rose-breasted grosbeak and cardinal grosbeak, which sing under some conditions. Birds do most of their singing in the early morning and during the spring and early summer months. The male birds have not only a favorite time of day and a particular season of the year during which they do most of their singing, but they even have a certain perch or narrowly defined territory from which they sing.

Each person will need to decide how he can best remember bird songs. Most people will doubtless use such methods as were used by earlier bird students. Long literary descriptions were given for each song. Alexander Wilson, for instance, describes the call of the male blue jay as "repeated creakings of an ungreased wheelbarrow." Often the call of a particular bird is put into words; in many cases these words have come to be accepted as the common name of the bird, such as bobwhite and whip-poor-will. The imagination of students may suggest certain words to represent the song or call notes of a bird. These are often more easily remembered than the song itself.

Some ornithologists have developed

complicated systems of recording bird songs as musical scores. Wilson Flagg and F. S. Mathews are well-known names in this field. Such a method has its limitations because many variations of bird songs cannot be indicated by the characters used in writing music. The song of a bird written as music is not usually recognizable when played on a musical instrument. Other ornithologists have developed more graphic methods of recording bird songs. One leader in this field, A. A. Saunders, has proposed and used a system employing lines, dots, dashes, and syllables. This system is very interesting and is a useful one to a person who has a good ear for music. One of the latest methods of recording bird songs has been developed by the Department of Ornithology, Cornell University, Ithaca, New York. By this method bird songs are photographed on moving picture film and later may be recorded on phonograph records; these records can be played over and over again to give the student practice in identifying bird songs. Sound pictures have also been produced; the pictures of the various birds are shown on the screen as their songs are being heard by the audience.

Suggested Reading — *Bird Friends,* by Gilbert H. Trafton; *Birds and Their Attributes,* by Glover M. Allen; *The Book of Bird Life,* by A. A. Allen; *The Book of Birds,* edited by Gilbert Grosvenor and Alexander Wetmore; *Field Book of Wild Birds and Their Music,* by F. Schuyler Mathews; *A Guide to Bird Songs,* by Aretas A. Saunders; *Songs of Wild Birds* and *More Songs of Wild Birds,* by Albert R. Brand.

ATTRACTING BIRDS

If suitable and sufficient food, water, shelter, and nesting sites are provided, and if protection is given from such enemies as cats and thoughtless men, it is possible to attract many kinds of birds to home grounds or gardens. The most logical time to begin to attract birds is during the winter months; but the best time is whenever one is really interested and is willing to provide the things most needed by the birds. Certain types of food, such as suet or sunflower seeds, are sought by birds at any season. During the summer months water for drinking and bathing may be more desired than food, but in the winter almost any seeds, fruits, or fatty foods are welcome.

In the spring nesting boxes properly constructed and placed will do much to attract some kinds of birds, especially those that normally nest in holes in trees. An abundance of choice nesting materials will entice orioles, robins, or chipping sparrows to nest near by. Straws, sticks, feathers, cotton, strings, or even hairs from old mattresses may be put out as inducements to prospective bird tenants.

An invitation to our garden friends to partake of suet and peanuts in addition to their regular fare

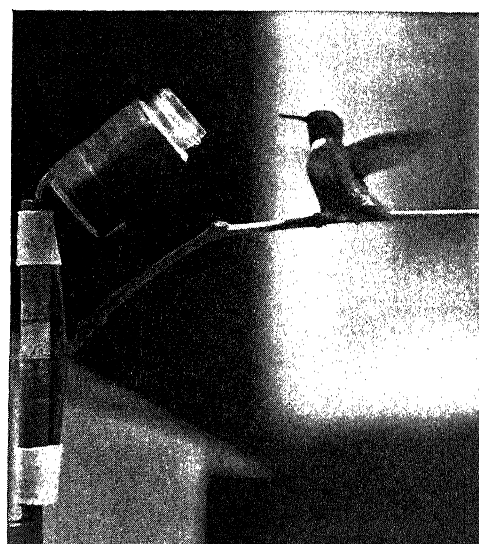
The spring is also a good time to plant fruit-bearing trees, shrubs, and vines; these

A bird bath in the author's garden

natural food counters become more attractive each year as they grow larger and produce more fruit and better nesting places for birds.

Autumn is the ideal time to establish feeding centers to which the birds may be attracted during the winter months. Food, such as suet or seeds, should be put at a great many places throughout the area in which one wishes to attract birds. The birds will gradually work their way from one of these feedings points to another; soon it will be possible to concentrate the feeding at one point, and the birds will continue to come to that point as long as food is provided there.

SUGGESTED READING — *The A B C of Attracting Birds,* by Alvin M. Peterson; *Bird Houses Boys Can Build,* by Albert F. Siepert; *Birds of the Wild — How to Make Your Home Their Home,* by Frank C. Pellett; *Bird Study for Schools Series,* published by the National Association of Audubon Societies (Part III, Winter Feeding, Part IV, Bird Houses); *The Book of Bird Life,* by A. A. Allen; *Boy Bird House Architecture,* by Leon H. Baxter; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *Homes for Birds,* by E. R. Kalmbach and W. L. McAtee (U. S. Department of Agriculture, Farmers' Bulletin 1456); *How to Attract Birds in Northeastern United States, How to Attract Birds in Northwestern United States, How to Attract Birds in the Middle Atlantic States, How to Attract Birds in the East Central States,* by W. L. McAtee (U. S. Department of Agriculture, Farmers' Bulletins 621, 760, 844, 912); *How to Have Bird Neighbors, by* S. Louise Patteson; *Our Winter Birds,* by Frank M. Chapman; *Permanent Bird Houses,* by Gladstone Califf; *Song-bird Sanctuaries, with Tables of Trees, Shrubs and Vines Attractive to Birds,* by Roger T. Peterson; *Wild Bird Guests,* by Ernest H. Baynes; *Methods of Attracting Birds,* by Gilbert H. Trafton.



Olin Sewall Pettingill, Jr.

Ruby-throated hummingbird attracted to a vial containing sweetened water

VALUE OF BIRDS

Did you ever try to calculate in dollars the pleasure that you receive from seeing or hearing the first spring migrants? The robin, bluebird, and meadowlark bring cheer to thousands of people every year. Indeed, it would be difficult to find anyone, except perhaps in large cities, who does not notice the arrival of at least some spring birds — the robins on the lawn, the honk of the wild geese overhead, or the song sparrows as they sing from the top of a shrub. Birds are interesting to most people because of their mere presence, their songs, their colors, or their habits. Persons engaged in nature-study are led outdoors and thus have opened to them many other nature fields.

One needs to observe a bird for only a short time to discover for himself what has been known by scientists for many years, that birds are of great economic importance. Watch a chickadee or nuthatch as it makes its feeding rounds on a winter day. Note how carefully each tiny branch is covered by the chickadee and what a thorough examination of the limbs and trunks is made by the nuthatch. Countless insect eggs as well as insects are consumed. On a sunny day in spring, observe the warblers as they feed about the newly opened leaves and blossoms of the trees. See them as they hunt tirelessly for their quota of the tiny insects so small that they are generally overlooked by larger birds. It must be remembered too that some birds do, at times, take a toll of cultivated crops; this is especially true of the seed-eating and insectivorous birds. But they deserve some pay for the work they do for man, and so in reality he should not begrudge them a little fruit or grain.

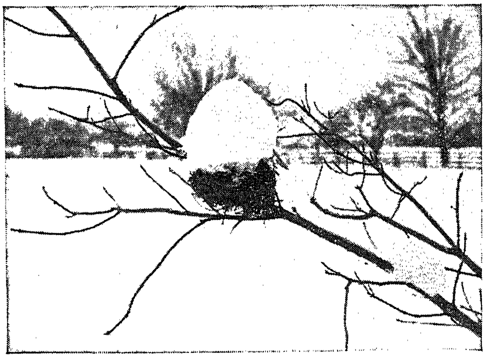
Some of the birds of prey are active all the time; the hawks work in the daytime and the owls come on duty for the night shift. Countless destructive small mammals and insects are eaten by them; thus they tend to regulate the numbers of numerous small pests of field and wood, thereby preventing serious outbreaks of such animals. There has been much discussion of the real economic status of hawks and owls; many food studies have been made and the general conclusion is that most species are more useful than harmful. It is true that some species do take a toll of game birds, song birds, and poultry; but they include also in their diet other animal forms, many of which are considered harmful. One individual bird may be especially destructive and thus give a bad name to an entire species.

Leonard K. Beyer

A red-eyed vireo on her nest. Vireos live largely on insects gleaned from the under surfaces of leaves and from crevices in bark

There are even garbage gatherers among the birds; vultures, gulls, and crows serve in this capacity. The vultures are commonly found in the warmer parts of the country and serve a most useful purpose by their habit of devouring the unburied bodies of dead animals. The gulls are the scavengers of waterways and shore lines. The crow is omnivorous — that is, it eats both plant and animal food; but it seems to like carrion as well as fresh meat.

The farmer and the gardener owe quite a debt of thanks to the birds that eat weed seeds. Of course there are still bountiful crops of weeds each year; but there would



Verne Morton

A goldfinch nest in winter

be even more weeds if it were not for the army of such seed-eating birds as sparrows, bobwhites, and doves.

The game birds, such as grouse, pheasant, and bobwhite are important today, chiefly from the standpoint of the recreation they afford sportsmen and other lovers of the outdoors. The food habits of game birds do not present much of an economic problem; the birds are not numerous enough at the present time to be an important source of meat for man as they were in pioneer days.

Thus, a brief consideration of a few types of birds will show even a casual observer that birds have economic importance and that each species seems to have a definite work to perform.

SUGGESTED READING — *Bird Friends*, by Gilbert H. Trafton; *Birds and Their Attributes*, by Glover M. Allen; *Birds in Their Relation to Man*, by Clarence M. Weed and Ned Dearborn; *The Book of Bird Life*, by A. A. Allen; *The Book of Birds*, edited by Gilbert Grosvenor and Alexander Wetmore; *The Children's Book of Birds* (First Book of Birds and Second Book of Birds), by Olive Thorne Miller; *The Practical Value of Birds*, by Junius Henderson.

LESSON 7

THE STUDY OF BIRDS' NESTS IN WINTER

There are very good reasons for not studying birds' nests in summer, since the birds misinterpret familiarity on the part of eager children and are likely, in consequence, to abandon both nest and locality. But after the birds have gone to sunnier climes and the empty nests are the only mementos we have of them, then we may study these habitations carefully and learn how to appreciate properly the small architects which made them. I think that every one of us who carefully examines the way that a nest is made must have a feeling of respect for its clever little builder.

I know of certain schools where the children make large collections of these winter nests, properly labeling each, and thus gain a new interest in the bird life of their locality. A nest when collected should be labeled in the following manner:

The name of the bird which built the nest.

Where the nest was found.

If in a tree, what kind?

How high from the ground?

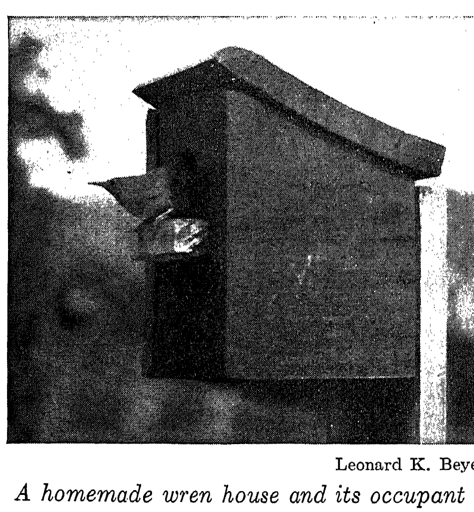
After a collection of nests has been made, let the pupils study them according to the following outline:

1. Where was the nest found?

   (a) If on the ground, describe the locality.

   (b) If on a plant, tree, or shrub, tell the species, if possible.

   (c) If on a tree, tell where it was on a branch — in a fork, or hanging by the end of the twigs.



Leonard K. Beyer

A homemade wren house and its occupant

(d) How high from the ground, and what was the locality?

(e) If on or in a building, how situated?

2. Did the nest have any arrangement to protect it from rain?

3. Give the size of the nest, the diameter of the inside and the outside; also the depth of the inside.

4. What is the form of the nest? Are its sides flaring or straight? Is the nest shaped like a cup, basket, or pocket?

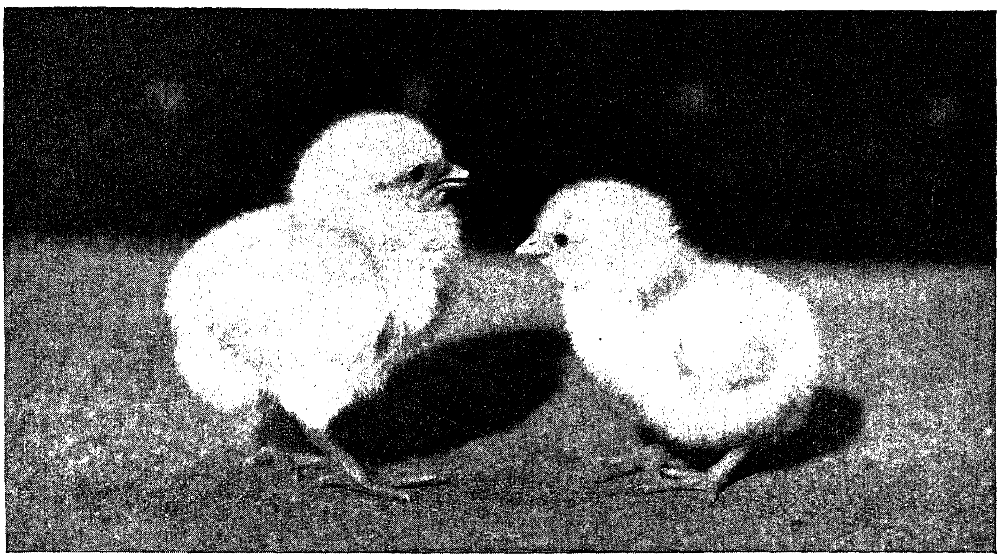
5. What materials compose the outside of the nest and how are they arranged?

6. Of what materials is the lining made, and how are they arranged? If hair or feathers are used, on what creature did they grow?

7. How are the materials of the nest held together, that is, are they woven, plastered, or held in place by environment?

8. Had the nest anything peculiar about it either in situation, construction, or material that would tend to render it invisible to the casual glance?

SUGGESTED READING — *The Book of Bird Life*, by A. A. Allen; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals; Ornithology Laboratory Notebook*, by A. A. Allen; *A Year in the Wonderland of Birds*, by Hallam Hawksworth.

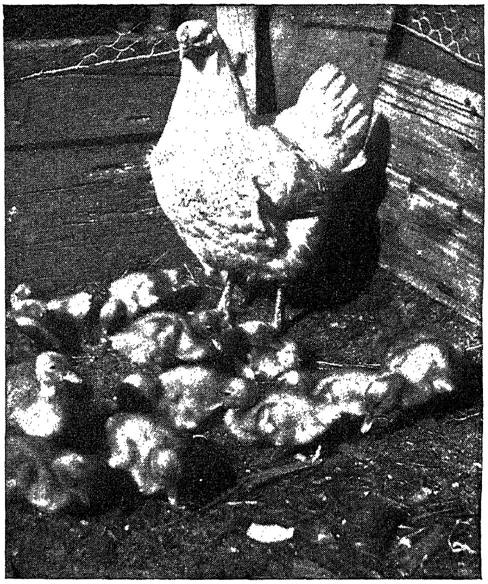


U. S. Department of Agriculture

Chicks, a few days old

CHICKEN WAYS

Dame Nature certainly pays close attention to details. An instance of this is the little tooth on the tip of the upper mandible of the young chick, which aids it in breaking out of its egg-shell prison; since a tooth in this particular place is of no use later, it disappears. The children are delighted with the beauty of a fluffy little chick with its bright, questioning eyes and its life of activity as soon as it is freed from the shell. What a contrast to the blind, bare, scrawny young robin, which seems to be all mouth! The difference between the two is fundamental since it gives a means for distinguishing ground birds from perching birds. The young partridge, quail, turkey, and chick are clothed and active and ready to go with the mother in search of food as soon as they are hatched; while the young of

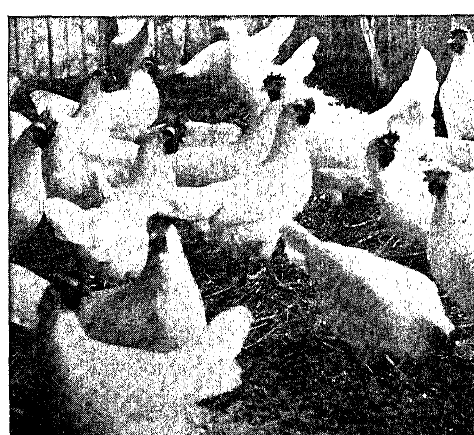


An anxious stepmother. The ducklings pay her little heed

the perching birds are naked and blind, being kept warm by the brooding mother, and fed and nourished by food brought by their parents, until they are large enough to leave the nest. The down which covers the young chick differs from the feathers which come later; the down has no quill but consists of several flossy threads coming from the same root; later on, this down is pushed out and off by the true feathers which grow from the same sockets. The pupils should see that the down is so soft that the little, fluffy wings of the chick are useless until the real wing feathers appear.

We chew food until it is soft and fine, then swallow it, but the chick swallows it whole; after being softened by juices from the stomach the food passes into a little mill, in which is gravel that the chicken has swallowed. This gravel helps to grind up the food. This mill is called the gizzard and the pupils should be taught to look carefully at this organ the next time they have chicken for dinner. A chicken has no muscles in the throat, like ours, to enable it to swallow water as we do. Thus, it has first to fill its beak with water, then hold it up so the water will flow down the throat. As long as the little chick has its mother's wings to sleep under, it does not need to put its head under its own wing; but when it grows up and spends the night upon a roost, it usually tucks its head under its wing while sleeping.

The conversation of the barnyard fowl covers many elemental emotions and is easily comprehended. It is well for the children to understand from the first that the notes of birds mean something definite. The hen clucks when she is leading her chicks afield so that they will know where she is in the tall grass; the chicks follow "cheeping" or "peeping," as the children say, so that she will know where they are; but if a chick feels itself lost its "peep" becomes loud and disconsolate; on the other hand, there is no sound in the world so full of cosy contentment as the low notes of the chick when it cuddles under the mother's wing. When a hen finds a bit of food she utters rapid notes which call the chicks in a hurry, and when she sees a hawk she gives a warning "q-r-r" which makes every chick run for cover and keep quiet. When hens are taking their sun and dust baths together, they seem to gossip and we can almost hear them saying, "Didn't you think Madam Dorking made a great fuss over her egg today?" Or, "That overgrown young rooster has got a crow to match his legs, hasn't he?" Contrast these low tones with the song of the hen as she issues forth in the first warm days



Poultry Dept., N. Y. State College of Agriculture

White leghorns are prolific layers

of spring and gives to the world one of the most joyous songs of all nature. There is quite a different quality in the triumphant cackle of a hen telling to the world that she has laid an egg and the cackle which comes from being startled. When a hen is sitting or is not allowed to sit, she is nervous and irritable, and voices her mental state by scolding. When she is really afraid, she squalls; and when seized by an enemy, she utters long, horrible squawks. The rooster crows to assure his flock that all is well; he also crows to show other roosters what he thinks of himself and of them. The rooster also has other notes; he will question you as you approach him and his flock, and he will give a warning note when he sees a hawk; when he finds some dainty tidbit, he calls his flock of hens to him and they usually arrive just in time to see him swallow the morsel.

When roosters fight, they confront each other with their heads lowered and then try to seize each other by the back of the neck with their beaks, or strike each other with the wing spurs, or tear with the leg spurs. Weasels, skunks, rats, hawks, and crows are the most common enemies of the fowls, and often a rooster will attack one of these invaders and fight valiantly; the hen also will fight if her brood is disturbed.

Suggested Reading — *Farm Animals*, by James G. Lawson; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 3, *Surprises*; *The Pet Book*, by Anna B. Comstock.

LESSON 8

Chicken Ways

Leading Thought — Chickens have interesting habits of life and extensive conversational powers.

Method — For this lesson it is necessary that the pupils observe the inhabitants of the poultry yard and answer these questions a few at a time.

Observations — 1. Did the chick get out of the egg by its own efforts? Of what use is the little tooth which is on the tip of the upper part of a young chick's beak? Does this remain?

2. What is the difference between the down of the chick and the feathers of the hen? The little chick has wings; why can it not fly?

3. Why is the chick just hatched so pretty and downy, while the young robin is so bare and ugly? Why is the young chick able to see while the young robin is blind?

4. How does the young chick get its food?

5. Does the chick chew its food before swallowing? If not, why?

6. How does the chick drink? Why does it drink this way?

7. Where does the chick sleep at night? Where will it sleep when it is grown up?

8. Where does the hen usually put her head when she is sleeping?

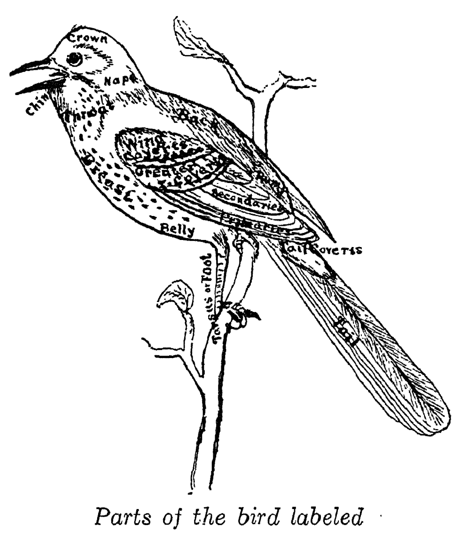
9. How does the hen call her chicks when she is with them in the field?

10. How does she call them to food?

11. How does she tell them there is a hawk in sight?

12. What notes does the chick make when it is following its mother? When it gets lost? When it cuddles under her wing?

13. What does the hen say when she has laid an egg? When she is frightened?



Parts of the bird labeled

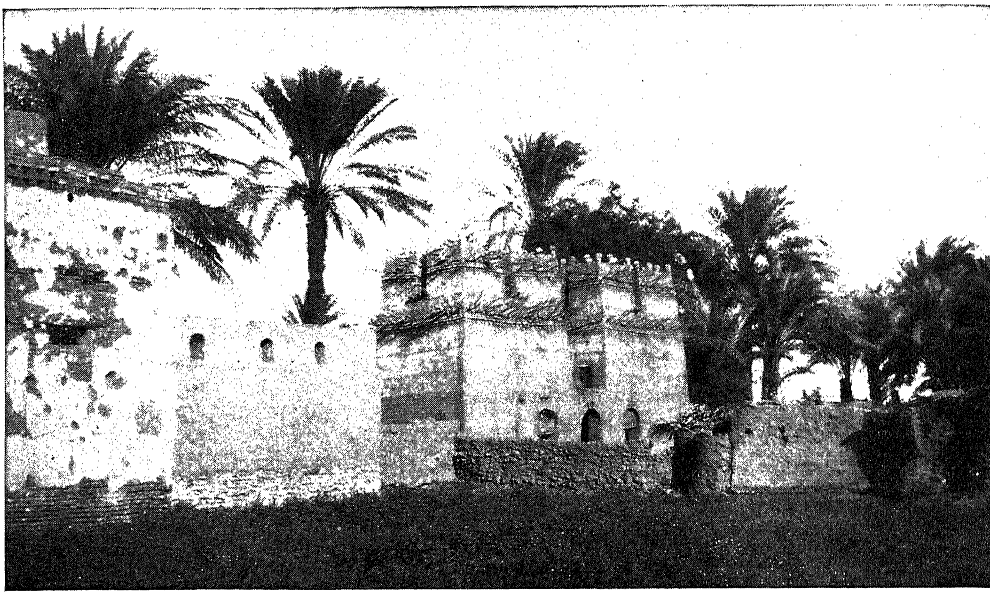
This figure may be placed on the blackboard where pupils may consult it when studying colors and markings of birds.

When she is disturbed while sitting on eggs? When she is grasped by an enemy? How do hens talk together? Describe a hen's song.

14. When does the rooster crow? What other sounds does he make?

15. With what weapons does the rooster fight his rivals and his enemies?

16. What are the natural enemies of the barnyard fowls and how do they escape them?



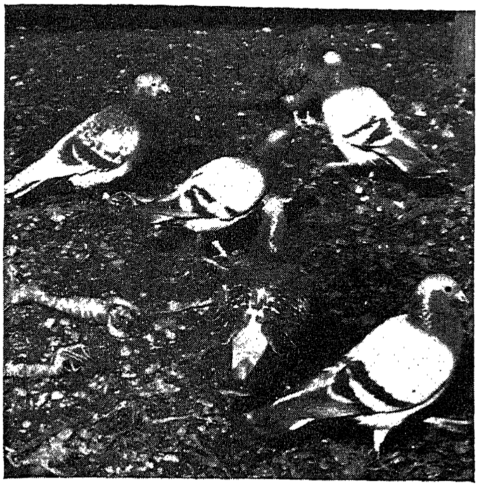
J. H. Comstock

Pigeon houses of the upper Nile

PIGEONS

There is mention of domesticated pigeons by writers three thousand years ago; and Pliny relates that the Romans were fervent pigeon fanciers at the beginning of the Christian era. All of our domestic varieties of pigeons have been developed from the Rock pigeon, a wild species common in Europe and Asia. The carrier pigeon was probably the first to be specially developed because of its usefulness; its love and devotion to its mate and young and its homesickness when separated from them were used by man for his own interests. When a knight of old started off on a Crusade or to other wars, he took with him several pigeons from the home cote; and after riding many days he wrote a letter and tied it to the neck or under the wing of one of his birds, which he then set free, and it flew home with its message; later he would set free another in like manner. The drawback to this correspondence was that it went only in one direction; no bird from home brought message of cheer to the wandering knight. Nowadays mail routes, telegraph wires, and wireless currents enmesh our globe, and the pigeon as a carrier is out-of-date; but fanciers still perfect the homer breed and train pigeons for very difficult flight competitions, some of them over distances of hundreds of miles. Recently a homer made one thousand miles in two days, five hours, and fifty minutes.

The natural food of pigeons is grain; we feed them cracked corn, wheat, peas, Kafir corn, millet, and occasionally hemp



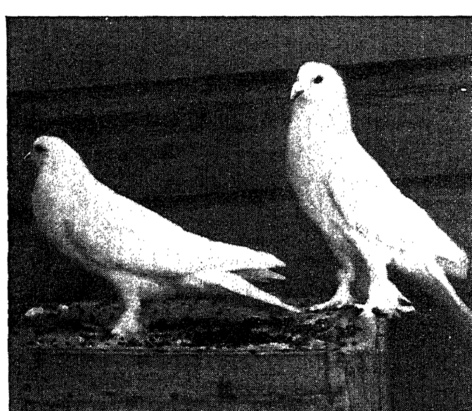
Verne Morton

Homing pigeons

seed; it is best to feed mixed rations as the birds tire of a monotonous diet. Pigeons should be fed twice a day; the pigeons and their near relatives, the doves, are the only birds which can drink like a horse, that is, with the head lowered. The walk of a pigeon is accompanied by a peculiar nodding as if the head were in some way attached to the feet, and this movement sends waves of iridescent colors over the bird's plumage. The flight of the pigeon is direct without soaring, the wings move rapidly and steadily, the birds circling and sailing as they start or alight. The crow flaps hard and then sails for a distance when it is inspecting the ground, while the hawk soars on motionless wings. It requires closer attention to understand the language of the pigeon than that of the hen, nor has it so wide a range of expression as the latter; however, some emotions which the children will understand are voiced in the cooing.

The nest is built of grass and twigs; the mother pigeon lays two eggs for a sitting; but in some breeds a pair will raise from seven to twelve broods per year. The eggs hatch in from sixteen to eighteen days, and both parents share the labors of incubating. In the case of the homer the father bird sits from about 10 A.M. to 4 P.M. and the mother the remainder of the day and night. The devotion of pigeons to their mates and to their young is great, and has been sung by the poets and praised by the philosophers during many ages; some breeds mate for life. The young pigeons or squabs are fed in a peculiar manner; in the crops of both parents is secreted a cheesy substance, known as pigeon milk. The parent seizes the beak of the squab in its own and pumps food from its own crop into the stomach of the young. This nutritious food is given to the squab for about five days and then replaced by grain which has been softened in the parents' stomachs, until the squabs are old enough to feed themselves. Rats, mice, weasels, and hawks are the chief enemies of the pigeons; since pigeons cannot fight, their only safety lies in flight.

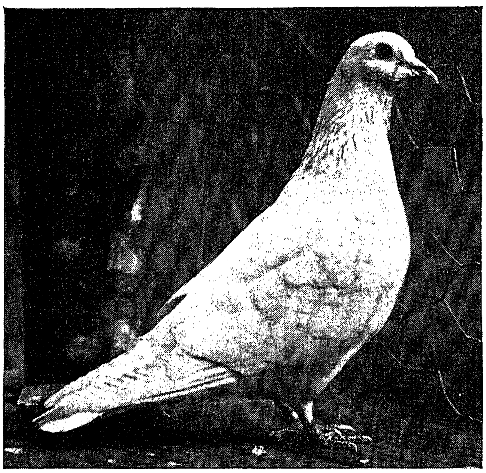
As the original Rock pigeon built in caves, our domesticated varieties naturally build in the houses we provide for them. A pigeon house should not be built for more than fifty pairs; it should be well ventilated and kept clean; it should face the south or east and be near a shallow, running stream if possible. The nest boxes should be about twelve inches square and nine inches in height with a door at one side, so that the nest may remain hidden. In front of each door there should be a little shelf to act as a balcony on which the resting parent bird may sit and coo to relieve the monotony of the sitter's task. Some breeders make a double compart-



J. Demary

Pouter pigeons

ment instead of providing a balcony, while in Egypt branches are inserted in the wall just below the doors of the very ornamental pigeon houses. The houses should be kept clean and whitewashed with lime to which carbolic acid is added in the proportion of one teaspoonful of acid to two gallons of the wash; the leaf stems of tobacco may be given to the pigeons as material for building their nests, so as to help keep in check the



Hugh Spencer

Domestic pigeon

bird lice. There should be near the pigeon house plenty of fresh water for drinking and bathing; also a box of table salt, and another of cracked oyster shell and one of charcoal as fine as ground coffee. Salt is very essential to the health of pigeons. The house should be high enough from the ground to keep the inmates safe from rats and weasels.

Suggested Reading — *Animal Heroes,* by Ernest Thompson Seton (Story of Arnaux); *Audubon Bird Leaflets* 2, 6, 101; *Cher Ami, the Story of a Carrier Pigeon,* by Marion B. Cothren; *Farm Animals,* by James G. Lawson; *Homing Pigeons: Their Care and Training* (U.S. Department of Agriculture, Farmers' Bulletin 1373); *Mother Nature Series,* by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest; The Pet Book,* by Anna B. Comstock; also, readings on pages 28–29.

LESSON 9

Pigeons

Leading Thought — The pigeons differ from other birds in appearance and also in their actions. Their nesting habits are very interesting and there are many things that may be done to make the pigeons comfortable. They were, in ancient days, used as letter carriers.

Method — If there are pigeons kept in the neighborhood, it is best to encourage the pupils to observe these birds out-of-doors. Begin the work with an interesting story and with a few questions which will arouse the pupils' interest in the birds.

Observations — 1. For an out-of-door exercise during recess let the pupils observe the pigeon and tell the colors of the beak, eyes, top of the head, back, breast, wings, tail, feet, and claws. This exercise is excellent training to fit the pupils to note quickly the colors of wild birds.

2. On what do pigeons feed? Are they fond of salt?

3. Describe how a pigeon drinks. How does it differ in this respect from other birds?

4. Describe the peculiar movement of the pigeon when walking.

5. Describe the pigeon's flight. Is it rapid, high in the air, do the wings flap constantly, etc.? What is the chief difference between the flight of pigeons and that of crows or hawks?

6. Listen to the cooing of a pigeon and see if you can understand the different notes.

7. Describe the pigeon's nest. How many eggs are laid at a time?

8. Describe how the parents share the labors in hatching the eggs. How long is it after the eggs are laid before the young hatch?

9. How do the parents feed their young and on what material?

10. What are some enemies of pigeons and how do they escape from them? How can we protect the pigeons?

11. Describe how a pigeon house should be built.

12. What must you do for pigeons to keep them healthy and comfortable?

13. How many breeds of pigeons do you know? Describe them.

For my own part I readily concur with you in supposing that housedoves are derived from the small blue rock-pigeon, Columba livia, *for many reasons. . . . But what is worth a hundred arguments is the instance you give in Sir Roger Mostyn's housedoves in Cærnarvonshire; which, though tempted by plenty of food and gentle treatment, can never be prevailed on to inhabit their cote for any time; but as soon as they begin to breed, betake themselves to the fastnesses of Ormshead, and deposit their young in safety amidst the inaccessible caverns and precipices of that stupendous promontory. " You may drive nature out with a pitchfork, but she will always return ":*
" Naturam expellas furca . . . tamen usque recurret."

Virgil, as a familiar occurrence, by way of simile, describes a dove haunting the cavern of a rock in such engaging numbers, that I cannot refrain from quoting the passage.

Qualis spelunca subito commota Columba,
Cui domus, et dulces latebroso in pumice nidi,
Fertur in arva volans, plausumque exterrita pennis
Dat tecto ingentem, mox aere lapsa quieto,
Radit iter liquidum, celeres neque commovet alas.
(Virg. Aen. v. 213–217)

As when a dove her rocky hold forsakes,
Roused, in a fright her sounding wings she shakes;
The cavern rings with clattering: — out she flies,
And leaves her callow care, and cleaves the skies;
At first she flutters: — but at length she springs
To smoother flight, and shoots upon her wings.
(Dryden's Translation)
— White of Selbourne

THE CANARY AND THE GOLDFINCH

In childhood the language of birds and animals is learned unconsciously. What child, who cares for a canary, does not understand its notes which mean loneliness, hunger, eagerness, joy, scolding, fright, love, and song!

The pair of canaries found in most cages are not natural mates. The union is one *de convenance*, forced upon them by people who know little of bird affinities. We could hardly expect that such a mating would be always happy. The singer, as the male is called, is usually arbitrary and tyrannical and does not hesitate to lay chastising beak upon his spouse. The expression of affection of the two is usually very practical, consisting of feeding each other with many beguiling notes and much fluttering of wings. The singer may have several songs; whether he has many or few depends chiefly upon his education; he usually shows exultation when singing by throwing the head back like a prima donna, to let the music well

Leonard K. Beyer

A goldfinch on her nest in a hawthorn

forth. He is usually brighter yellow in color with more brilliantly black markings than his mate; she usually has much gray in her plumage. But there are about fifty varieties of canaries and each has distinct color and markings.

Canaries should be given a more varied diet than most people think. The seeds we buy or that we gather from the plantain or wild grasses, they eat eagerly. They like fresh, green leaves of lettuce and chickweed and other tender herbage; they enjoy bread and milk occasionally. There should always be a piece of cuttlefish bone or sand and gravel where they can get it, as they need grit for digestion. Above all, they should have fresh water. Hard-boiled egg is given them while nesting. The canary seed which we buy for them is the product of a grass in the Canary Islands. Hemp and rape seed are also sold for canary food.

The canary's beak is wide and sharp and fitted for shelling seeds; it is not a beak fitted for capturing insects. The canary, when drinking, does not have to lift the beak so high in the air in order to swallow the water as do some birds. The nostrils are in the beak and are easily seen; the ear is hidden by the feathers. The canary is a fascinating little creature when it shows interest in an object; it has such a knowing look, and its perfectly round, black eyes are so intelligent and cunning. If the canary winks, the act is so rapid as to be seen with difficulty, but when it is drowsy, the little inner lid appears at the inner corner of its eye and the outer lids close so that we may be sure that they are there; the lower lid covers more of the eye than the upper.

The legs and toes are covered with scale armor; the toes have long, curved claws that are neither strong nor sharp but are especially fitted for holding to the perch; the long hind toe with its stronger claw makes complete the grasp on the twig. When the canary is hopping about on the bottom of the cage we can see that its toes are more fitted for holding to the perch than for walking or hopping on the ground.

When the canary bathes, it ducks its head and makes a great splashing with its wings and likes to get thoroughly wet. Afterward, it sits all bedraggled and "humped up" for a time and then usually preens its feathers as they dry. When going to sleep, it at first fluffs out its feathers and squats on the perch, draws back its head, and looks very drowsy. Later it tucks its head under its wing for the night and looks like a little ball of feathers on the perch.

Canaries make a great fuss when building their nest. A pasteboard box is usually given them with cotton and string for lining; usually one pulls out what the other puts in; and they both industriously tear the paper from the bottom of the cage to add to their building material. Finally, a makeshift of a nest is completed and the eggs are laid. If the singer is a good husband, he helps incubate the eggs and feeds his mate and sings to her frequently; but often he is quite the reverse and abuses her abominably. The nest of the caged bird is very different in appearance from the neat nests of grass, plant down, and moss which the wild ancestors of these birds made in some safe retreat in the shrubs or evergreens of the Canary Islands. The canary eggs are pale blue, marked with reddish-brown. The incubation period is 13 to 14 days. The young are as scrawny and ugly as most little birds and are fed upon food partially digested in the parents' stomachs. Their first plumage usually resembles that of the mother.

In their wild state in the Canary Islands and the Azores, the canaries are olive green above with golden yellow breasts. When the heat of spring begins, they move up the mountains to cooler levels and come down again in the winter. They may rear three or four broods on their way up the mountains, stopping at successive heights as the season advances, until finally they reach the high peaks.

The Goldfinch or Thistle Bird

The goldfinches are small birds but their songs are so sweet and reedy that they seem to fill the world with music more effectually than many larger birds. They are fond of the seeds of wild grass, and especially of thistle seed; and they throng the pastures and fence corners where the thistles hold sway. In summer, the male has bright yellow plumage with a little black cap " pulled down over his nose " like that of a grenadier. He has also a black tail and wings with white-tipped coverts and primaries. The tail feathers have white on their inner webs also, which does not show when the tail is closed. The head and back of the female are brown and the under parts yellowish white, with wings and tail resembling those of the male except that they are not so vividly black. In winter the male dons a dress more like that of his mate; he loses his black cap but keeps his black wings and tail.

The song of the goldfinch is exquisite and he sings during the entire period of his golden dress; he sings while flying as well as when at rest. The flight is in itself beautiful, being wavelike up and down, in graceful curves. Mr. Chapman says that on the descending half of the curve the male sings " Per-chick or-ree." The

Audubon Educational Leaflet No. 17

A pair of goldfinches

A. A. Allen

The nest and eggs of a goldfinch in an elm tree

goldfinch's call notes and alarm notes are very much like those of the canary.

Since the goldfinches live so largely upon seeds of grasses, they stay with us in small numbers during the winter. During this period both parents and young are dressed in olive green, and their sweet call notes are a surprise to us of a cold, snowy morning, for they are associated in our memory with summer. The male dons his winter suit in October.

The goldfinch nest is a mass of fluffiness. These birds make feather beds for their young, or perhaps we should say beds of down, since it is the thistledown which is used for this mattress. The outside of the nest consists of fine shreds of bark or fine grass closely woven; but the inner portion is a mat of thistledown — a cushion an inch and a half thick for a nest which has an opening of scarcely three inches; sometimes the outside is ornamented with lichens. The nest is usually placed in some bush or tree, often in an evergreen, and ordinarily not more than five or six feet from the ground; but sometimes it is placed thirty feet high. The eggs are from four to six in number and bluish white in color. The female builds the nest, her mate cheering her with song meanwhile; he feeds her while she is incubating and helps feed the young. A strange thing about the nesting habits of the goldfinches is that the nest is not built until August. It has been surmised that this nesting season is delayed until there is an abundance of thistledown for building material.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 17; *Bird Stories from Burroughs*, by John Burroughs; *Canaries: Their Care and Management*, by Alexander Wetmore (U. S. Department of Agriculture, Farmers' Bulletin 1327); *The Pet Book*, by Anna B. Comstock (Canary); also, readings on pages 28–29.

LESSON 10

The Canary and the Goldfinch

Leading Thought — The canary is a close relative of the common wild goldfinch. If we compare the habits of the two we can understand how a canary might live if it were free.

Method — Bring a canary to the schoolroom and ask for observations. Ask the pupils to compare the canary with the goldfinches which are common in the summer. The canary offers opportunity for very close observation, which will prove excellent training for the pupils for beginning bird study.

Observations — 1. If there are two canaries in the cage, are they always pleasant to each other? Which one is the "boss"? How do they show displeasure or bad temper? How do they show affection for each other?

2. Which one is the singer? Does the other one ever attempt to sing? What other notes do the canaries make besides singing? How do they greet you when you bring their food? What do they say when they are lonesome and hungry?

3. Does the singer have more than one song? How does he act while singing? Why does he throw back his head like an opera singer when singing?

4. Are the canaries all the same color? What is the difference in color between the singer and the mother bird? Describe the colors of each in your notebook as follows: top and sides of head, back, tail, wings, throat, breast, and under parts.

5. What does the canary eat? What sort of seeds do we buy for it? What seeds do we gather for it in our garden? Do the goldfinches live on the same seeds? What does the canary do to the seeds before eating them? What tools does he use to take off the shells?

6. Notice the shape of the canary's beak. Is it long and strong like a robin's? Is it wide and sharp so that it can shell seeds? If you should put an insect in the cage would the canary eat it?

7. Why do we give the canary cuttlebone? Note how it takes off pieces of the bone. Could it do this if its beak were not sharp?

8. Note the actions of the birds when they drink. Why do they do this?

9. Can you see the nostrils? Where are they situated? Why can you not see the ear?

10. When the canary is interested in looking at a thing how does it act? Look closely at its eyes. Does it wink? How does it close its eyes? When it is drowsy can you see the little inner lid come from the corner of the eye nearest the beak? Is this the only lid?

11. How are the legs and feet covered? Describe the toes. Compare the length of the claw with the length of the toe. What is the shape of the claw? Do you think that claws and feet of this shape are better fitted for holding to a branch than for walking? Note the arrangement of the toes when the bird is on its perch. Is the hind toe longer and stronger? If so, why? Do the canaries hop or walk about the bottom of the cage?

12. What is the attitude of the canary when it goes to sleep at night? How does it act when it takes a bath? How does it get the water over its head? Over its back? What does it do after the bath? If we forget to put in the bath dish how does the bird get its bath?

Nesting Habits to be Observed in the Spring

13. When the canaries are ready to build a nest, what material do we furnish them for it? Does the father bird help the mother to build the nest? Do they strip off the paper on the bottom of the

cage for nest material? Describe the nest when it is finished.

14. Describe the eggs carefully. Does the father bird assist in sitting on the eggs? Does he feed the mother bird when she is sitting?

15. How long after the eggs are laid before the young ones hatch? Do both parents feed the young? Do they swallow the food first and partially digest it before giving it to the young?

16. How do the very young birds look? What is their appearance when they leave the nest? Does the color of their plumage resemble that of the father or the mother?

17. Where did the canaries originally come from? Find the place on the map.

The Goldfinch

Leading Thought — Goldfinches are seen at their best in late summer or September, when they appear in flocks wherever the thistle seeds are found in abundance. Goldfinches so resemble the canaries in form, color, song, and habits that they are called wild canaries.

Method — The questions for this lesson may be given to the pupils before the end of school in June. The results may be reported to the teacher in class when the school begins in the autumn.

Observations — 1. Where do you find the goldfinches feeding? How can you distinguish the father from the mother birds and from the young ones in color?

2. Describe the colors of the male goldfinch and also of the female as follows: crown, back of head, back, tail, wings, throat, breast, and lower parts. Describe in particular the black cap of the male.

3. Do you know the song of the goldfinch? Is it like the song of the canary? What other notes has the goldfinch?

4. Describe the peculiar flight of the goldfinches. Do they fly high in the air? Do you usually see them singly or in flocks?

5. Where do the goldfinches stay during the winter? What change takes place in the coat of the male during the winter? What do they eat during the winter?

6. At what time of year do the goldfinches build their nests? Describe the nest. Where is it placed? How far above the ground? How far from a stream or other water? Of what is the outside made? The lining? What is the general appearance of the nest? What is the color of the eggs?

Sometimes goldfinches one by one will drop
From low-hung branches; little space they stop,
But sip, and twitter, and their feathers sleek,
Then off at once, as in a wanton freak;
Or perhaps, to show their black and golden wings;
Pausing upon their yellow flutterings.

— John Keats

THE ROBIN

Most of us think we know the robin well, but very few of us know definitely the habits of this, our commonest bird. The object of this lesson is to form in the pupils a habit of careful observation, and to enable them to read for themselves the interesting story of this little life which is lived every year before their eyes. Moreover, a robin notebook, if well kept, is a treasure for any child; and the close observation necessary for this lesson trains the pupils to note in a comprehending way the habits of other birds. It is the very best preparation for bird study of the right sort.

A few robins occasionally find a swamp where they can obtain food to nourish them during the northern winter, but for the most part they go in flocks to our southern states, where they settle in swamps and cedar forests and live chiefly upon fruits and berries. The robins do not

Leonard K. Beyer

A robin and its hungry young

nest or sing while in Southland. When the robins first come to us in the spring they feed on wild berries, being especially fond of those of the Virginia creeper. As soon as the frost is out of the ground they begin feeding on earthworms, cutworms, white grubs, and other insects. The male robins come first, but do not sing much until their mates arrive.

The robin is ten inches long and the English sparrow is only six and one-third inches long; the pupils should get the sizes of these two birds fixed in their minds for comparison in measuring other birds. The father robin is much more decided in color than his mate; his beak is yellow, there is a yellow ring about the eye and a white spot above it. The head is black and the back slaty-brown; the breast is brilliant reddish brown or bay and the throat is white, streaked with black. The mother bird has paler back and breast and has no black upon the head. The wings of both are a little darker than the back; the tail is black with the two outer feathers tipped with white. These white spots do not show except when the bird is flying and are " call colors " — that is, they enable the birds to see each other and thus keep together when flying in flocks during the night. The white patch made by the under tail-coverts serves a similar purpose. The feet and legs are strong and dark in color.

The robin has many sweet songs and he may be heard in the earliest dawn and also in the evenings; if he wishes to cheer his mate he may burst into song at any time. He feels especially songful before the summer showers, when he seems to sing, " I have a theory, a theory, it's going to rain." And he might well say that he also has a theory, based on experience, that a soaking shower will drive many of the worms and larvæ in the soil up to the surface where he can get them. Besides these songs the robins have a great variety of notes which the female shares, although she is not a singer. The agonizing, angry cries they utter when they see a cat or squirrel must express their feelings fully; they give a very different warning note when they see crow or hawk. This note is hard to describe; it is a long, not very loud squeak.

A robin can run or hop as pleases him best, and it is interesting to see one, while hunting earthworms, run a little distance, then stop to bend the head and listen and look; when he finally seizes the earthworm he braces himself on his strong legs and tugs manfully until he sometimes al-

Herbert E. Gray

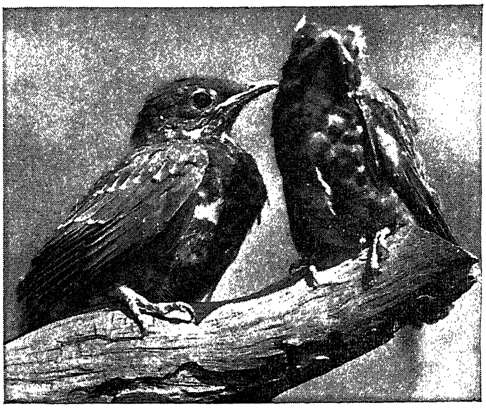
Four blue eggs in a nest on a rail fence most falls over backward as the worm lets go its hold. The robins, especially at nesting time, eat many insects as well as earthworms.

The beginning of a robin's nest is very interesting; much strong grass, fine straw, leaves, and rootlets are brought and placed on a secure support. When enough of this material is collected and arranged, the bird goes to the nearest mud puddle or stream margin and fills its beak with soft mud; it then goes back and "peppers" it into the nest material; after the latter is soaked, the bird gets into it and molds it to the body by turning around and around. In one case which the author watched the mother bird did this part of the building, although the father worked industriously in bringing the other materials. After the nest is molded but not yet hardened, it is lined with fine grass or rootlets. If the season is very dry and there is no soft mud at hand, the robins can build without the aid of this plaster. Four eggs, which are an exquisite greenish blue in color, are usually laid.

Both parents share the monotonous business of incubating, and in the instance under the eyes of the author the mother bird was on the nest at night; the period of incubating is from eleven to fourteen days. The most noticeable thing about

Leonard K. Beyer

A robin on its nest



A. A. Allen

Young robins. Their spotted breasts show their relationship to the thrushes

a very young robin is its wide, yellow-margined mouth, which it opens like a satchel every time the nest is jarred. This wide mouth cannot but suggest to anyone who sees it that it is meant to be stuffed, and the two parents work very hard to fill it. Both parents feed the young and often the father feeds the mother bird while she is brooding. Professor Treadwell experimented with young robins and found that each would take 68 earthworms daily; these worms if laid end to end would measure about 14 feet. Think of 14 feet of earthworm being wound into the little being in the nest; no wonder that it grows so fast! I am convinced that each pair of robins about our house has its own special territory for hunting worms, and that any trespasser is quickly driven off. The young birds' eyes are opened when they are from six to eight days old, and by that time the feather tracts, that is, the places where the feathers are to grow, are covered by the spinelike pin-feathers; these feathers push the down out and it often clings to their tips. In eleven days the birds are pretty well feathered; their wing feathers are fairly developed, but alas, they have no tail feathers! When a young robin flies from the nest he is a very uncertain and tippy youngster, not having any tail to steer him while flying, or to balance him when alighting.

It is an anxious time for the old robins when the young ones leave the nest, and they flutter about and scold at anyone who comes in sight, so afraid are they that injury will come to their inexperienced young ones: for some time the parents care for the fledglings, solicitously feeding them and giving them warnings of danger. The young robin shows in its plumage its relation to the thrush family, for it is yellowish and very spotted and speckled, especially on the breast. The parents may raise several broods, but they rarely use the

Leonard K. Beyer

This robin became so entangled in material it had gathered for its nest that it was unable to fly

same nest for two consecutive broods, both because it may be infested with parasites and because it is more or less soiled, although the mother robin works hard to keep it clean; she carries away all waste matter in her beak and drops it at some distance from the nest. Robins do not sing much after the breeding season is over until after they have molted. They are fond of cherries and other pulp fruits and often do much damage to such crops. The wise orchardist will plant a few Russian mulberry trees at a reasonable distance from his cherry trees, and thus, by giving the robins a fruit which they like better, and which ripens a little earlier, he may save his cherries. It has been proved conclusively that the robins are far more beneficial than damaging to the farmer; they destroy many noxious insects, two-thirds of their food throughout the year consisting of insects; during April and May they do a great work in destroying cutworms.

The robins stay in the North later than most migrating birds, often not leaving us entirely before November. Occasional stragglers may remain all winter, in some protected areas. Their chief enemies in northern climates are cats, crows, and squirrels. Cats should be taught to let birds alone (see lesson on cat) or should be killed. The crows have driven the robins into villages where they can build their nests under the protection of man. If crows venture near a house to attack the robins, firing a gun at them once or twice will give them a hint which they are not slow to take. The robins of an entire neighborhood will attack a nest-robbing crow, but usually too late to save the nestlings. The robins can defend themselves fairly well against the red squirrel unless he steals the contents of the nest while the owners are away. There can be no doubt that the same pair of robins return to the same nesting place year after year. On the Cornell University campus a robin lacking the white tip on one side of his tail was noted to have returned to the same particular feeding ground for several years; and we are very certain that the same female bird built in the vines of our piazza for seven consecutive years; it took two years to win her confidence, but after that she seemed to feel as if she were a part of the family and regarded us all as friends. We were sure that during her fifth year she brought a new young husband to the old nesting site; probably her faithful old husband had met with some mischance during the winter.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 46; *Bird-House to Let*, by Mary F. Terrel; *Bird Stories from Burroughs*, by John Burroughs; *First Lessons in Nature Study*, by Edith M. Patch; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*, Book 5, *Science at Home*; *Nature Stories for Chil-*

dren, *Autumn*, by Eva L. Gordon and Jennie Hall; *Science Stories*, by Wilbur L. Beauchamp, W. S. Gray and Co-authors, Book 1; also, readings on pages 28–29.

LESSON 11

The Robin

Leading Thought — To understand all we can about the life and ways of the robin.

Method — For first and second grades this work may be done by means of an extra blackboard, or what is far better, sheets of ordinary, buff, manila wrapping paper fastened together at the upper end, so that they may be hung and turned over like a calendar. On the outside page make a picture of a robin in colored chalk or crayons, coloring according to the children's answers to questions of series "*b*." Devote each page to one series of questions, as given below. Do not show these questions to the pupils until the time is ripe for the observations. Those pupils giving accurate answers to these questions should have their names on a roll of honor on the last page of the chart.

For third or higher grades the pupils may have individual notebooks in which each one may write his own answers to the questions of the successive series, which should be written on the blackboard at the proper time for the observations. This notebook should have a page about 6 x 8 inches and may be made of any blank paper. The cover or first page should show the picture of the robin colored by the pupil, and may contain other illustrative drawings, and any poems or other literature pertinent to the subject.

Observations by Pupils — *Series a* (to be given in March in the northern states).

1. At what date did you see the first robin this year?
2. Where did the robin spend the winter? Did it build a nest or sing when in its winter quarters?
3. What does it find to eat when it first comes in the spring? How does this differ from its ordinary food?
4. Does the robin begin to sing as soon as it comes north?

Series b (to be given the first week of April).

1. How large is the robin compared with the English sparrow?
2. What is the color of the beak? The eye? Around and above the eye?
3. The color of the top of the head? The back? The throat? The breast?
4. Do all the robins have equally bright colors on head, back, and breast?
5. What is the color of the wing feathers?
6. What is the color of the tail feathers? Where is the white on them? Can the white spots be seen except during flight of the bird? Of what use to the robin are these spots?
7. Is there white on the underside of the robin as it flies over you? Where?
8. What is the color of the feet and legs?

Series c (to be given the second week of April).

1. At what time of day does the robin sing? Is it likely to sing before a rain? How many different songs does a robin sing?
2. What note does a robin give when it sees a cat?
3. What sounds do the robins make when they see a crow or a hawk?
4. Does a robin run or walk or hop?
5. Do you think it finds the hidden earthworm by listening? If so, describe the act.
6. Describe how a robin acts as it pulls a big earthworm out of the ground.
7. Do robins eat other food than earthworms?

Series d (to be given in the middle of April or a little later).

1. At what date did your pair of robins begin to build their nest?
2. Where was the nest placed and with what material was it begun?
3. Can you tell the difference in colors between the father and mother birds? Do both parents help in making the nest?

4. How and with what material is the plastering done? How is the nest molded into shape? Do both birds do this part of the work?

5. Where is the mud obtained and how carried to the nest?

6. How is the nest lined?

Series e (to be given a week after series *d*).

1. What is the number and color of the eggs in the nest?

2. Do both parents do the sitting? Which sits on the nest during the night?

3. Give the date when the first nestling hatches.

4. How does the young robin look? The color and size of its beak? Why is its beak so large? Can it see? Is it covered with down? Compare it to a young chick and describe the difference between the two.

5. What does the young robin do if it feels any jar against the nest? Why does it do this?

6. Do the young robins make any noise?

7. What do the parents feed their young? Do both parents feed them? Are the young fed in turns?

8. Do you believe each pair of robins has a certain territory for hunting worms which is not trespassed upon by other robins?

Series f (to be given three days after series e).

1. How long after hatching before the young robin's eyes are open? Can you see where the feathers are going to grow? How do the young feathers look?

2. How long after hatching before the young birds are covered with feathers?

3. Do their wing or tail feathers come first?

4. How is the nest kept clean?

5. Give the date when the young robins leave the nest. How do the old robins act at this important crisis?

6. Describe the young robin's flight. Why is it so unsteady?

7. How do the young robins differ in colors of breast from the parents?

8. Do the parents stay with the young for a time? What care do they give them?

9. If the parents raise a second brood, do they use the same nest?

Series g (to be given for summer reading and observations).

1. Do the robins sing all summer? Why?

2. Do the robins take your berries and cherries? How can you prevent them from doing this?

3. How does the robin help us?

4. How long does it stay with us in the fall?

5. What are the chief enemies of the robin and how does it fight or escape them? How can we help protect it?

6. Do you think the same robins come back to us each year?

THE BLUEBIRD

Stern as were our Pilgrim Fathers, they could not fail to welcome certain birds with plumage the color of June skies, whose sweet voices brought hope and cheer to their homesick hearts at the close of that first, long, hard winter of 1621. The red breasts of these birds brought to memory the robins of old England, and so they were called "blue robins"; and this name expresses well the relationship implied, because the bluebirds and robins of America are both members of the thrush family, a family noted for exquisite song.

The bluebirds are usually ahead of the robins in the northward journey and often arrive in New York amid the blizzards of early March, their soft, rich "curly" notes bringing, even to the doubting mind, glad convictions of coming spring. There is a family resemblance between voices of bluebird and robin, a certain rich quality of tone; but the robin's song is far more assertive and complex than is the soft, "purling" song of the bluebird, which has been vocalized as "tru-al-ly, tru-al-ly." These love songs cease with the hard work of feeding the nestlings, but may be heard again as a prelude to the second brood in June. The red breast of the bluebird is its only color resemblance to the robin, although the young bluebirds and robins are both spotted, showing the thrush colors. The robin is so much larger than the bluebird that commonly the relationship is not noticed. This is easily explained because there is nothing to suggest a robin in the exquisite cerulean blue of the bluebird's head, back, tail, and wings. This color is most brilliant when the bird is on the wing, in the sunshine. However, there is a certain mirror-like quality in these blue feathers; and among leaf shadows or even among bare branches they in a measure reflect the surroundings and thus render the bird less noticeable. The female is paler, being grayish blue above and with only a tinge of red-brown

Leonard K. Beyer

A hollow fence post is a common home of the bluebird. The young are fed chiefly on insects

This bluebird is nesting in a cavity drilled by a woodpecker the previous year

on the breast; both birds are white beneath.

The bluebirds haunt open woods, fields of second growth, and especially old orchards. They flit about in companies of three or four until they mate for nesting. While feeding, the bluebird usually sits on a low branch keeping a keen eye on the ground below, now and then dropping suddenly on an unsuspecting insect and then returning to its perch; it does not remain on the ground hunting food as does the robin. The nest is usually built in a hole in a tree or post and is made of soft grass. A hollow apple tree is a favorite nesting site.

In building birdhouses we should bear in mind that a cavity about ten inches deep and six inches in height and width will give a pair of bluebirds room for building a nest. The opening should not be more than two or two and one-half inches in diameter and there should be no threshold; this latter is a very particular point. If there is a threshold or place to alight upon, the sparrows are likely to dispute with the bluebirds and drive them away, but the sparrow does not care for a place which has no threshold. The box for the bluebird may be made out of old boards or may be a section of an old tree trunk; it should be fastened from six to fifteen feet above the ground, and should be in nowise noticeable in color from its surroundings. To protect the nest from cats, barbed wire should be wound around the tree or post below the box. If the box for the nest is placed upon a post, the barbed wire will also protect it from the squirrels. The eggs are bluish white; the young birds in their first feathers are spotted on the back and have whitish breasts mottled with brown. The food of the nestlings is almost entirely insects. In fact, this bird during its entire life is a great friend to man. The food of the adult is more than three-fourths insects and the remainder is wild berries and fruits, the winter food being largely mistletoe berries. It makes a specialty of beetles, caterpillars, and grasshoppers, and seems never to touch any of our cultivated fruits. We should do everything in our power to encourage and protect these birds from their enemies, which are chiefly cats, squirrels, and English sparrows.

The migration takes place in flocks during autumn, but it is done in a most leisurely manner with frequent stops where food is plenty. The bluebirds we see in September are probably not the ones we have had with us during the summer, but are those which have come from farther north.

They winter largely in the Gulf states; the writer has often heard them singing in midwinter in southern Mississippi. The bluebirds seem to be the only ones that sing while at their winter resorts. They live the year round in the Bermudas, contrasting their heavenly blue plumage with the vivid red of the cardinals. The bluebird should not be confused with the indigo bunting; the latter is darker blue and has a blue breast.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 24; *Bird-House to Let*, by Mary F. Terrel; *Bird Stories from Burroughs*, by John Burroughs; *First Lessons in Nature Study*, by Edith M. Patch; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*; *Science Stories*, by Wilbur L. Beauchamp, W. S. Gray and Co-authors, Book 1; also, readings on pages 28–29.

Winged lute that we call a bluebird,
You blend in a silver strain
The sound of the laughing waters,
The patter of spring's sweet rain,
The voice of the winds, the sunshine,
And fragrance of blossoming things.
Ah! You are an April poem,
That God has dowered with wings.
— "The Bluebird," Rexford

LESSON 12

The Bluebird

Leading Thought — The bluebird is related to the robins and thrushes and is as beneficial as it is beautiful. We should study its habits and learn how to make nesting boxes for it, and protect it in all ways.

Method — The observations of this lesson must be made in the field and by the pupils individually. Give to each an outline of questions to answer through seeing. There should follow reading lessons on the bluebird's value to us and its winter migrations, and the lesson should end in discussions of the best way to build boxes for its use in nesting season, its protection from cats and other enemies.

Observations — 1. Which comes north earlier in spring, the robin or the bluebird?

2. How do the two resemble each other and differ from each other?

3. Describe the bluebirds' song. Do they sing all summer?

4. Describe the colors of the bluebird as follows: the head, back, breast, under parts, wings, tail. How does the male bluebird differ from his mate in colors?

5. Where were the bluebirds you saw? What were they doing? If feeding, how did they act?

6. Can you see the color of the blue-

bird as plainly when it is in a tree as when it is flying? If not, why?

7. Where do the bluebirds build their nests? Of what material are the nests made? Do both parents work at the nest building?

8. What is the color of the eggs? How do the young birds look, when old enough to leave the nest, as compared with their parents?

9. What do the bluebirds eat? How do they benefit us?

10. What can we do to induce the bluebirds to live near our houses? How can we protect them?

11. Where do the bluebirds spend the winter?

12. Make a colored picture of a bluebird. How can we tell the bluebird from the indigo bunting?

13. What are the bluebirds' chief enemies?

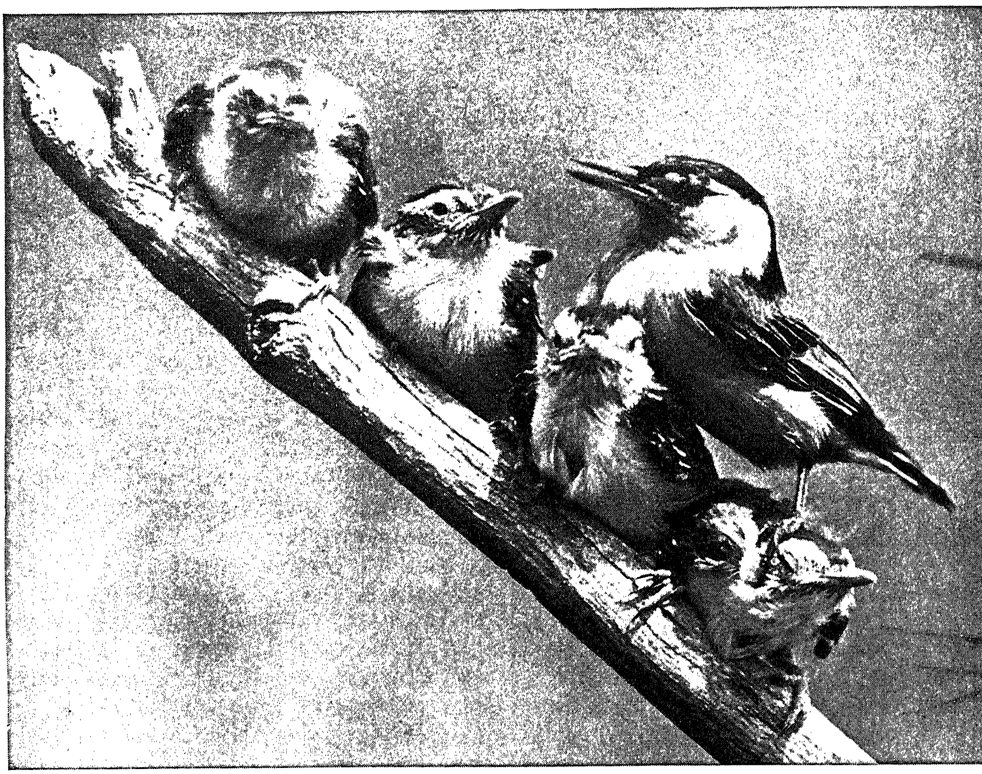
Hark! 'tis the bluebird's venturous strain
High on the old fringed elm at the gate —
Sweet-voiced, valiant on the swaying bough,
Alert, elate,
Dodging the fitful spits of snow,
New England's poet-laureate
Telling us Spring has come again!
— Thomas Bailey Aldrich

THE WHITE-BREASTED NUTHATCH

The busy nuthatch climbs his tree
Around the great bole spirally,
Peeping into wrinkles gray,
Under ruffled lichens gay,
Lazily piping one sharp note
From his silver mailèd throat.
— Maurice Thompson

Blithe and mellow is the ringing " ank, ank " note of the nuthatch, and why need we allude to its nasal timbre! While it is not a strictly musical note, it has a most enticing quality and translates into sound the picture of bare-branched trees and the feeling of enchantment which permeates the forest in winter; it is one of the most " woodsy " notes in the bird repertoire. And while the singer of this note is not so bewitching as his constant chum the chickadee, yet he has many interesting ways quite his own. Nor is this " ank, ank " his only note. I have often heard a pair talking to each other in sweet confidential syllables, " wit, wit, wit," very different from the loud note meant for the world at large. The nuthatches and chickadees hunt together all winter; it is no mere business partnership but a matter of congenial tastes. The chickadees hunt over the twigs and smaller branches, while the nuthatches usually prefer the tree trunks and the bases of the branches; both birds like the looks of the world upside down, and while the chickadee hangs head down from a twig, the nuthatch is quite likely to alight head down on a tree bole, holding itself safely in this position by thrusting its toes out at right angles to the body, thus getting a firm hold upon the bark. Sometimes its foot will be twisted completely around, the front toes pointed up the tree. The foot is well adapted for clinging to the bark as the front toes are strong and the hind toe is very long and is armed with a strong claw. Thus equipped, this bird runs about on the tree so rapidly that it has earned the name of " tree mouse." It often ascends a tree trunk spirally but is not so hidebound in this habit as is the brown creeper. It runs up or down freely, head first, and never flops down backwards like a woodpecker.

In color the nuthatch is bluish gray above with white throat and breast and reddish underparts. The sides of the head are white; the black cap extends back upon the neck but is not " pulled down " to the eyes as with the chickadees. The wing feathers are dark brown edged with pale gray. The upper middle tail feathers are bluish like the back; the others are dark brown and tipped with white in such a manner that the tail when spread shows a broad white border on both sides. The most striking contrast between the chickadee and nuthatch in markings is that the latter lacks the black bib. However, its entire shape is very different from that of the chickadee and its beak is long and slender, being as long as its head or longer, while the beak of the chickadee is a short, sharp little pick. The bill of the nuthatch is fitted to reach in crevices of the bark and pull out hiding insects, or to hammer open the shell of nut or acorn and get both the meat of the nut and the grub feeding upon it. It will wedge an acorn into a seam in the bark and then throw back its head, woodpecker fashion, and drive home its chisel beak. But it does not always use common sense in this habit. I have often seen one cut off a piece of suet, fly off and thrust it into some crevice, and hammer it as hard as if it were encased in a walnut shell. This always seems bad manners, like carrying off fruit from *table d'hôte*; but the nuthatch is polite enough in using a napkin, for after eating the suet, it invariably wipes its bill on a branch most assiduously, first one side then the other, until it is perfectly clean.



S. A. Grimes

A family of white-breasted nuthatches

The nuthatches are a great benefit to our trees in winter, for then is when they hunt for hiding pests on the trunks. Their food consists of beetles, caterpillars, pupæ of various insects, also seeds of ragweed, sunflowers, acorns, etc. While the nuthatch finds much of its food on trees, yet Mr. Torrey has seen it awkwardly turning over fallen leaves hunting for insects, and Mr. Baskett says it sometimes catches insects on the wing and gets quite out of breath from this unusual exercise.

It is only during the winter that we commonly see the nuthatches, for during the nesting season they usually retire to the deep woods, where they may occupy a cavity in a tree used by a woodpecker last year, or may make a hole for themselves with their sharp beaks. The nest is lined with leaves, feathers, and hair; from five to nine creamy, speckled eggs are the treasure of this cave.

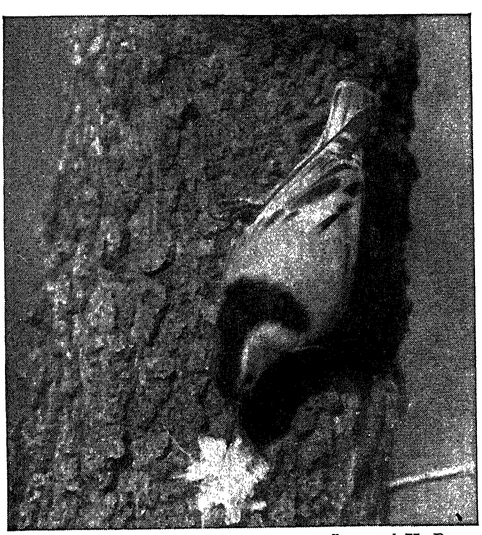
SUGGESTED READING — *Audubon Bird Leaflet* 59; *The Nature Hour*, by Lucille Nicol, S. M. Levenson, and Teressa Kahn, *Sixth Year, Spring;* also, readings on pages 28–29.

LESSON 13

THE NUTHATCH

LEADING THOUGHT — The nuthatch is often a companion of the chickadees and woodpeckers. It has no black bib, like the chickadee, and it alights on a tree trunk head downward, which distinguishes it from woodpeckers.

METHOD — This bird, like the chickadee and downy, gladly shares the suet banquet we prepare for them and may be observed at leisure while "at table." The contrast between the habits of the nuthatch and those of its companions makes it a most valuable aid in stimulating close and keen observation on the part of the pupils.



Leonard K. Beyer

The nuthatch runs head first down tree trunks in search of insects. Here he is eating suet which has been fastened to the tree

L. H. Bailey

A characteristic pose

OBSERVATIONS — 1. Where have you seen the nuthatches? Were they with other birds? What other birds?

2. Does a nuthatch usually alight on the ends of the branches of a tree or on the trunk and larger limbs? Does it usually alight head down or up? When it runs down the tree, does it go head first or does it back down? When it ascends the tree, does it follow a spiral path? Does it use its tail for a brace when climbing, as does the downy?

3. How does the arrangement of the nuthatch's toes assist it in climbing? Are the three front toes of each foot directed downward when the bird alights head downward? How does it manage its feet when in this position?

4. What is the general color of the nuthatch above and below? The color of the top and sides of head? Color of back? Wings? Tail? Throat? Breast?

5. Does the black cap come down to

the eyes on the nuthatch as on the chickadee? Has the nuthatch a black bib?

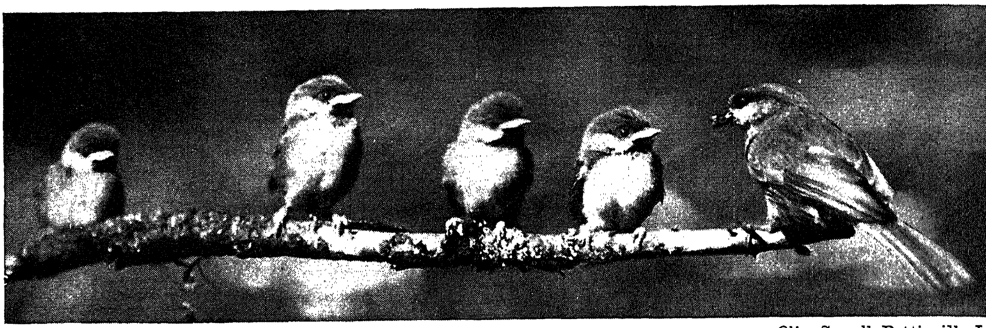
6. What is the shape of the beak of the nuthatch? For what is it adapted? How does it differ from the beak of the chickadee?

7. What is the food of the nuthatch? Where is it found? Does it open nuts for the grubs or the nut meat? Observe the way it strikes its beak into the suet; why does it strike so hard?

8. How would you spell this bird's note? Have you heard it give more than one note?

9. How does the nuthatch benefit our trees? At what season does it benefit them most? Why?

10. Where do the nuthatches build their nests? Why do we see the nuthatches oftener in winter than in summer?



Olin Sewall Pettingill, Jr.

Acadian chickadees

THE CHICKADEE

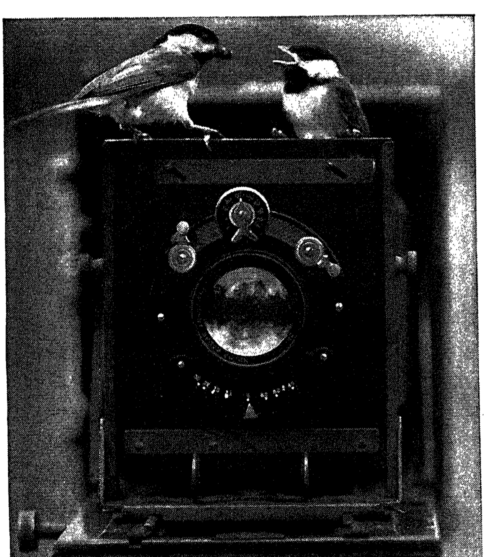
He is the hero of the woods; there are courage and good nature enough in that compact little body, which you may hide in your fist, to supply a whole groveful of May songsters. He has the Spartan virtue of an eagle, the cheerfulness of a thrush, the nimbleness of Cock Sparrow, the endurance of the sea-birds condensed into his tiny frame, and there have been added a pertness and ingenuity all his own. His curiosity is immense, and his audacity equal to it; I have even had one alight upon the barrel of the gun over my shoulders as I sat quietly under his tree.

— Ernest Ingersoll

However careless we may be of our bird friends when we are in the midst of the luxurious life of summer, even the most careless among us give pleased attention to the birds that bravely endure with us the rigors of winter. And when this winged companion of winter proves to be the most fascinating little ball of feathers ever created, constantly overflowing with cheerful song, our pleased attention changes to active delight. Thus it is, that in all the lands of snowy winters the chickadee is a loved comrade of the country wayfarer; that happy song "chick-a-dee-dee-dee" finds its way to the dullest consciousness and the most callous heart.

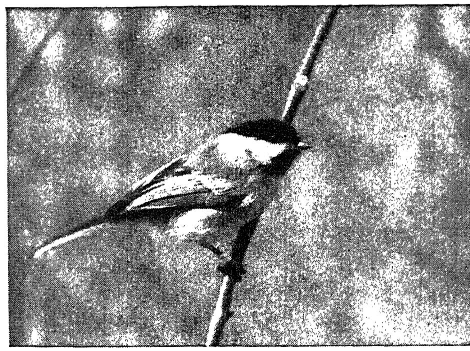
The chickadees appear in small flocks in the winter and often in company with the nuthatches. The chickadees work on the twigs and ends of branches, while the nuthatches usually mine the bark of the trunk and larger branches, the former hunting insect eggs and the latter, insects tucked away in winter quarters. When the chickadee is prospecting for eggs, it first looks the twig over from above and then hangs head down and inspects it from below; it is a thorough worker and doesn't intend to overlook anything whatever; and however busily it is hunting, it always finds time for singing; whether on the wing or perched upon a twig or hanging from it like an acrobat, head down, it sends forth its happy "chickadeedee" to assure us that this world is all right and good enough for anybody. Besides this song, it begins in February to sing a most seductive "fee-bee," giving a rising inflection to the first syllable and a long, falling inflection to the last, which makes it a very different song from the short, jerky notes of the flycatcher called phœbe, which cuts the last syllable short and gives it a rising inflection. More than this, the chickadee has some chatty conversational notes, and now and then performs a bewitching little yodel, which is a fit expression of its own delicious personality.

The general effect of the colors of the chickadee is grayish brown above and grayish white below. The top of the head is black, the sides white, and it has a seductive little black bib under its chin. The back is grayish, the wings and tail are dark gray, the feathers having white margins. The breast is grayish white changing to buff or brownish at the sides and below. It is often called the "Black-capped Titmouse," and it may always be distinguished by black cap and black bib. It is smaller than the English sparrow; its beak is a sharp little pick just fitted for taking insect eggs off twigs and from under bark. Insects are obliged to pass the winter in some stage of their existence, and many of them wisely remain in the egg until there is something worth doing in the way of eating. These eggs are glued fast to the food trees by the mother insect and thus provide abundant food for the chickadees. It has been estimated that one chickadee will destroy several hundred insect eggs in one day, and it has been proved that orchards frequented by these birds are much more free from insect pests than other orchards in the same locality. They can be enticed into orchards by putting up beef fat or bones and thus we can secure their valuable service. In summer these birds attack caterpillars and other insects.



S. A. Grimes

Black-capped chickadees. The friendly chickadee is easily tamed



Leonard K. Beyer

A "banded" chickadee

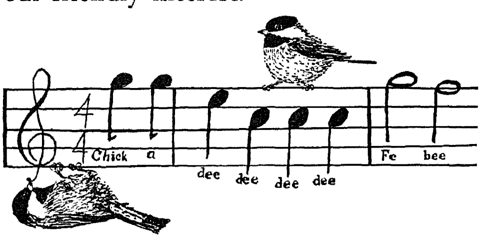
When it comes to nest building, if the chickadees cannot find a house to rent they proceed to dig out a proper hole from some decaying tree, which they line with moss, feathers, fur, or some other soft material. The nest is often not higher than six to ten feet from the ground. One which I studied was in a decaying fence post. The eggs are white, sparsely speckled and spotted with lilac or rufous. The young birds are often eight in number. How these fubsy birdlings manage to pack themselves in such a small hole is a wonder; it probably gives them good discipline in bearing hardships cheerfully.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 61; *Bird Stories*, by Edith M. Patch; *Bird Stories from Burroughs*, by John Burroughs; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; Winter*, by Dallas Lore Sharp; also, readings on pages 28–29.

LESSON 14

The Chickadee

Leading Thought — The chickadee is as useful as it is delightful; it remains in the North during winter, working hard to clear our trees of insect eggs and singing cheerily all day. It is so friendly that we can induce it to come even to the window sill by putting out suet to show our friendly interest.



Method — Put beef fat on the trees near the schoolhouse in December and replenish it about every two or three weeks. The chickadees will come to the feast and may be observed all winter. Give the questions a few at a time and let the children read in the bird books a record of the benefits derived from this bird.

Observations — 1. Where have you seen the chickadees? What were they doing? Were there several together?

2. What is the common song of the chickadee? What other notes has it? Have you heard it yodel? Have you heard it sing " fee-bee, fee-bee "? How does this song differ from that of the phœbe? Does it sing on the wing or when at rest?

3. What is the color of the chickadee: top and sides of head, back, wings, tail, throat, breast, under parts?

4. Compare the size of the chickadee with that of the English sparrow.

5. What is the shape of the chickadee's bill and for what is it adapted? What is the food in winter? Where does the bird find it? How does it act when feeding and hunting for food?

6. Does the chickadee usually alight on the ends of the branches or on the larger portions near the trunk of the tree?

7. How can you distinguish the chickadees from their companions, the nuthatches?

8. Does the chickadee ever seem discouraged by the snow and cold weather? Do you know another name for the chickadee?

9. Where does it build its nest? Of what material? Have you ever watched one of these nests? If so, tell about it.

10. How does the chickadee benefit our orchards and shade trees? How can we induce it to feel at home with us and work for us?

THE DOWNY WOODPECKER

Friend Downy is the name this attractive little neighbor has earned, because it is so friendly to those of us who love trees. Watch it as it hunts each crack and crevice of the bark of your favorite apple or shade tree, seeking assiduously for cocoons and insects hiding there, and you will soon, of your own accord, call it friend; you will soon love its black and white uniform, which consists of a black coat speckled and barred with white, and whitish gray vest and trousers. The front of the head is black and there is a black streak extending backward from the eye with a white streak above and also below it. The male has a vivid red patch on the back of the head, but his wife shows no such giddiness; plain black and white are good enough for her. In both sexes the throat and breast are white, the middle tail feathers black, while the side tail feathers are white, barred with black at their tips.

The downy has a way of alighting low

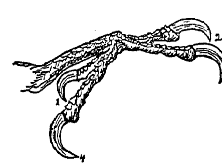
down on a tree trunk or at the base of a larger branch and climbing upward in a jerky fashion; it never runs about over the tree nor does it turn around and go down head first, like the nuthatch; if it wishes to go down a short distance it accomplishes this by a few awkward, backward hops; but when it really wishes to descend, it flies off and down. The downy, like other woodpeckers, has a special arrangement of its physical machinery which enables it to climb trees in its own manner. It can grasp the bark on the side of a tree more firmly because its fourth toe is turned backward and works as a companion with the thumb. Thus it is able to clutch the bark as with a pair of nippers, two claws in front and two claws behind; and as another aid, the tail is arranged to prop the bird, like a bracket. The tail is rounded in shape and the middle feathers have rather strong quills; but the secret of the adhesion of the tail to the bark lies in the great profusion of barbs which, at the edge of the feathers, offer bristling tips, and when applied to the side of the tree act like a wire brush with all the wires pushing downward. This explains why the woodpecker cannot go backward without lifting the tail.

But even more wonderful than this is the mechanism by which the downy and hairy woodpeckers get their food, which consists largely of wood-borers or larvæ working under the bark. When the woodpecker wishes to get a grub in the wood, it seizes the bark firmly with its feet, uses its tail as a brace, throws its head and upper part of the body as far back as possible, and then drives a powerful blow with its strong beak. The beak is adapted for just this purpose, as it is wedge-shaped at the end, and is used like a mason's drill sometimes, and sometimes like a pick. When the bird uses its beak as a pick, it strikes hard, deliberate blows and the chips fly; but when it is drilling, it strikes rapidly and not so hard and quickly drills a small, deep hole leading directly to the burrow of the grub. When finally the grub is reached, it would seem well-nigh impossible to pull it out through a hole which is

L. W. Brownell

Friend Downy

too small and deep to admit of the beak being used as pincers. This is another story and a very interesting one; the downy and hairy can both extend their tongues far beyond the point of the beak, and the tip of the tongue is hard and horny and covered with short backward-slanting hooks acting like a spear or harpoon; and thus when the tongue is thrust into the grub it pulls it out easily. The bones of the tongue have a spring arrangement; when not in



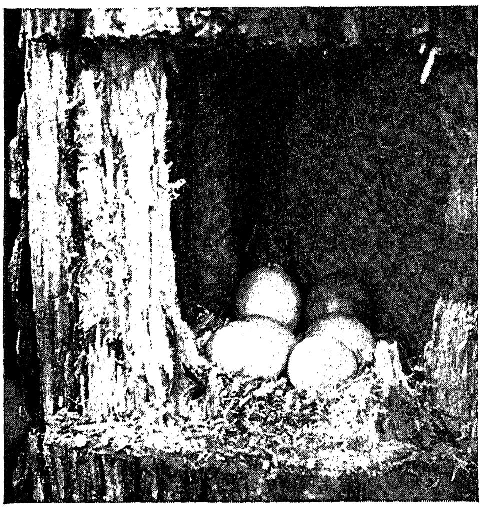
Friend Downy's foot

use, the tongue lies soft in the mouth, like a wrinkled earthworm, but when in use, the bones spring out, stretching it to its full length, and it is then slim and small. The process is like fastening a pencil to the tip of a glove finger; when drawn back the finger is wrinkled together, but when thrust out, it straightens. This spring arrangement of the bones of the woodpecker's tongue is a marvelous mechanism and should be studied through pictures.

Since the food of the downy and the

hairy is where they can get it all winter, there is no need for them to go south; thus they stay with us and work for us the entire year. We should try to make them feel at home with us in our orchards and shade trees by putting up pieces of beef fat, to convince them of their welcome. No amount of free food will pauperize these birds, for as soon as they have eaten of the fat, they commence to hunt for grubs on the tree and thus earn their feast. They never injure live wood.

James Whitcomb Riley describes the drumming of the woodpecker as " weeding out the lonesomeness " and that is exactly what the drumming of the woodpecker means. The male selects some dried limb of hard wood and there beats out his well-known signal which advertises far and near, " Wanted, a wife." And after he wins her, he still drums on for a time to cheer her while she is busy with her family cares. The woodpecker has no voice for singing, like the robin or thrush; and luckily, he does not insist on singing, like the peacock, whether he can or not. He chooses rather to devote his voice to terse and business-like conversation; and when he is musically inclined, he turns drummer. He is rather particular about his instrument, and having found one that is sufficiently resonant he returns to it day after day. While it is ordinarily the male that drums, I once observed a female drumming. I told her that she was a bold minx and ought to be ashamed of herself; but within twenty minutes she had drummed up two red-capped suitors who chased each other about with great animosity, so her performance was evidently not considered improper in woodpecker society. I have watched a rival pair of male downies fight for hours at a time, but their duel was of the French brand — much fuss and no bloodshed. They advanced upon each other with much haughty glaring and many scornful bobs of the head, but when they were sufficiently near to stab each other they beat a mutual and circumspect retreat. Although we hear the male downies drumming every spring, I doubt if they are calling for new wives; I believe they are, instead, calling the attention of their lawful spouses to the fact that it is time for nest building to begin. I have come to this conclusion because the downies and hairies which I have watched for years have always come in pairs to partake of suet during the entire winter; and while only one at a time sits at meat and the lord and master is somewhat bossy, yet they seem to get along as well as most married pairs.



A. A. Allen

Part of the tree has been cut away to show Downy's nest

The downy's nest is a hole, usually in a partly decayed tree; an old apple tree is a favorite site and a fresh excavation is made each year. There are from four to six white eggs, which are laid on a nice bed of chips almost as fine as sawdust. The door to the nest is a circle about an inch and a quarter across.

The hairy woodpecker is fully one-third larger than the downy, measuring nine inches from tip of beak to tip of tail, while the downy measures only about six inches. The tail feathers at the side are white for the entire length, while they are barred at the tips in the downy. There is a black " parting " through the middle of the red patch on the back of the hairy's head. The two species are so much alike that it is difficult for the beginner to tell them apart. Their habits are very similar, except that the hairy lives in the woods and is not so commonly seen in orchards or on shade trees. The food of the hairy is much like that of the downy; it is, therefore, a beneficial bird and should be protected.

Suggested Reading — *Audubon Bird Leaflet* 55; *Bird Stories from Burroughs*, by John Burroughs; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*; also, readings on pages 28–29.

LESSON 15

The Downy Woodpecker

Leading Thought — The downy woodpecker remains with us all winter, feeding upon insects that are wintering in crevices and beneath the bark of our trees. It is fitted especially by shape of beak, tongue, feet, and tail to get such food and is a " friend in need " to our forest, shade, and orchard trees.

Method — If a piece of beef fat be fastened upon the trunk or branch of a tree which can be seen from the schoolroom windows, there will be no lack of interest in this friendly little bird; for the downy will sooner or later find this feast spread for it and will come every day to partake. Give out the questions, a few at a time, and discuss the answers with the pupils.

Observations — 1. What is the general color of the downy above and below? The color of the top of the head? Sides of the head? The throat and breast? The color and markings of the wings? Color and markings of the middle and side tail feathers?

2. Do all downy woodpeckers have the red patch at the back of the head?

3. What is the note of the downy? Does it make any other sound? Have you ever seen one drumming? At what time of the year? On what did it drum? What did it use for a drumstick? What do you suppose was the purpose of this music?

4. How does the downy climb a tree trunk? How does it descend? How do its actions differ from those of the nuthatch?

5. How does the arrangement of the woodpecker's toes help it in climbing a tree trunk? How does this arrangement of toes differ from that of other birds?

6. How does the downy use its tail to assist it in climbing? What is the shape of the tail and how is it adapted to assist?

7. What does the downy eat and where does it find its food? Describe how it gets at its food. What is the shape of its bill and how is it fitted for getting the food? Tell how the downy's tongue is used to spear the grub.

8. Why do you think the downy does not go south in winter?

9. Of what use is this bird to us? How should we protect it and entice it into our orchards?

10. Write an account of how the downy builds its nest and rears its young.

A few seasons ago a downy woodpecker, probably the individual one who is now my winter neighbor, began to drum early in March in a partly decayed apple-tree that stands in the edge of a narrow strip of woodland near me. When the morning was still and mild I would often hear him through my window before I was up, or by half-past six o'clock, and he would keep it up pretty briskly till nine or ten o'clock, in this respect resembling the grouse, which do most of their drumming in the forenoon. His drum was the stub of a dry limb about the size of one's wrist. The heart was decayed and gone, but the outer shell was loud and resonant. The bird would keep his position there for an hour at a time. Between his drummings he would preen his plumage and listen as if for the response of the female, or for the drum of some rival. How swift his head would go when he was delivering his blows upon the limb! His beak wore the surface perceptibly. When he wished to change the key, which was quite often, he would shift his position an inch or two to a knot which gave out a higher, shriller note. When I climbed up to examine his drum he was *much disturbed. I did not know he was in the vicinity, but it seems he saw me from a near tree, and came in haste to the neighboring branches, and with spread plumage and a sharp note demanded plainly enough what my business was with his drum. I was invading his privacy, desecrating his shrine, and the bird was much put out. After some weeks the female appeared; he had literally drummed up a mate; his urgent and oft-repeated advertisement was answered. Still the drumming did not cease, but was quite as fervent as before. If a mate could be won by drumming she could be kept and entertained by more drumming; courtship should not end with marriage. If the bird felt musical before, of course he felt much more so now. Besides that, the gentle deities needed propitiating in behalf of the nest and young as well as in behalf of the mate. After a time a second female came, when there was war between the two. I did not see them come to blows, but I saw one female pursuing the other about the place, and giving her no rest for several days. She was evidently trying to run her out of the neighborhood. Now and then she, too, would drum briefly as if sending a triumphant message to her mate.* — "WINTER NEIGHBORS," JOHN BURROUGHS

THE SAPSUCKER

L. A. Fuertes

The yellow-bellied sapsucker

The sapsucker is a woodpecker that has strayed from the paths of virtue; he has fallen into temptation by the wayside, and instead of drilling a hole for the sake of the grub at the end of it, he drills for drink. He is a tippler, and sap is his beverage; and he is also fond of the soft, inner bark. He often drills his holes in regular rows and thus girdles a limb or a tree, and for this is pronounced a rascal by men who have themselves ruthlessly cut from our land millions of trees that should now be standing. It is amusing to see a sapsucker take his tipple, unless his saloon happens to be one of our prized young trees. He uses his bill as a pick and makes the chips fly as he taps the tree; then he goes away and taps another tree. After a time he comes back and holding his beak close to the hole for a long time seems to be sucking up the sap; he then throws back his head and "swigs" it down with every sign of delirious enjoyment. The avidity with which these birds come to the bleeding wells which they have made, has in it all the fierceness of a toper crazy for drink; they are particularly fond of the sap of the mountain ash, apple, thorn apple, canoe birch, cut-leaf birch, red maple, red oak, white ash, and young pines. However, the sapsucker does not live solely on sap; he also feeds upon insects whenever he can find them. When feeding their young, the sapsuckers are true flycatchers snatching insects while on the wing. The male has the crown and throat crimson, edged with black with a black line extending back of the eye, bordered with white above and below. There is a large, black circular patch on the breast which is bordered at the sides and below with lemon yellow. The female is similar to the male and has a red forehead, but she has a white bib instead of a red one beneath the chin. The distinguishing marks of the sapsucker should be learned by the pupils. The red is on the front of the head instead of on the crown, as is the case with the downy and hairy; when the bird is flying the broad, white stripes extending from the shoulders backward, form a long, oval figure, which is very characteristic.

The sapsuckers spend the winter in the southern states where they drill wells in the white oak and other trees. From Virginia to northern New York and New England, where they breed, they are seen only during migration, which occurs in April; then the birds appear two and three together and are very bold in attacking shade trees, especially the white birch. They nest only in the northern United States and northward. The nest is usually a hole in a tree about forty feet from the ground, and is likely to be in a dead birch.

Suggested Reading — *Audubon Bird Leaflet* 102; also, readings on pages 28–29.

LESSON 16

The Sapsucker

Leading Thought — The sapsucker has a red cap, a red bib, and a yellow breast; it is our only woodpecker that does injury to trees. We should learn to distinguish it from the downy and hairy, as the latter are among the best bird friends of the trees.

Method — Let the observations begin with the study of the trees (common almost everywhere) which have been attacked by the sapsucker, and thus lead to an interest in the culprit.

Observations — 1. Have you seen the work of the sapsucker? Are the holes drilled in rows completely around the tree? If there are two rows or more, are the holes set evenly one below another?

2. Do the holes sink into the wood, or are they simply through the bark? Why does it injure or kill a tree to be girdled with these holes? Have you ever seen the sapsuckers making these holes? If so, how did they act?

3. How many kinds of trees can you find punctured by these holes? Are they likely to be young trees?

4. How can you distinguish the sapsucker from the other woodpeckers? How have the hairy and downy which are such good friends of the trees been made to suffer for the sapsucker's sins?

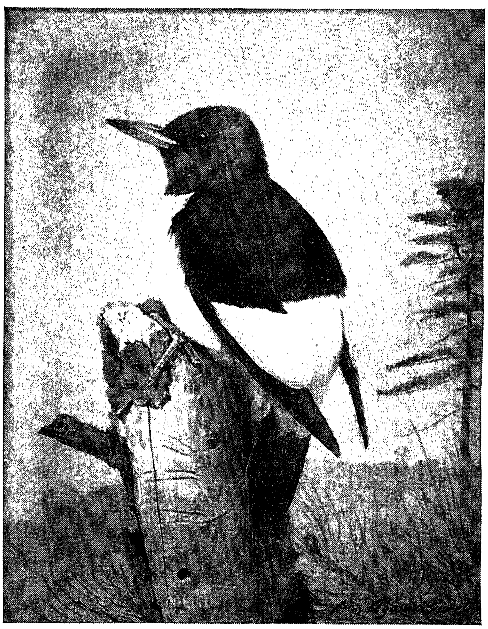
5. What is the color of the sapsucker: forehead, sides of head, back, wings, throat, upper and lower breast? What is the difference in color between the male and female?

6. In what part of the country do the sapsuckers build their nests? Where do they make their nests and how?

In the following winter the same bird (a sapsucker) *tapped a maple-tree in front of my window in fifty-six places; and, when the day was sunny and the sap oozed out he spent most of his time there. He knew the good sap-days, and was on hand promptly for his tipple; cold and cloudy days he did not appear. He knew which side of the tree to tap, too, and avoided the sunless northern exposure. When one series of well-holes failed to supply him, he would sink another, drilling through the bark with great ease and quickness. Then, when the day was warm, and the sap ran freely, he would have a regular sugar-maple debauch, sitting there by his wells hour after hour, and as fast as they became filled sipping out the sap. This he did in a gentle, caressing manner that was very suggestive. He made a row of wells near the foot of the tree, and other rows higher up, and he would hop up and down the trunk as they became filled.* — "Winter Neighbors," John Burroughs

THE REDHEADED WOODPECKER

The redhead is well named, for his helmet and visor show a vivid glowing crimson that stirs the sensibilities of the color lover. It is readily distinguished from the other woodpeckers because its entire head and bib are red. For the rest, it is a beautiful dark metallic blue with the lower back, a band across the wing, and the under parts white; its outer tail feathers are tipped with white. The female is colored like the



L. A. Fuertes

The redheaded woodpecker

male, but the young have the head and breast gray, streaked with black and white, and the wings barred with black. It may make its nest by excavating a hole in a tree or a stump or even in a telegraph pole; the eggs are glossy white. This woodpecker is quite different in habits from the hairy and downy, as it likes to flit along from stump to fence post and catch insects on the wing, like a flycatcher. The only time that it pecks wood is when it is making a hole for its nest.

As a drummer, the redhead is most adept and his roll is a long one. He is an adaptable fellow, and if there is no resonant dead limb at hand, he has been known to drum on tin roofs and lightning rods; and once we also observed him executing a most brilliant solo on the wire of a barbed fence. He is especially fond of beechnuts and acorns, and being a thrifty fellow as well as musical, in time of plenty he stores up food against time of need. He places his nuts in crevices and forks of the branches or in holes in trees or any other hiding place. He can shell a beechnut quite as cleverly as can the deer mouse; and he is own cousin to the carpenter woodpecker of the Pacific Coast, which is also redheaded and which drills holes in the oak trees wherein he drives acorns like pegs for later use.

Suggested Reading — *Audubon Bird Leaflet* 43; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest; Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting;* also, readings on pages 28–29.

LESSON 17

The Redheaded Woodpecker

Leading Thought — The redheaded woodpecker has very different habits from the downy and is not so useful to us. It lives upon nuts and fruit and such insects as it can catch upon the wing.

Method — If there is a redhead in the vicinity of your school the children will be sure to see it. Write the following questions upon the blackboard and offer a prize to the first one who will make a note on where the redhead stores his winter food.

Observations — 1. Can you tell the redhead from the other woodpeckers? What colors especially mark his plumage?

2. Where does the redhead nest? Describe eggs and nest.

3. What have you observed the redhead eating? Have you noticed it storing nuts and acorns for the winter? Have you noticed it flying off with cherries or other fruit?

4. What is the note of the redhead? Have you ever seen one drumming? What did he use for a drum? Did he come back often to this place to make his music?

Another trait our woodpeckers have that endears them to me, and that has never been pointedly noticed by our ornithologists, is their habit of drumming in the spring. They are songless birds, and yet all are musicians; they make the dry limbs eloquent of the coming change. Did you think that loud, sonorous hammering which proceeded from the orchard or from the near woods on that still March or April morning was only some bird getting its breakfast? It is downy, but he is not rapping at the door of a grub; he is rapping at the door of spring, and the dry limb thrills beneath the ardor of his blows. Or, later in the season, in the dense forest or by some remote mountain lake, does that measured rhythmic beat that breaks upon the silence, first three strokes following each other rapidly, succeeded by two louder ones with longer intervals between them, and that has an effect upon the alert ear as if the solitude itself had at last found a voice — does that suggest anything less than a deliberate musical performance? In fact, our woodpeckers are just as characteristically drummers as is the ruffed grouse, and they have their particular limbs and stubs to which they resort for that purpose. Their need of expression is apparently just as great as that of the songbirds, and it is not surprising that they should have found out that there is music in a dry, seasoned limb which can be evoked beneath their beaks.

The woodpeckers do not each have a particular dry limb to which they resort at all times to drum, like the one I have described. The woods are full of suitable branches, and they drum more or less here and there as they are in quest of food; yet I am convinced each one has its favorite spot, like the grouse, to which it resorts, especially in the morning. The sugar-maker in the maple woods may notice that this sound proceeds from the same tree or trees about his camp with great regularity. A woodpecker in my vicinity has drummed for two seasons on a telegraph-pole, and he makes the wires and glass insulators ring. Another drums on a thin board on the end of a long grape-arbor, and on still mornings can be heard a long distance.

A friend of mine in a Southern city tells me of a redheaded woodpecker that drums upon a lightning-rod on his neighbor's house. Nearly every clear, still morning at certain seasons, he says, this musical rapping may be heard. "He alternates his tapping with his stridulous call, and the effect on a cool, autumn-like morning is very pleasing." — "BIRDS, BEES AND SHARP EYES," JOHN BURROUGHS

THE FLICKER OR YELLOW-HAMMER

The first time I ever saw a flicker I said, "What a wonderful meadowlark and what is it doing on that ant hill?" But another glance revealed to me a red spot on the back of the bird's neck, and as soon as I was sure that it was not a bloody gash, I knew that it marked no meadowlark. The top of the flicker's head and its back are slaty-gray, which is much enlivened by a bright red band across the nape of the neck. The tail is black above and yellow tipped with black below; the wings are black, but have a beautiful luminous yellow beneath, which is very noticeable during flight. There is a locket adorning the breast; it is a thin, black crescent, much narrower than that of the meadowlark. Below the locket, the breast is yellowish white thickly marked with circular, black spots. The throat and sides of the head

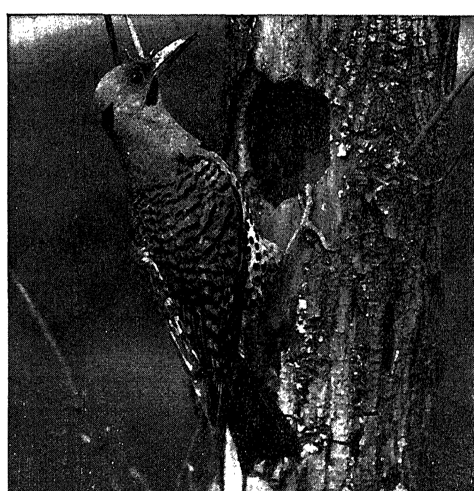
Olin Sewall Pettingill, Jr.

A brood of seven young flickers

are pinkish brown, and the male has a black mustache extending backward from the beak with a very fashionable droop. Naturally enough the female, although she resembles her spouse, lacks his mustache. The beak is long, strong, somewhat curved and dark colored. This bird is distinctly larger than the robin. The white patch on the rump shows little or not at all when the bird is at rest. This white mark is known as a " color call " — for it has been said that it serves as a rear signal by means of which the flock of migrating birds are able to keep together in the night. The yellow-hammer's flight is wave-like and jerky — quite different from that of the meadowlark; it does not stay so constantly in the meadows, but often frequents woods and orchards.

The flicker has many names, such as golden-winged woodpecker, yellow-hammer, highhole, yarup, wake-up, clape, and many others. It earned the name of highhole because of its habit of excavating its nest high up in trees, usually between ten and twenty-five feet from the ground. It especially loves an old apple tree as a site for a nest, and most of our large old orchards can boast of a pair of these handsome birds during the nesting season of May and June. The flicker is not above renting any house he finds vacant, excavated by some other birds last year. He earned his name of yarup or wake-up from his spring song, which is a rollicking, jolly " wick-a, wick-a, wick-a-wick " — a song commonly heard the last of March or early April. The chief insect food of the flicker is ants, although it also eats beetles, flies, and wild fruit; it does little or no damage to planted crops. Its tongue has become modified, like that of the anteater; it is long and is covered with a sticky substance; and when it is thrust into an ant hill, all of the little citizens, disturbed in their communal labors, at once bravely attack the intruder and become glued fast to it; they are thus withdrawn and transferred to the capacious stomach of the bird. It has been known to eat three thousand ants at a single meal.

Those who have observed the flicker during the courting season declare him to be the most silly and vain of all bird wooers. Mr. Baskett says: " When he wishes to charm his sweetheart he mounts a small twig near her, and lifts his wings, spreads his tail, and begins to nod right and left as he exhibits his mustache to his charmer. He sets his jet locket first on one side of the twig and then on the other. He may even go so far as to turn his head half around to show her the pretty spot



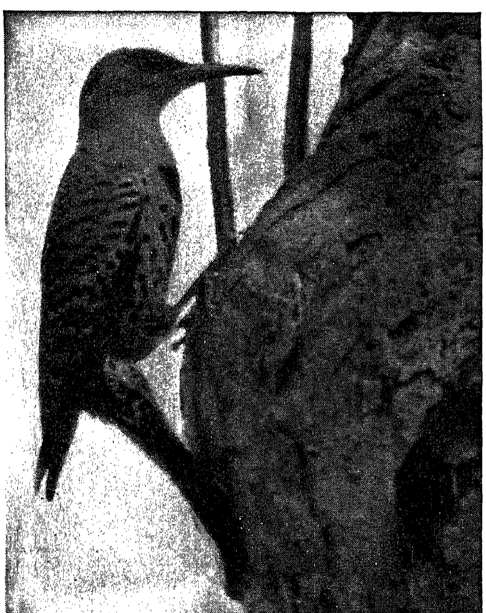
A. A. Allen

The male flicker has a black mustache

on his back hair. In doing all this he performs the most ludicrous antics and has the silliest expression of face and voice as if in losing his heart, as some one phrases it, he had lost his head also."

The nest hole is quite deep and the white eggs are from four to ten in number. The feeding of the young flickers is a process painful to watch. The parent takes the food into its own stomach and partially digests it, then thrusts its own bill down the throat of the young one and pumps the soft food into it "kerchug, kerchug," until it seems as if the young one must be shaken to its foundations. The young flickers as soon as they leave the nest climb around freely on the home tree in a delightful, playful manner.

SUGGESTED READING — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 5; *Bird Stories from Burroughs*, by John Burroughs; *First Lessons in Nature Study*, by Edith M. Patch; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 5, *Science at Home*; also, readings on pages 28–29.



Olin Sewall Pettingill, Jr.

The female flicker

Stanley Mythaler

The homes of flickers

LESSON 18

THE FLICKER

LEADING THOUGHT — The flicker is a true woodpecker but has changed its habits and spends much of its time in meadows hunting for ants and other insects; it makes its nest in trunks of trees, like its relatives. It can be distinguished from the meadowlark by the white patch above the tail which shows during flight.

METHOD — This is one of the most important of the birds of the meadow. The work may be done in September, when there are plenty of young flickers which have not learned to be wary. The observations may be made in the field, a few questions being given at a time.

OBSERVATIONS — 1. Where do you find the flicker in the summer and early autumn? How can you tell it from the meadowlark in color and in flight?

2. What is it doing in the meadows? How does it manage to trap ants?

3. What is the size of the flicker as compared to the robin? What is its general color as compared to the meadowlark?

4. Describe the colors of the flicker as follows: top and sides of the head, back of the neck, lower back, tail, wings, throat, and breast. Describe the color and shape of the beak. Is there a difference in markings between the males and females?

5. Does the patch of white above the tail show, except when the bird is flying? Of what use is this to the bird?

6. What is the flicker's note? At what time of spring do you hear it first?

7. Where does the flicker build its nest and how? What is the color of the eggs? How many are there?

8. How does it feed its young? How do the young flickers act?

9. How many names do you know for the flicker?

The high-hole appears to drum more promiscuously than does the downy. He utters his long, loud spring call, whick-whick-whick, and then begins to rap with his beak upon his perch before the last note has reached your ear. I have seen him drum sitting upon the ridge of the barn. The log-cock, or pileated woodpecker, the largest and wildest of our Northern species, I have never heard drum. His blows should wake the echoes.

When the woodpecker is searching for food, or laying siege to some hidden grub, the sound of his hammering is dead or muffled, and is heard but a few yards. It is only upon dry, seasoned timber, freed of its bark, that he beats his reveille to spring and woos his mate. — "BIRDS, BEES AND SHARP EYES," JOHN BURROUGHS

THE MEADOWLARK

L. A. Fuertes

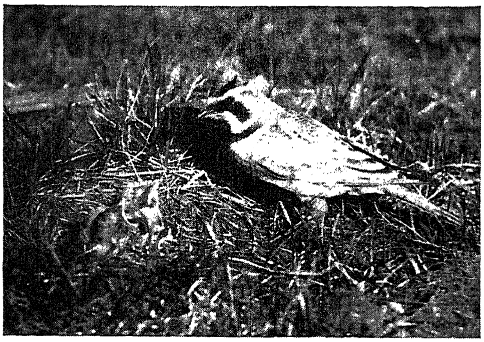
The meadowlark

The first intimation we have in early spring that the meadowlark is again with us comes to us through his soft, sweet, sad note which Van Dyke describes so graphically when he says it "leaks slowly upward from the ground." One wonders how a bird can express happiness in these melancholy, sweet, slurred notes, and yet undoubtedly it is a song expressing joy, the joy of returning home, the happiness of love and of nest building.

The meadowlark, as is indicated by its name, is a bird of the meadow. It is often confused with another bird of the meadow which has very different habits, the flicker. The two are approximately of the same size and color and each has a black crescent or locket on the breast and each shows the "white feather" during flight. The latter is the chief distinguishing characteristic; the outer tail feathers of the meadowlark are white, while the tail feathers of the flicker are not white at all, but it has a single patch of white on the rump. The flight of the two is quite different. The lark lifts itself by several sharp movements and then soars smoothly over the course, while the flicker makes a continuous up-and-down, wavelike flight. The songs of the two would surely never be confused, for the meadowlark is among our sweetest singers, to which class the flicker with his "flick-a-flick" hardly belongs.

The colors of the meadowlark are most harmonious shades of brown and yellow, well set off by the black locket on its breast. Its wings are light brown, each feather being streaked with black and brown; the line above the eye is yellow, bordered with black above and below; a buff line extends from the beak backward over the crown. The wings are light brown and have a mere suggestion of white bars; portions of the outer feathers on each side of the tail are white, but this white does not show except during flight. The sides of the throat are greenish, the middle part and breast are lemon-yellow, with the large, black crescent just below the throat. The beak is long, strong, and black, and the meadowlark is decidedly a low-browed bird, the forehead being only slightly higher than the upper part of the beak. It is a little larger than the robin, which it rivals in plumpness.

The meadowlark has a particular liking for meadows which border streams. It sings when on the ground, on the bush or fence and while on the wing; and it sings during the entire period of its northern stay, from April to November, except while it is moulting in late summer. Mr. Mathews, who is an eminent authority on bird songs, says that the meadowlarks of New York have a different song from those of Vermont or Nantucket, although the music has always the same general characteristics. The western species has a longer and more complex song than ours of the East. It is one of the few California birds that is a genuine joy to the eastern visitor; during February and March its heavenly music is as pervasive as the California sunshine.



R. W. Hegner

A father prairie horned lark at his nest. These birds nest in early March, and often snow falls on the nest and brooding bird

The meadowlark's arched nest

The nest is built in a depression in the ground near a tuft of grass; it is constructed of coarse grass and sticks and is lined with finer grass; there is usually a dome of grass blades woven above the nest; and often a long, covered vestibule leading to the nest is made in a similar fashion. This is evidently for protection from the keen eyes of hawks and crows. The eggs are laid about the last of May and are usually from five to seven in number; they are white, speckled with brown and purple. The young meadowlarks are usually large enough to be out of the way before haying time in July.

The food of the meadowlark during the entire year consists almost exclusively of insects which destroy the grass of our meadows. It eats great quantities of grasshoppers, cutworms, chinch bugs, army worms, wireworms, and weevils, and also destroys some weed seeds. Each pupil should make a diagram in his notebook showing the proportions of the meadowlark's different kinds of food. This may be copied from *Audubon Leaflet* 3. Everyone should use his influence to the uttermost to protect this valuable bird. It has been estimated that the meadowlarks save to every township where hay is produced, twenty-five dollars each year on this crop alone.

SUGGESTED READING — *Audubon Bird Leaflets* 3 and 111; *Holiday Meadow*, by Edith M. Patch; also, readings on pages 28–29.

LESSON 19

The Meadowlark

Leading Thought — The meadowlark is of great value in delivering the grass of our meadows from insect destroyers. It has a song which we all know; it can be identified by color as a large, light brown bird with white feathers on each side of the tail, and in flight by its quick up-and-down movements finishing with long, low, smooth sailing.

Method — September and October are good months for observations on the flight, song, and appearance of the meadowlark, and also for learning how to distinguish it from the flicker. The notes must be made by the pupils in the field, and after they know the bird and its song let them, if they have opportunity, study the bird books and bulletins, and prepare written accounts of the way the meadowlark builds its nest and of its economic value.

Observations — 1. Where have you seen the meadowlark? Did you ever see it in the woods? Describe its flight. How can you identify it by color when it is flying? How do its white patches and its flight differ from those of the flicker?

2. Try to imitate the meadowlark's notes by song or whistle. Does it sing while on the ground, or on a bush or fence, or during flight?

3. Note the day when you hear its last song in the fall and also its first song in the spring. Does it sing during August and September? Why? Where does it spend the winter? On what does it feed while in the South?

4. Is the meadowlark larger or smaller than the robin? Describe from your own observations, as far as possible, the colors of the meadowlark as follows: top of head, line above the eye, back, wings, tail, throat, breast, locket, color and shape of beak. Make a sketch of your own or a copy from Louis Fuertes' excellent picture of the meadowlark in the *Audubon Leaflet*, and color it accurately.

5. When is the nest built; where is it placed; of what material is it built? How is it protected from sight from above? Why this protection? How many eggs are there in the nest? What are their colors and markings?

6. What is the food of the meadowlark? Copy the diagram from the *Audubon Leaflet*, showing the proportions of the different kinds of insects which it destroys.

Sweet, sweet, sweet! O happy that I am!
(Listen to the meadow-larks, across the fields that sing!)
Sweet, sweet, sweet! O subtle breath of balm,
O winds that blow, O buds that grow, O rapture of the spring!

Sweet, sweet, sweet! O happy world that is!
Dear heart, I hear across the fields my mateling pipe and call
Sweet, sweet, sweet! O world so full of bliss,
For life is love, the world is love, and love is over all!

— Ina Coolbrith

S. A. Grimes

English sparrows at a feeding station

THE ENGLISH SPARROW

So dainty in plumage and hue,
A study in grey and in brown,
How little, how little we knew
The pest he would prove to the town!
From dawn until daylight grows dim,
Perpetual chatter and scold.
No winter migration for him,
Not even afraid of the cold!
Scarce a song-bird he fails to molest,
Belligerent, meddlesome thing!
Wherever he goes as a guest
He is sure to remain as a King.

— Mary Isabella Forsyth

The English sparrow, like the poor and the housefly, is always with us; and since he is here to stay, let us make him useful if we can devise any means of doing so. There is no bird that gives the pupils a more difficult exercise in describing colors and markings than does he; and his wife is almost equally difficult. I have known fairly skilled ornithologists to be misled by some variation in color of the hen sparrow, and it is safe to assert that the majority of people " do not know her from Adam." The male has the top of the head gray with a patch of reddish brown on either side; the middle of the throat and upper breast is black; the sides of the throat white; the lower breast and under parts grayish white; the back is brown streaked with black; the tail is brown, rather short, and not notched at the tip; the wings are brown with two white bars and a jaunty dash of reddish brown. The female has the head grayish brown, the breast, throat, and under parts grayish white; the back is brown streaked with black and dirty yellow, and she is, on the whole, a " washed out " looking lady bird. The differences in color and size between the English sparrow and the chippy are quite noticeable, as the chippy is an inch shorter and far more slender in appearance, and is especially marked by the reddish brown crown.

When feeding, the English sparrows are aggressive, and their lack of table manners make them the "goops" among all birds; in the winter they settle in noisy flocks on the street to pick up the grain undigested by the horses, or in barnyards where the grain has been scattered by the farm animals. They only eat weed seeds when other food fails them in the winter, for they are civilized birds even if they do not act so, and they much prefer the cultivated grains. It is only during the nesting season that they destroy insects to any extent; over one-half the food of nestlings is insects, such as weevils, grasshoppers, cutworms, etc.; but this good work is largely offset by the fact that these same nestlings will soon give their grown-up energies to attacking grain fields, taking the seed after sowing, later the new grain in the milk, and later still the ripened grain in the sheaf. Wheat, oats, rye, barley, corn, sorghum, and rice are thus attacked. Once I saw on the upper Nile a native boat loaded with millet which was attacked by thousands of sparrows; when driven off by the sailors they would perch on the rigging like flies, and as soon as the men turned their backs they would drop like bullets to the deck and gobble the grain before they were again driven off. English sparrows also destroy for us the buds and blossoms of fruit trees and often attack the ripening fruit.

The introduction of the English sparrow into America is one of the greatest arguments possible in favor of nature-study; for ignorance of nature-study methods in this single instance costs the United States millions of dollars every year. The English sparrow is the European house sparrow, and people had a theory that it was an insect eater, but never took the pains to ascertain if this theory were a fact. About 1850, some people with more zeal than wisdom introduced these birds into New York, and for twenty years afterwards there were other importations of the sparrows. In twenty years more, people discovered that they had taken great pains to establish in our country one of the worst nuisances in all Europe. In addition to all the direct damage which the English sparrows do, they are so quarrelsome that they have driven away many of our native beneficial birds from our premises, and now vociferously acclaim their presence in places which were once the haunts of birds with sweet songs. After they drive off the other birds they quarrel among themselves, and there is no rest for tired ears in their vicinity. There are various noises made by these birds which we can understand if we are willing to take the pains: the harassing chirping is their song; they squall when frightened and peep plaintively when lonesome, and make a disagreeable racket when fighting.

But to "give the devil his due" we must admit that the house sparrow is as clever as it is obnoxious, and its success is doubtless partly due to its superior cleverness and keenness. It is quick to take a hint, if sufficiently pointed; firing a shotgun twice into a flock of these birds has driven them from our premises; and tearing down their nests assiduously for a month seems to convey to them the idea that they are not welcome. Another instance of their cleverness I witnessed one day: I was watching a robin, worn and nervous with her second brood, fervently hunting earthworms in the lawn to fill the gaping mouths in the nest in the Virginia creeper shading the piazza. She finally pulled up a large, pink worm, and a hen sparrow flew at her viciously; the robin dropped the worm to protect herself, and the sparrow snatched it and carried it off triumphantly to the grape arbor where she had a nest of her own full of gaping mouths. She soon came back, and at a safe distance watched the robin pull out another worm, and by the same tactics again gained the squirming prize. Three times was this repeated in an hour, and then the robin, discouraged, flew up into a Norway spruce and in a monologue of sullen cluckings tried to reason out what had happened.

The English sparrow's nest is quite in

keeping with the bird's other qualities; it is usually built in a hole or box or in some protected corner beneath the eaves; it is also often built in vines on buildings and occasionally in trees. It is a good example of " fuss and feathers "; coarse straw, or any other kind of material, and feathers of hens or of other birds, mixed together without fashion or form, constitute the nest. In these sprawling nests the whitish, brown or gray-flecked eggs are laid and the young reared; several broods are reared by one pair in a season. The nesting begins almost as soon as the snow is off the ground and lasts until late fall.

During the winter, the sparrows gather in flocks in villages and cities, but in the spring they scatter out through the country where they can find more grain. The only place where this bird is welcome is possibly in the heart of a great city, where no other bird could pick up a livelihood. It is a true cosmopolite and is the first bird to greet the traveler in Europe or northern Africa. These sparrows will not build in boxes suspended by a wire; and they do not like a box where there is no resting place in front of the door leading to the nest.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 90; *Bird Friends*, by Gilbert H. Trafton; *English Sparrow Control* (U. S. Department of Agriculture, Leaflet 61); *Lives of the Hunted*, by Ernest Thompson Seton (A Street Troubadour); *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; see also readings on pages 28–29.

LESSON 20

The English Sparrow

Leading Thought — The English sparrow was introduced into America by people who knew nothing of its habits. It has finally overrun our whole country, and to a great extent has driven out from towns and villages our useful American song birds; it should be discouraged and not allowed to nest around our houses and grounds. As a sparrow it has interesting habits which we should observe.

A. A. Allen

The sprawling nest of the English sparrow

Method — Let the pupils make their observations in the street or wherever they find the birds. The greatest value of this lesson is to teach the pupils to observe the coloring and markings of a bird accurately and describe them clearly. This is the best of training for later work with the wild birds.

Observations — 1. How many kinds of birds do you find in a flock of English sparrows?

2. The ones with the black cravat are naturally the men of the family, while their sisters, wives, and mothers are less ornamented. Describe in your notebook or from memory the colors of the cock sparrow as follows: top of head, sides of the head, the back, the tail, the wings, wing bars, throat and upper breast, lower breast and under parts.

3. Describe the hen sparrow in the same manner and note the difference in markings between the two. Are the young birds, when they first fly, like the father or the mother?

4. Compare the English sparrow with the chippy and describe the differences in size and color.

5. Is the tail when the bird is not flying square across the end or notched?

6. What is the shape of the beak? For what sort of food is it adapted?

7. What is the food of the English sparrows and where do they find it? Describe the actions of a flock feeding in the yard or street. Are the English sparrows kindly or quarrelsome in disposition?

8. Why do the English sparrows stay in the North during the coldest of winters? Do they winter out in the country or in villages?

9. Describe by observation how they try to drive away robins or other native birds.

10. Describe the nest of this sparrow. Of what material is it made? How is it supported? How sheltered? Is it a well-built nest?

11. Describe the eggs. How many broods are raised a year? What kind of food do the parents generally give the nestlings?

12. If you have ever seen these sparrows do anything interesting, describe the circumstance.

13. In what ways are these birds a nuisance to us?

14. How much of English sparrow talk do you understand?

15. How can we build bird-boxes so that the English sparrows will not try to take possession of them?

Do not tire the child with questions; lead him to question you, instead. Be sure, in any case, that he is more interested in the subject than in the questions about the subject.

THE CHIPPING SPARROW

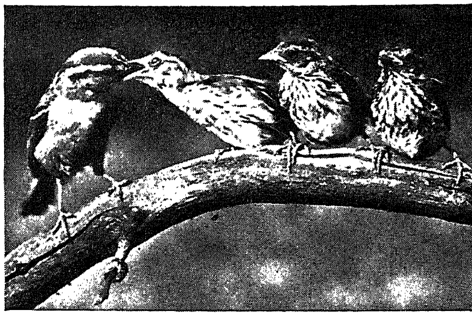
Leonard K. Beyer

A chipping sparrow on its nest

This midget lives in our midst, and yet among all bird kind there is not another which so ignores us as does the chippy. It builds its nest about our houses, it hunts for food all over our premises, it sings like a tuneful grasshopper in our ears, it brings up its young to disregard us, and every hour of the day it "tsip-tsips" us to scorn. And, although it has well earned the name of "doorstep sparrow," since it frugally gathers the crumbs about our kitchen doors, yet it rarely becomes tame or can be induced to eat from the hand, unless it is trained so to do as a nestling.

Its cinnamon-brown cap and tiny black forehead, the gray streak over the eye and the black through it, the gray cheeks and the pale gray, unspotted breast distinguish it from the other sparrows, although its brown back streaked with darker color, and brown wings and blackish tail, have a very sparrowish look; the two whitish wing bars are not striking; it has a bill fitted for shelling seeds, a characteristic of all the sparrows. Despite its seed-eating bill, the chippy's food is about one-third insects, and everyone should know that this little bird does good to our gardens and trees. It takes in large numbers cabbage caterpillars, pea lice, the beet leaf-miners, leaf hoppers, grasshoppers, and cutworms, and does its share in annihilating the caterpillars of the terrible gypsy and browntail moths. In fact, it works for our benefit even in its vegetable food, as this consists largely of the seeds of weeds and undesirable grasses. It will often fly up from its perch after flies or moths, like a flycatcher; and the next time we note it, it will be hopping around hunting for the crumbs we have scattered for it on the porch floor. The song of the chippy is more interesting to it than to us; it is a continuous performance of high, shrill, rapid notes, all alike so far as I can detect; when it utters many of these in rapid succession it is singing, but when it gives them singly they are call notes or mere conversation.

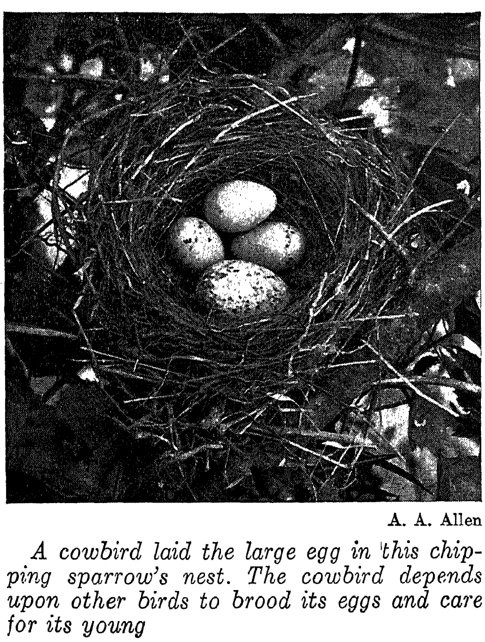
One peculiarity of the nest has given this sparrow the common name of hairbird, for the lining is almost always of long, coarse hair, usually treasure trove from the tails of horses or cattle, switched off against boards, burs, or other obstacles. Of the many nests I have examined, black horsehair was the usual lining; but two nests in our yard show the chippy to be a resourceful bird; evidently the hair market was exhausted and the soft, dead needles of the white pine were used instead and made a most satisfactory lining. The nest is tiny and shallow; the outside is of fine grass or rootlets carefully but not closely woven together; it is placed



A. A. Allen

" The breadline." Young chipping sparrows being fed by one of their parents

in vine or tree, usually not more than ten or fifteen feet from the ground; a vine on a house is a favorite nesting site. Once a bold pair built directly above the entrance to our front door and mingled cheerfully with other visitors. Usually, however, the nest is so hidden that it is not discovered until after the leaves have fallen. The eggs are light blue tinged with green, with fine, purplish brown specks or markings scrawled about the larger end.



A. A. Allen

A cowbird laid the large egg in this chipping sparrow's nest. The cowbird depends upon other birds to brood its eggs and care for its young

The chippy comes to us in early spring and usually raises two broods of from three to five " piggish " youngsters, which even after they are fully grown follow pertinaciously their tired and " frazzled out " parents and beg to be fed; the chippy parents evidently have no idea of discipline but indulge their teasing progeny until our patience, at least, is exhausted. The young differ from the parents in having streaked breasts and lacking the reddish crown. In the fall the chippy parents lose their red-brown caps and have streaked ones instead; and then they fare forth in flocks for a seed-harvest in the fields. Thereafter our chippy is a stranger to us; we do not know it in its new garb, and it dodges into the bushes as we pass, as if it had not tested our harmlessness on our own door-stone.

Suggested Reading — Audubon *Bird Leaflet* 80; *Bird-House to Let*, by Mary F. Terrel; *Bird Stories from Burroughs*, by John Burroughs; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; also, readings on pages 28–29.

LESSON 21

The Chipping Sparrow

Leading Thought — The chipping sparrow is a cheerful and useful little neighbor. It builds a nest, lined with horsehair, in the shrubbery and vines about our homes and works hard in ridding our gardens of insect pests and seeds of weeds.

Method — Begin this lesson with a nest of the chippy, which is so unmistakable that it may be collected and identified in the winter. Make the study of this nest so interesting that the pupils will wait anxiously to watch for the birds which made it. As soon as the chippies appear, the questions should be asked, a few at a time, giving the children several weeks for the study.

The Nest

Observations — 1. Where was this nest found? How high from the ground?

2. Was it under shelter? How was it supported?

3. Of what material is the outside of the nest? How is it fastened together? How do you suppose the bird wove this material together?

4. Of what material is the lining? Why is the bird that built this nest called the "hair-bird"? From what animal do you think the lining of the nest came? How do you suppose the bird got it?

5. Do you think the nest was well hidden when the leaves were about it? Measure the nest across and also its depth; do you think the bird that made it is as large as the English sparrow?

The Bird

6. How can you tell the chippy from the English sparrow?

7. Describe the colors of the chippy as follows: beak, forehead, crown, marks above and through the eyes, cheeks, throat, breast, wings, and tail. Note if the wings have whitish bars and how many.

8. Describe the shape of the beak as compared with that of the robin. What is this shaped bill adapted for?

9. What is the food of the chippy? Why has it been called the doorstep sparrow?

10. Note whether the chippy catches flies or moths on the wing like the phœbe.

11. Why should we protect the chippy and try to induce it to live near our gardens?

12. Does it run or hop when seeking food on the ground?

13. How early in the season does the chippy appear and where does it spend the winter?

14. Can you describe the chippy's song? How do you think it won the name of chipping sparrow?

15. If you have the luck to find a pair of chippies nesting, keep a diary of your observations in your notebook covering the following points: Do both parents build the nest? How is the framework laid? How is the finishing done? What is the number and color of the eggs? Do both parents feed the young? How do young chippies act when they first leave the nest? How large are the young birds before the parents stop feeding them? What are the differences in color and markings between parents and young?

THE FIELD-SPARROW

A bubble of music floats, the slope of the hillside over;
A little wandering sparrow's notes; and the bloom of yarrow and clover,
And the smell of sweet-fern and the bayberry leaf, on his ripple of song are stealing,
For he is a cheerful thief, the wealth of the fields revealing.

One syllable, clear and soft as a raindrop's silvery patter,
Or a tinkling fairy-bell; heard aloft, in the midst of the merry chatter
Of robin and linnet and wren and jay, one syllable, oft repeated;
He has but a word to say, and of that he will not be cheated.

The singer I have not seen; but the song
I arise and follow
The brown hills over, the pastures green,
and into the sunlit hollow.
With a joy that his life unto mine has
lent, I can feel my glad eyes glisten,
Though he hides in his happy tent, while
I stand outside, and listen.

This way would I also sing, my dear little
hillside neighbor!
A tender carol of peace to bring to the
sunburnt fields of labor
Is better than making a loud ado; trill on,
amid clover and yarrow!
There's a heart-beat echoing you, and
blessing you, blithe little sparrow!

— Lucy Larcom

THE SONG SPARROW

He does not wear a Joseph's coat of many colors, smart and gay
His suit is Quaker brown and gray, with darker patches at his throat.
And yet of all the well-dressed throng, not one can sing so brave a song.
It makes the pride of looks appear a vain and foolish thing to hear
In " Sweet, sweet, sweet, very merry cheer."

A lofty place he does not love, he sits by choice and well at ease
In hedges and in little trees, that stretch their slender arms above
The meadow brook; and then he sings till all the field with pleasure rings;
And so he tells in every ear, that lowly homes to heaven are near
In " Sweet, sweet, sweet, very merry cheer."

— Henry van Dyke

Children may commit to memory the poem from which the above stanzas were taken; seldom in literature have detailed accurate observation and poetry been so happily combined as in these verses. The lesson might begin in March when we are all listening eagerly for bird voices, and the children should be asked to look out for a little, brown bird which sings, " Sweet, sweet, sweet, very merry cheer," or, as Thoreau interprets it, " Maids! Maids! Maids! Hang on the teakettle, teakettle-ettle-ettle." In early childhood I learned to distinguish this sparrow by its " Teakettle " song. Besides this song, it has others quite as sweet; and when alarmed it utters a sharp " T'chink, t'chink."

The song sparrow prefers the neighborhood of brooks and ponds which are bordered with bushes, and also the hedges planted by nature along rail or other field fences, and it has a special liking for the shrubbery about gardens. Its movements and flight are very characteristic; it usually sits on the tip-top of a shrub or low tree when it sings; when disturbed, however, it never rises in the air but drops into a low flight and plunges into a thicket with a defiant twitch of the tail which says plainly, " Find me if you can."

Leonard K. Beyer

The song sparrow usually builds its nest on the ground

A. A. Allen

The eggs are bluish white with many brown markings

The color and markings of this bird are typical of the sparrows. The head is a warm brown with a gray streak along the center of the crown and one above each eye, with a dark line through the eye. The back is brown with darker streaks. The throat is white with a dark spot on either side; the breast is white spotted with brown with a large, dark blotch at its very center; this breast blotch distinguishes this bird from all other sparrows. The tail and wings are brown and without buff or white bars or other markings. The tail is long, rounded, and very expressive of emotions, and makes the bird look more slender than the English sparrow.

The nest is usually placed on the ground or in low bushes not more than five feet from the ground; it varies much in both size and material; it is sometimes constructed of coarse weeds and grasses; and sometimes only fine grass is used. Sometimes it is lined with hair, and again, with fine grass; sometimes it is deep, but occasionally is shallow. The eggs have a whitish ground-color tinged with blue or green, but are so blotched and marked with brown that they are safe from observation of enemies. The nesting season begins in May, and there are usually three and sometimes four broods; but so far as I have observed, a nest is never used for two consecutive broods. The song sparrows stay with us in New York State very late in the fall, and a few stay in sheltered places all winter. The quality in this bird which endears him to us all is the spirit of song which stays with him; his sweet trill may be heard almost any month of the year, and he has a charming habit of singing in his dreams.

The song sparrow is not only the dearest of little neighbors, but it also works lustily for our good and for its own food at the same time. It destroys cutworms, plant lice, caterpillars, canker-worms, ground beetles, grasshoppers, and flies; in winter it destroys thousands of weed seeds, which otherwise would surely plant themselves to our undoing. Every boy and girl should take great pains to drive away stray cats and to teach the family puss not to meddle with birds; for cats are the worst of all the song sparrow's enemies, destroying thousands of its nestlings every year.

Suggested Reading — *Audubon Bird Leaflet* 31; *Bird Stories from Burroughs*, by John Burroughs; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; also, readings on pages 28–29.

LESSON 22

The Song Sparrow

Leading Thought — The beautiful song of this sparrow is usually heard earlier in the spring than the notes of bluebird or robin. The dark blotch in the center of its speckled breast distinguishes this sparrow from all others; it is very beneficial and should be protected from cats.

"Sweet, sweet, sweet, very merry cheer"

METHOD — All the observations of the song sparrow must be made in the field, and they are easily made because the bird builds near houses, in gardens, and in the shrubbery. Poetry and other literature about the song sparrow should be given to the pupils to read or to memorize.

OBSERVATIONS — 1. Have you noticed a little brown bird singing a very sweet song in the early spring? Did the song sound as if set to the words " Little Maid! Little Maid! Little Maid! Put on the teakettle, teakettle-ettle-ettle "?

2. Where was this bird when you heard him singing? How high was he perched above the ground? What other notes did you hear him utter?

3. Describe the colors and markings of the song sparrow on head, back, throat, breast, wings, and tail. Is this bird as large as the English sparrow? What makes it look more slim?

4. How can you distinguish the song sparrow from the other sparrows? When disturbed does it fly up or down? How does it gesture with its tail as it disappears in the bushes?

5. Where and of what material does the song sparrow build its nest?

6. What colors and markings are on the eggs? Do you think these colors and markings are useful in concealing the eggs when the mother bird leaves the nest?

7. How late in the season do you see the song sparrows and hear their songs?

8. How can we protect these charming little birds and induce them to build near our houses?

9. What is the food of the song sparrows and how do they benefit our fields and gardens? Name some of the injurious insects that they eat.

THE SING-AWAY BIRD

Have you ever heard of the Sing-away bird,
That sings where the Runaway River
Runs down with its rills from the bald-headed hills
That stand in the sunshine and shiver?
" Oh, sing! sing-away! sing-away! "
How the pines and the birches are stirred
By the trill of the Sing-away bird!

And the bald-headed hills, with their rocks and their rills,
To the tune of his rapture are ringing;
And their faces grow young, all the gray mists among,
While the forests break forth into singing.
" Oh, sing! sing-away! sing-away! "
And the river runs singing along;
And the flying winds catch up the song.

'Twas a white-throated sparrow, that sped a light arrow
Of song from his musical quiver,
And it pierced with its spell every valley and dell
On the banks of the Runaway River.
" Oh, sing! sing-away! sing-away! "
The song of the wild singer had
The sound of a soul that is glad.

— LUCY LARCOM

THE MOCKINGBIRD

Among all the vocalists in the bird world, the mockingbird is seldom rivaled in the variety and richness of his repertoire. The mockingbirds go as far north as southern New England, but they are found at their best in the Southern states and in California. On the Gulf Coast the mockers begin singing in February; in warmer climates they sing almost the year through. During the nesting season, the father mocker is so busy with his cares and duties during the day that he does not have time to sing, and so he devotes the nights to serenading; he may sing almost all night long if there is moonlight, and even on dark nights he gives now and then a happy, sleepy song. Not all mockingbirds are mockers; some sing their own song, which is rich and beautiful; while others learn, in addition, not only the

L. A. Fuertes

The mockingbird

songs of other birds, but their call notes as well. One authority noted a mocker which imitated the songs of twenty species of birds during a ten-minute performance. When singing, the mocker shows his relationship to the brown thrasher by lifting the head and depressing and jerking the tail. A good mocker will learn a tune, or parts of it, if it is whistled often enough in his hearing; he will also imitate other sounds and will often improve on a song he has learned from another bird by introducing frills of his own; when learning a song, he sits silent and listens intently, but will not try to sing it until it is learned.

Although the mockingbirds live in wild places, they prefer the haunts of men, taking up their home sites in gardens and cultivated grounds. Their flight is rarely higher than the tree tops and is decidedly jerky in character with much twitching of the long tail. For nesting sites, they choose thickets or the lower branches of trees, being especially fond of orange trees; the nest is usually from four to twenty feet from the ground. The foundation of the nest is made of sticks, grasses, and weed stalks interlaced and crisscrossed; on these is built the nest of softer materials, such as rootlets, horsehair, cotton, or in fact anything suitable which is at hand. The nest is often in plain sight, since the mocker trusts to his strength as a fighter to protect it. He will attack cats with great ferocity and vanquish them; he will often kill snakes; good-sized black snakes have been known to end thus; he will also drive away birds much larger than himself. In making his attack, the mocker hovers above his enemy and strikes it at the back of the head or neck.

The female lays from four to six pale greenish or bluish eggs blotched with brown which hatch in about two weeks; then comes a period of hard work for the parents, as both are indefatigable in catching insects to feed the young. The mocker, by the way, is an amusing sight as he chases a beetle on the ground, lifting his wings in a pugnacious fashion. The mockers often raise three broods a season; the young birds have spotted breasts, showing their relationship to the thrasher.

As a wooer, the mocker is a bird of much ceremony and dances into his lady's graces. Mrs. F. W. Rowe, in describing this, says that the birds stand facing each other with heads and tails erect and wings drooping; " then the dance would begin, and this consisted of the two hopping sideways in the same direction and in rather a straight line a few inches at a

A. A. Allen

A mockingbird on her nest in a thicket time, always keeping directly opposite each other and about the same distance apart. They would *chassez* this way four or five feet, then go back over the same line in the same manner." Mrs. Rowe also observed that the male mockers have hunting preserves of their own, not allowing any other males of their species in these precincts. The boundary was sustained by tactics of both offense and defense; but certain other species of birds were allowed to trespass without reproof.

Maurice Thompson describes in a delightful manner the "mounting" and "dropping" songs of the mocker which occur during the wooing season. The singer flits up from branch to branch of a tree, singing as he goes, and finally on the topmost bough gives his song of triumph to the world; then, reversing the process, he falls backward from spray to spray, as if drunk with the ecstasy of his own song, which is an exquisitely soft "gurgling series of notes, liquid and sweet, that seem to express utter rapture."

The mockingbirds have the same colors in both sexes; the head is black, the back is ashy-gray; the tail and wings are so dark brown that they look black; the tail is very long and has the outer tail feathers entirely white and the two next inner ones are white for more than half their length; the wings have a strikingly broad, white bar, which is very noticeable when the bird is flying. The under parts and breast are grayish white; the beak and legs are blackish. The food of the mockingbirds is about half insects and half fruit. They live largely on the berries of the red cedar, myrtle, and holly, and we must confess are often too much devoted to the fruits in our orchards and gardens; but let us put down to their credit that they do their best to exterminate the cotton boll caterpillars and moths, and also many other insects injurious to crops.

The mocker is full of tricks and is distinctly a bird of humor. He will frighten other birds by screaming like a hawk and then seem to chuckle over the joke.

Sidney Lanier describes him well:

Leonard K. Beyer

The brown thrasher, a close relative of the mockingbird, is also an accomplished musician

Whate'er birds did or dreamed, this bird could say.
Then down he shot, bounced airily along
The sward, twitched in a grasshopper, made song
Midflight, perched, prinked, and to his art again.

SUGGESTED READING — *Audubon Bird Leaflet* 41; also, readings on pages 28–29.

LESSON 23

THE MOCKINGBIRD

LEADING THOUGHT — The mockingbird is the only one of our common birds that sings regularly at night. It imitates the songs of other birds and has also a beautiful song of its own. When feeding their nestlings, the mockers do us great service by destroying insect pests.

METHOD — Studies of this bird are best made individually by the pupils through watching the mockers which haunt the houses and shrubbery. If there are mockingbirds near the schoolhouse, the work can be done in the most ideal way by keeping records in the school of all the observations made by the pupils, thus bringing out an interesting mockingbird story.

OBSERVATIONS — 1. During what months of the year and for how many months does the mockingbird sing in this locality?

2. Does he sing only on moonlight nights? Does he sing all night?

3. Can you distinguish the true mockingbird song from the songs which he has learned from other birds? Describe the actions of a mocker when he is singing.

4. How many songs of other birds have you heard a mocker give and what are the names of these birds?

5. Have you ever taught a mocker a tune by whistling it in his presence? If so, tell how long it was before he learned it and how he acted while learning.

6. Describe the flight of the mockingbirds. Do they fly high in the air like crows?

7. Do these birds like best to live in wild places or about houses and gardens?

8. Where do they choose sites for their nests? Do they make an effort to hide the nest? If not, why?

9. Of what material is the nest made? How is it lined? How far from the ground is it placed?

10. What are the colors of the eggs? How many are usually laid? How long before they hatch?

11. Give instances of the parents' devotion to the young birds.

12. Have you seen two mockingbirds dancing before each other just before the nesting season?

13. In the spring have you heard a mocker sing while mounting from the lower to the upper branches of a tree and then after pouring forth his best song fall backward with a sweet, gurgling song as if intoxicated with his music?

14. How many broods does a pair of mockers raise during one season? How does the color of the breast of the young differ from that of the parent?

15. How does the father bird protect the nestlings from other birds, cats, and snakes?

16. Does the mocker select certain places for his own hunting grounds and drive off other mockers which trespass?

17. Describe the colors of the mockingbird as follows: beak, head, back, tail, wings, throat, breast, under parts and feet.

18. What is the natural food of the mockingbirds and how do they benefit the farmer? How does the mocker act when attacking a ground beetle?

19. Have you seen mockingbirds frighten other birds by imitating the cry of a hawk? Have you seen them play other tricks?

20. Tell a story which includes your own observations on the ways of mockingbirds which you have known.

Soft and low the song began: I scarcely caught it as it ran
Through the melancholy trill of the plaintive whip-poor-will,
Through the ringdove's gentle wail, chattering jay and whistling quail,
Sparrow's twitter, catbird's cry, redbird's whistle, robin's sigh;
Blackbird, bluebird, swallow, lark, each his native note might mark.

Oft he tried the lesson o'er, each time louder than before;
Burst at length the finished song, loud and clear it poured along;
All the choir in silence heard, hushed before this wondrous bird.
All transported and amazed, scarcely breathing, long I gazed.
Now it reached the loudest swell; lower, lower, now it fell, —
Lower, lower, lower still, scarce it sounded o'er the rill.

— JOSEPH RODMAN DRAKE

THE CATBIRD

The Catbird sings a crooked song, in minors that are flat,
And, when he can't control his voice he mews just like a cat,
Then nods his head and whisks his tail and lets it go at that.
— OLIVER DAVIE

As a performer, the catbird distinctly belongs to the vaudeville, even going so far as to appear in slate-colored tights. His specialties range from the most exquisite song to the most strident of scolding notes; his nasal " n-y-a-a-h, n-y-a-a-h " is not so very much like the cat's mew after all, but when addressed to the intruder it means " get out "; and not in the whole gamut of bird notes is there another which so quickly inspires the listener with this desire. I once trespassed upon the territory of a well-grown catbird family and the squalling that ensued was ear-splitting; as I retreated, the triumphant youngsters followed me for a few rods with every sign of triumph in their actions and voices; they obviously enjoyed my apparent fright. The catbirds have rather a pleasant " cluck, cluck " when talking to each other, hidden in the bushes, and they also have a variety of other notes. The true song of the catbird, usually given in the early morning, is very beautiful. Mr. Mathews thinks it is a medley gathered from other birds, but it seems to me very individual. However, true to his vaudeville training, this bird is likely to introduce into the middle or at the end of his exquisite song some phrase that suggests his cat call. He is, without doubt, a true mocker and will often imitate the robin's song, and also if opportunity offers learns to converse fluently in chicken language. One spring morning I heard outside my window the mellow song of the cardinal, which is a rare visitor in New York, but there was no mistaking the " tor-re-do, tor-re-do." I sprang from my bed and rushed to the window, only to see a catbird singing the cardinal song, and thus telling me that he had come from the sunny South and the happy companionship of these brilliant birds. Often when the catbird is singing, he sits on the topmost spray of some shrub lifting his head and depressing his tail, like a brown thrasher; and again, he sings completely hidden in the thicket.

In appearance the catbird is tailor-made, belonging to the same social class as the cedar-bird and the barn swallow.

Robert Matheson

A catbird on its nest

However, it affects quiet colors, and its well-fitting costume is all slate-gray except the top of the head and the tail which are black; the feathers beneath the base of the tail are brownish. The catbird is not so large as the robin, and is of very different shape; it is far more slender and has a long, emotional tail. The way the catbird twitches and tilts its tail, as it hops along the ground or alights in a bush, is very characteristic. It is a particularly alert and nervous bird, always on the watch for intruders, and the first to give warning to all other birds of their approach. It is a good fighter in defending its nest, and there are several observed instances where it has fought to defend the nest of other species of birds; and it has gone even

The catbird lays three to five eggs of a rich greenish blue in a well constructed nest in a dense thicket

further in its philanthropy, by feeding their orphaned nestlings.

The catbird chooses a nesting site in a low tree or shrub or brier, where the nest is built usually about four feet from the ground. The nest looks untidy, but is strongly made of sticks, coarse grass, weeds, bark strips, and occasionally paper; it is lined with soft roots and is almost always well hidden in dense foliage. The eggs are from three to five in number and are dark greenish blue. Both parents work hard feeding the young and for this purpose destroy many insects which we can well spare. Sixty-two per cent of the food of the young has been found in one instance to be cutworms, showing what a splendid work the parents do in our gardens. In fact, during a large part of the summer, while these birds are rearing their two broods, they benefit us greatly by destroying the insect pests; and although later they may attack our fruits and berries, it almost seems as if they had earned the right to their share. If we only had the wisdom to plant along the fences some elderberries or Russian mulberries, the catbirds as well as the robins would feed upon them instead of the cultivated fruits.

The catbirds afford a striking example for impressing upon children that each species of birds haunts certain kinds of places. The catbirds are not often found in deep woods or in open fields, but usually near low thickets along streams, and in shrubbery along fences, in tangles of vines, and especially do they like to build about our gardens, if we protect them. They are very fond of bathing, and if fresh water is given them for this purpose, we may have opportunity to witness the most thorough bath a bird can take. A catbird takes a long time to bathe and preen its feathers and indulges in most luxurious sun baths and thus deservedly earns the epithet of " well-groomed "; it is one of the most intelligent of all our birds and soon learns " what is what," and repays in the most surprising way the trouble of careful observation.

Suggested Reading — *Audubon Bird Leaflet* 70; *Bird-House to Let,* by Mary F. Terrel; *Bird Stories from Burroughs,* by John Burroughs; also, readings on pages 28–29.

LESSON 24

The Catbird

Leading Thought — The catbird has a beautiful song as well as the harsh " miou," and can imitate other birds, although not so well as the mockingbird. It builds in low thickets and shrubbery and during the nesting season is of great benefit to our gardens.

Method — First, let the pupils study and report upon the songs, scoldings, and other notes of this our northern mockingbird; then let them describe its appearance and habits.

Observations — 1. Do you think the squall of the catbird sounds like the mew of a cat? When does the bird use this note and what for? What other notes have you heard it utter?

2. Describe as well as you can the catbird's true song. Are there any harsh notes in it? Where does he sit while singing? Describe the actions of the catbird while he is singing.

3. Have you ever heard the catbird imi-

tate the songs of other birds or other noises?

4. Describe the catbird as follows: its size and shape compared to the robin; the color and shape of head, beak, wings, tail, breast, and under parts.

5. Describe its peculiar actions and its characteristic movements.

6. Where do catbirds build their nests? How high from the ground? What material is used? Is the nest compact and carefully finished? Is it hidden?

7. What is the color of the eggs? Do both parents care for the young?

8. What is the food of the catbird? Why is it an advantage to us to have catbirds build in our gardens?

9. Do you ever find catbirds in the deep woods or out in the open meadows? Where do you find them?

10. Put out a pan of water where the catbirds can use it and then watch them make their toilets and describe the process. Describe how the catbirds take sun baths.

He sits on a branch of yon blossoming bush,
This madcap cousin of robin and thrush,
And sings without ceasing the whole morning long;
Now wild, now tender, the wayward song
That flows from his soft, gray, fluttering throat;
But often he stops in his sweetest note,
And, shaking a flower from the blossoming bough,
Drawls out, " Mi-eu, mi-ow! "

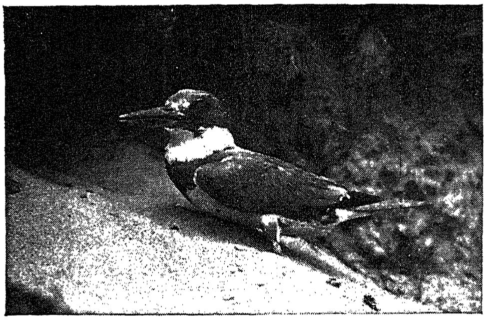
— " THE CATBIRD," EDITH M. THOMAS

Olin Sewall Pettingill, Jr.

A family of seven young belted kingfishers that were posed for the camera

THE BELTED KINGFISHER

This patrol of our streams and lake shores, in his cadet uniform, is indeed a military figure as well as a militant personality. As he sits upon his chosen branch overhanging some stream or lake shore, his crest abristle, his keen eye fixed on the water below, his whole bearing alert, one must acknowledge that this fellow puts " ginger " into his environment, and that the spirit which animates him is very far from the " *dolce far niente* " which permeates the ordinary fisherman. However,



Olin Sewall Pettingill, Jr.

A moment between diggings. This male belted kingfisher hesitates on the doorstep of the nesting burrow which he is digging. To him, rather than to his mate, falls the task of home-building

he does not fish for fun but for business; his keen eye catches the gleam of a moving fin and he darts from his perch, holds himself for a moment on steady wings above the surface of the water, to be sure of his quarry, and then there is a dash and a splash and he returns to his perch with the wriggling fish in his strong beak. Usually he at once proceeds to beat its life out against a branch and then to swallow it sensibly, head first, so that the fins will not prick his throat nor the scales rasp it. He swallows the entire fish, trusting to his internal organs to select the nourishing part; and later he gulps up a ball of the indigestible scales and bones.

The kingfisher is very different in form from an ordinary bird; he is larger than a robin, and his head and fore parts are much larger in proportion; this is the more noticeable because of the long feathers

Kingfisher's foot. This shows the weak toes; the third and fourth are joined together, which undoubtedly assists the bird in pushing out soil when excavating

of the head which he lifts into a crest, and because of the shortness of the tail. The beak is very long and strong, enabling the kingfisher to seize the fish and hold it fast, but the legs are short and weak. The third and fourth toes are grown together for a part of their length; this is of use to the bird in pushing earth from the burrow, when excavating. The kingfisher has no need for running and hopping, like the robin, and therefore does not need the robin's strong legs and feet. His colors are beautiful and harmonious; the upper parts are grayish blue, the throat and collar white, as is also the breast, which has a bluish gray band across the upper part, this giving the name of the Belted Kingfisher to the bird. The feathers of the wings are tipped with white and the tail feathers narrowly barred with white. The under side of the body is white in the males, while in the females it is somewhat chestnut in color. There is a striking white spot just in front of the eye.

The kingfisher parents build their nest in a burrow which they tunnel horizontally in a bank; sometimes there is a vestibule of several feet before the nest is reached, and at other times it is built very close to the opening. Both parents are industrious in catching fish for their nestlings, but the burden of this duty falls heaviest upon the male. Many fish bones are found in the nest, and they seem so clean and white that they have been regarded as nest lining. Wonderful tales are told of the way the English kingfishers use

Olin Sewall Pettingill, Jr.

A large sharply pointed bill and a good aim behind it is all the equipment this feathered fisherman needs to catch his food fish bones to support the earth above their nests, and tributes have been paid to their architectural skill. But it is generally conceded that the lining of fish bones in the nests of our kingfisher is incidental, since the food of the young is largely fish, although frogs, insects, and other creatures are often eaten with relish. It is interesting to note the process by which the young kingfisher gets its skill in fishing. I have often seen one dive horizontally for a yard or two beneath the water and come up indignant and sputtering because the fish had escaped. It was fully two weeks more before this one learned to drop like a bullet on its quarry.

The note of the kingfisher is a loud rattle, not especially pleasant close at hand, but not unmusical at a little distance. It is a curious coincidence that it sounds very much like the clicking of the fisherman's reel; it is a sound that conjures visions of shade-dappled streams and the dancing, blue waters of tree-fringed lakes and ponds.

There seems to be a division of fishing ground among the kingfishers, one bird rarely trespassing upon its neighbor's preserves. Unless it be the parent pair working near each other for the nestlings, or the nestlings still under their care, we seldom see two kingfishers in the same immediate locality.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 19; also, readings on pages 28–29.

LESSON 25

The Kingfisher

Leading Thought — The kingfisher is fitted by form of body and beak to be a fisherman.

Method — If the school be near a stream or pond the following observations may be made by the pupils; otherwise let the boys who go fishing make a study of the bird and report to the school.

Observations — 1. Where have you seen the kingfisher? Have you often seen it on a certain branch which is its favorite perch? Is this perch near the water? What is the advantage of this position to the bird?

2. What does the kingfisher feed upon? How does it obtain its food? Describe the actions of one of these birds while fishing.

3. With what weapons does the kingfisher secure the fish? How long is its beak compared with the rest of its body? How does it kill the fish? Does it swallow the fish head or tail first? Why? Does it tear off the scales or fins before swallowing it? How does it get rid of these and the bones of the fish?

4. Which is the larger, the kingfisher or the robin? Describe the difference in shape of the bodies of these two birds; also in the size and shape of feet and beaks, and explain why they are so different in form. What is there peculiar about the kingfisher's feet? Do you know which two toes are grown together?

5. What are the colors of the kingfisher in general? The colors of head, sides of head, collar, back, tail, wings, throat, breast, and under parts? Is there a white spot near the eye? If so, where? Do you know the difference in colors between the parent birds?

6. Where is the nest built? How is it lined?

7. What is the note of the kingfisher? Does it give it while perching or while on the wing? Do you ever find more than one kingfisher on the same fishing grounds?

THE KINGFISHER (OF ENGLAND)

For the handsome Kingfisher, go not to the tree,
No bird of the field or the forest is he;
In the dry river rock he did never abide,
And not on the brown heath all barren and wide.

He lives where the fresh, sparkling waters are flowing,
Where the tall heavy Typha and Loosestrife are growing;
By the bright little streams that all joyfully run
Awhile in the shadow, and then in the sun.

He lives in a hole that is quite to his mind,
With the green mossy Hazel roots firmly entwined;
Where the dark Alder-bough waves gracefully o'er,
And the Sword-flag and Arrow-head grow at his door.

There busily, busily, all the day long,
He seeks for small fishes the shallows among;
For he builds his nest of the pearly fish-bone,
Deep, deep, in the bank, far retired, and alone.

Then the brown Water-Rat from his burrow looks out,
To see what his neighbor Kingfisher's about;
And the green Dragon-fly, flitting slowly away,
Just pauses one moment to bid him good-day.

O happy Kingfisher! What care should he know,
By the clear, pleasant streams, as he skims to and fro,
Now lost in the shadow, now bright in the sheen
Of the hot summer sun, glancing scarlet and green!

— Mary Howitt

THE SCREECH OWL

Disquiet yourselves not: 'Tis nothing but a little, downy owl. — Shelley

Of all the sounds to be heard at night in the woods, the screech owl's song is surely the most fascinating; its fascination does not depend on music but upon the chills which it sends up and down the spine of the listener, thus attacking a quite different set of nerves than do other bird songs. The weird wail, tremulous and long drawn out, although so blood-curdling, is from the standpoint of the owlet the most beautiful music in the world; by means of it he calls to his mate, cheering her with the assurance of his presence in the world; evidently she is not a nervous creature. The screech owls are likely to sing at night during any part of the year; nor should we infer that when they are singing they are not hunting, for perchance their music frightens their victims into fatal activity. Although the note is so unmistakable, yet there is great variation in the songs of individuals; the great variety of quavers in the song offers ample opportunity for the expression of individuality. Moreover, these owls often give themselves over to tremulous whispering and they emphasize excitement by snapping their beaks in an alarming manner.

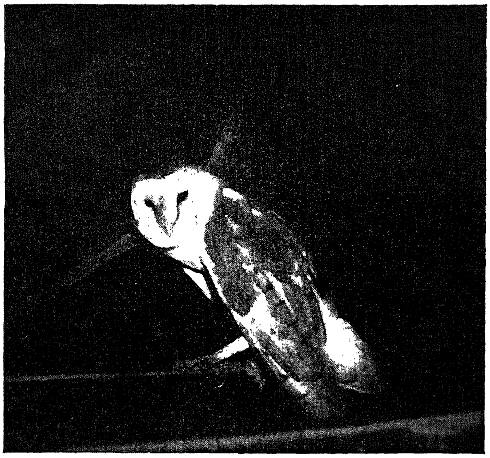
Country Life in America

Screech owls

Any bird that is flying about and singing in the night time must be able to see where it is going, and the owls have special adaptations for this. The eyes are very large and the yellow iris opens and closes about the pupil in a way quite similar to the arrangement in the cat's eye, except that the pupil in the owl's eye is round when contracted instead of elongated; in the night this pupil is expanded until it covers most of the eye. The owl does not need to see behind and at the sides, since it does not belong to the birds which are the victims of other birds and animals of prey. The owl is a bird that hunts instead of being hunted, and it needs only to focus its eyes on the creature it is chasing. Thus, its eyes are in the front of the head like our own; but it can see behind, in case of need, for the head turns upon the neck as if it were fitted on a ball-bearing joint. I have often amused myself by walking around a captive screech owl, which would follow me with its eyes by turning the head until it almost made the circle; then the head would twist back with such lightning rapidity that I could hardly detect the movement. It seemed almost as if the head were on a pivot and could be moved around and around indefinitely. Although the owl, like the cat, has eyes fitted for night hunting, it can also see fairly well during the daytime.

A beak with the upper mandible ending in a sharp hook signifies that its owner lives upon other animals and needs to rend and tear flesh. The owl's beak thus formed is somewhat buried in the feathers of the face, which gives it a striking resemblance to a Roman nose. This, with the great, staring, round eyes, bestows upon the owl an appearance of great wisdom. But it is not the beak which the owl uses for a weapon of attack; its strong feet and sharp, curved claws are its weapons for striking the enemy and also for grappling with its prey. The outer toe can be moved back at will, so that in grasping its prey or its perch, two toes may be directed forward and two backward, thus giving a stronger hold.

The ear is very different in form from the ear of other birds; instead of being a mere hole opening into the internal ear, it consists of a fold of skin forming a channel which extends from above the eye



S. A. Grimes

A barn or monkey-faced owl

around to the side of the throat. Thus equipped, while hunting in the dark the owl is able to hear any least rustle of mouse or bird and to know in which direction to descend upon it. There has been no relation established between the ear tufts of the screech owl and its ears, so far as I know, but the way the bird lifts the tufts when it is alert always suggests that this movement in some way opens up the ear.

In color there are two phases among the screech owls, one reddish brown, the other gray. The back is streaked with black, the breast is marked with many shaft-lines of black. The whole effect of the owl's plumage makes it resemble a branch of a tree or a part of the bark, and thus it is protected from prying eyes during the daytime when it is sleeping. Its plumage is very fluffy and its wing feathers, instead of being stiff to the very edge, have soft fringes which cushion the stroke upon the air. The owl's flight is, therefore, noiseless; and the bird is thus able to swoop down upon its prey without giving warning of its approach.

The screech owls are partial to old apple orchards for nesting sites. They will often use the abandoned nest of a woodpecker; the eggs are almost as round as marbles and as white as chalk; it is well that they are laid within a dark hole, for otherwise their color would attract the

S. A. Grimes

The great horned owl

eyes of enemies. There are usually four eggs; the fubsy little owlets climb out of their home cave by the end of May and are the funniest little creatures imaginable. They make interesting but decidedly snappy pets; they can be fed on insects and raw beef. It is most interesting to see one wake up late in the afternoon after its daytime sleep. All day it has sat motionless upon its perch with its toes completely covered with its fluffy feather skirt. Suddenly its eyes open, the round pupils enlarging or contracting with great rapidity as if adjusting themselves to the amount of light. When the owl winks it is like a moon in eclipse, so large are the eyes, and so entirely are they obscured by the lids, which seem like circular curtains. When it yawns, its wide bill absurdly resembles a human mouth, and the yawn is very human in its expression. It then stretches its wings; it is astonishing how far this wing can be extended below the feet. It then begins its toilet. It dresses its feathers with its short beak, nibbling industriously in the fluff; it scratches its under parts and breast with its bill, then cleans the bill with its foot, meanwhile moving the head up and down as if in an attempt to see its surroundings better.

The owls are loyal lovers and are said to remain mated through life, the twain being very devoted to their nests and nestlings. Sometimes the two wise-looking little parents sit together on the eggs, a most happy way to pass the wearisome incubation period.

The screech owls winter in the north and are distinctly foresighted in preparing for winter. They have often been observed catching mice, during the late fall, and placing them in some hollow tree for cold storage, whence they may be taken in time of need. Their food consists to some extent of insects, especially night-flying moths and beetles, and also caterpillars and grasshoppers. However, the larger part of their food is mice; sometimes small birds are caught, and the English sparrow is a frequent victim. Chickens are rarely taken, except when small, since this owlet is not as long as a robin. It swallows its quarry as whole as possible, trusting to its inner organs to do the sifting and selecting. Later it throws up pellets of the indigestible bones, hair, etc. By the study of these pellets, found under owl roosts, the scientists have been able to determine the natural food of the bird, and they all unite in assuring us that the screech owl does the farmer much more good than harm, since it feeds so largely upon creatures which destroy his crops.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 11; *Bird Stories*, by Edith M. Patch; *Bird Stories from Burroughs*, by John Burroughs; *Birds in the Wilderness*, by George M. Sutton; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; *Our Backdoor Neighbors*, by Frank C. Pellett; *The Pet Book*, by Anna B. Comstock; also, readings on pages 28–29.

LESSON 26

The Screech Owl

Leading Thought — This owl is especially adapted to get its prey at night. It feeds largely on field mice, grasshoppers, caterpillars, and other injurious insects and is therefore the friend of the farmer.

Method — This lesson should begin when the children first hear the cry of this owl; and an owl in captivity is a fascinating object for the children to observe. However, it is so important that the children learn the habits of this owl that the teacher is advised to hinge the lesson on any observation whatever made by the pupils, and illustrate it with pictures and stories.

OBSERVATIONS — 1. Have you ever heard the screech owl? At what time of the day or night? Why was this? Why does the owl screech? How did you feel when listening to the owl's song?

2. Describe the owl's eyes. Are they adapted to see by night? What changes take place in them to enable the owl to see by day also? In what way are the owl's eyes similar to the cat's? Why is it necessary for an owl to see at night? Are the owl's eyes placed so that they can see at the sides like other birds? How does it see an object at the sides or behind it?

3. Note the owl's beak. For what purpose is a hooked beak? How does the owl use its beak? Why do we think that the owl looks wise?

4. Describe the feet and claws of the screech owl. What are such sharp hooked claws meant for? Does an owl on a perch always have three toes directed forward and one backward?

5. Describe the colors of the screech owl. Are all these owls of the same color? How do these colors protect the bird from its enemies?

6. How is the owl's plumage adapted to silent flight? Why is silent flight advantageous to this bird?

7. How does the owl's ear differ from the ears of other birds? Of what special advantage is this? As the owl hunts during the night, what does it do in the daytime? How and by what means does it hide itself?

8. Where does the screech owl make its nest? Do you know anything about the devotion of the parent owls to each other and to their young? How many eggs are laid? What is their color? At what time of year do the little owls appear?

9. Where does the screech owl spend the winter? What do the screech owls feed upon? Do they chew their food? How do they get rid of the indigestible portion of their food? How does this habit help scientists to know the food of the owls?

10. How does the screech owl work injury to the farmers? How does it benefit them? Does not the benefit outweigh the injury?

11. How many other kinds of owls do you know? What do you know of their habits?

TWO WISE OWLS

We are two dusky owls, and we live in a tree;
Look at her, — look at me!
Look at her, — she's my mate, and the mother of three
Pretty owlets, and we
Have a warm cosy nest, just as snug as can be.

We are both very wise; for our heads, as you see,
(Look at her — look at me!)
Are as large as the heads of four birds ought to be;
And our horns, you'll agree,
Make us look wiser still, sitting here on the tree.

And we care not how gloomy the night-time may be;
We can see, — we can see;
Through the forest to roam, it suits her, it suits me;
And we're free, — we are free
To bring back what we find, to our nest in the tree.

— ANONYMOUS

S. A. Grimes

The fish hawk or osprey. This hawk builds its large nest from twenty to fifty feet above the ground. It subsists almost entirely on fish

THE HAWKS

Above the tumult of the cañon lifted, the gray hawk breathless hung,
Or on the hill a winged shadow drifted where furze and thornbush clung.
— BRET HARTE

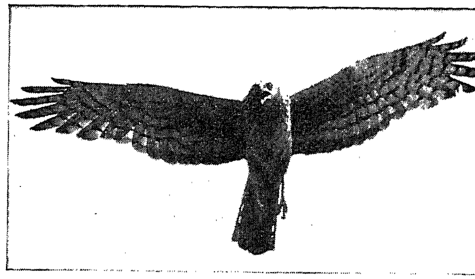
It is the teacher's duty and privilege to try to revolutionize some popular misconceptions about birds, and two birds, in great need in this respect, are the so-called hen hawks. They are most unjustly treated, largely because most farmers consider that a " hawk is a hawk," and should always be shot to save the poultry, although there is as much difference in the habits of hawks as there is in those of men. The so-called hen hawks are the red-shouldered and the red-tailed species, the latter being somewhat the larger and rarer of the two. Both are very large birds. The red-shouldered has cinnamon brown epaulets; the tail is blackish, crossed by five or six narrow white bars, and the wing feathers are also barred. The red-tailed species has dark brown wings; the feathers are not barred, and it is distinguished by its tail which is brilliant cinnamon color with a black bar across it near the end; it is silvery white beneath. When the hawk is soaring, its tail shows reddish as it wheels in the air. Both birds are brown above and whitish below, streaked with brown.

The flight of these hawks is similar and is very beautiful; it consists of soaring on outstretched wings in wide circles high in the air, and is the ideal of graceful aerial motion. In rising, the bird faces the wind and drops a little in the circle as its back turns to the leeward, and thus it climbs an invisible winding stair until it is a mere speck in the sky. When the bird wishes to drop, it lifts and holds its wings above its back, and comes down like a lump of lead, only to catch itself whenever it chooses to begin again to climb the invisible spiral. And all this is done without fatigue, for these birds have been observed to soar thus for hours together without coming to earth. When thus soaring the two species may be distinguished from each other by their cries; the red-tailed gives a high sputtering scream, which Chapman likens to the sound of escaping steam; while the red-shouldered calls in a high not unmusical note "kee-you, kee-you" or "tee-ur, tee-ur."

The popular fallacy for the teacher to correct about these birds is that they are enemies of the farmers. Not until a hawk has actually been seen to catch chickens should it be shot, for very few of them are guilty of this sin. Sixty-six per cent of the food of the red-tailed species consists of injurious animals, i.e., mice and gophers, etc., and only seven per cent consists of poultry; the victims are probably old or disabled fowls, and fall an easy prey; this bird much prefers mice and reptiles to poultry. The more common red-shouldered hawk feeds generally on mice, snakes, frogs, fish, and is very fond of grasshoppers. Ninety per cent of its food consists of creatures which injure our crops or pastures and scarcely one and one-half per cent is made up of poultry and game. These facts have been ascertained by the experts in the Department of Agriculture at Washington who have examined the stomachs of hundreds of these hawks taken from different localities. Furthermore, Dr. Fisher states that a pair of the red-shouldered hawks bred for successive years within a few hundred yards of a poultry farm containing 800 young chickens and 400 ducks, and the owner never saw them attempt to catch a fowl.

A. A. Allen

Red-tailed hawk



S. A. Grimes

The marsh hawk. This is a bird of the open fields. It flies low in search of rodents, reptiles, frogs, and insects. It may be identified by a white spot on the rump

However, there are certain species of hawks which are to be feared; these are the Cooper's hawk and the sharp-shinned hawk, the first being very destructive to poultry and the latter killing many wild birds. These are both somewhat smaller than the species we are studying. They are both dark gray above and have very long tails, and when flying they flap their wings for a time and then glide a distance. They do not soar on motionless outspread pinions by the hour.

When hawks are seen soaring, they are likely to be hunting for mice in the meadows below them. Their eyes are remarkably keen; they can see a moving creature from a great height, and can suddenly drop upon it like a thunderbolt out of a clear sky. Their wonderful eyes are far-sighted when they are circling in the sky,

BIRDS OF PREY AND SCAVENGERS

1. Sparrow Hawks. *In summer these birds will be found from northern Canada south to the Gulf states except in peninsular Florida and the arid regions of the Southwest; in winter from the northern United States to Panama. About eleven inches in length, this pretty little hawk has readily adapted itself to civilization and in densely populated areas makes its nest about buildings and even in birdhouses. The sparrow hawk should be protected everywhere, for it is useful to man; it feeds chiefly on mice and insects. (Photo by Dorothy M. Compton)*

2. Snowy Owl. *One of the largest and most handsome of owls, the snowy owl, is at home in the northern part of the Northern Hemisphere; it breeds as far north as land is found and as far south as northern Quebec, Manitoba, and British Columbia. In winter it migrates southward in search of food if mice and lemmings become scarce in the North. In North America the winter range may extend as far south as the Gulf states, in Europe as far south as France and Switzerland, and in Asia to northern India and Japan. This owl is seldom seen in trees, preferring the open country, probably because the rodents which are its principal food are found there. (Photo by Olin Sewall Pettingill, Jr.)*

3. A Young Screech Owl. *The range of these birds extends from southern Canada to the southern United States. They breed over most of this area. The screech owl is not quite so long as a robin. It often nests in a small cavity in a tree or even in a birdhouse. It is not unusual for the owl to use the same nesting place year after year. It feeds largely on mice, other small mammals, insects, and small birds. This owl is unique in that it has two color phases; both male and female may be either gray or reddish brown. (Photo by Dorothy M. Compton)*

4. Herring Gull. *These birds are scavengers found along the coasts and inland waters of the Northern Hemisphere. They nest in colonies, usually on islands but always near the water. The nest of seaweed, grasses, or moss is generally built on the ground. Flocks of herring gulls are often seen near piers and wharves where they perform a valuable service by feeding on garbage and refuse. It is generally this bird that follows coastwise boats waiting for refuse to be thrown overboard. (Photo by Olin Sewall Pettingill, Jr.)*

5. An Adult Screech Owl. *Perched in a tree, the screech owl is difficult to detect, for he is easily mistaken for branches and leaves. (Photo by A. A. Allen)*

6. A Black Vulture at the Entrance to Its Nest. *This is a scavenger of the South. Though it rarely breeds north of Maryland, it is occasionally seen in some of the central states. The value of these birds in removing health-menacing garbage and carrion is so great that they are protected by law and public sentiment. They are quite numerous in the South and are often seen in towns and cities. The black vulture does not build a nest; the eggs are laid in cavities in trees or rocks, in hollow stumps, or on the ground beneath bushes. (Photo by S. A. Grimes)*

7. Audubon's Caracara. *This bird's usual range is from Lower California, Arizona, Texas, and southern Florida southward to Ecuador; it has been reported as an accidental visitor as far north as Ontario. The nest is a bulky structure of sticks, branches, roots, grass, and leaves, usually placed in trees or on bushes or ledges. Caracaras are often seen in the company of vultures, feeding on carrion, and they also capture and eat snakes, frogs, and lizards. The caracara's flight is direct and rapid, not at all like that of the vulture, which sails and soars in spirals. (Photo by S. A. Grimes)*

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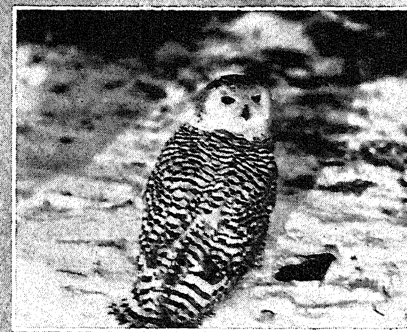

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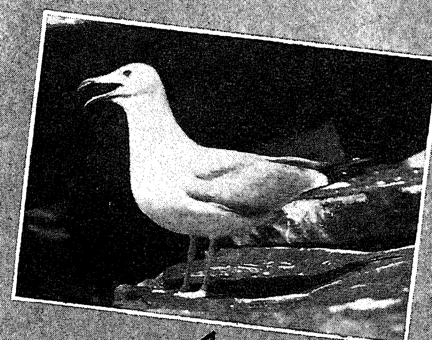

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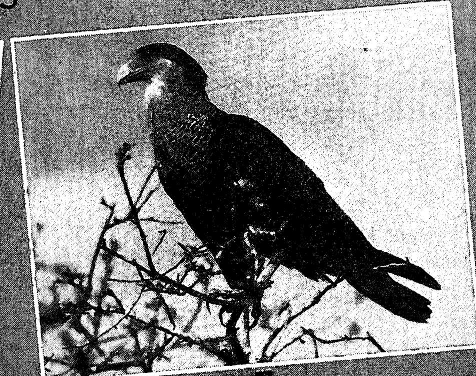


7

Leonard K. Beyer

Nest and eggs of the marsh hawk

but as they drop, the focus of the eyes changes automatically with great rapidity, so that by the time they reach the earth they are nearsighted, a feat quite impossible for our eyes unless aided by glasses or telescope.

These so-called hen hawks will often sit motionless, for hours at a time, on some dead branch or dead tree; they are probably watching for something eatable to stir within the range of their keen vision. When seizing its prey, a hawk uses its strong feet and sharp, curved talons. All hawks have sharp and polished claws, even as the warrior has a keen, bright sword; the legs are covered by a growth of feathers extending down from above, looking like feather trousers. The beak is hooked and very sharp and is used for tearing apart the flesh of the quarry. When a hawk fights some larger animal or man, it throws itself over upon its back and strikes its assailant with its strong claws as well as with its beak; but the talons are its chief weapons.

Both species build a large, shallow nest of coarse sticks and grass, lined with moss, feathers, etc.; it is a rude, rough structure, and is placed in tall trees from fifty to seventy-five feet from the ground. Only two to four eggs are laid; these are whitish, spotted with brown. These hawks are said to remain mated for life and are devoted to each other and to their young. Hawks and eagles are very similar in form and habits, and if the eagle is a noble bird, so is the hawk.

Suggested Reading — *Audubon Bird Leaflets* 8, 9, 10, 37, 82, 122; *Bird Stories from Burroughs*, by John Burroughs; *Food Habits of Common Hawks*, by W. L. McAtee (U. S. Department of Agriculture, Circular 370); *The Hawks of North America*, by John B. May; *Our Backdoor Neighbors*, by Frank C. Pellett; also, readings on pages 28–29.

LESSON 27

The Hawks

Leading Thought — Uninformed people consider all hawks dangerous neighbors because they are supposed to feed exclusively on poultry. This idea is false and we should study carefully the habits of hawks before we shoot them. The ordinary large reddish "hen hawks," which circle high above meadows, are doing great good to the farmer by feeding upon the mice and other creatures which steal his grain and girdle his trees.

Method — Begin by observations on the flight of one of these hawks and supplement this with such observations as the pupils are able to make, or facts which they can discover by talking with hunters or others, and by reading.

Observations — 1. How can you tell a

Leonard K. Beyer

Young marsh hawks

hawk, when flying, from a crow or other large bird? Describe how it soars. Does it move off in any direction? If so, does it move off in circles? How often does it make strokes with its wings? Does it rise when it is facing the wind and fall as it turns its back to the wind?

2. Have you seen a hawk flap its wings many times and then soar for a time? If so, what hawk do you think it was? How does it differ in habits from the "hen hawks"?

3. Have you noticed a hawk when soaring drop suddenly to earth? If so, why did it do this?

4. How does a hawk hunt? How, when it is so high in the air that it looks like a circling speck in the sky, can it see a mouse in a meadow? If it is so farsighted as this, how can it be nearsighted enough to catch the mouse when it is close to it? Would you not have to use field glasses or telescope to do this?

5. When a hawk alights what sort of place does it choose? How does it act?

6. Do hawks seize their prey with their claws or their beaks? What sort of feet and claws has the hawk? Describe the beak. What do you think a beak of this shape is meant for?

7. Why do people shoot hawks? Why is it a mistake for people to wish to shoot all hawks?

8. What is the food of the red-shouldered hawk as shown by the bulletin of the U. S. Department of Agriculture or by the Audubon leaflets?

9. Where does the hawk place its nest? Of what does it build its nest?

10. Compare the food and the nesting habits of the red-shouldered and red-tailed hawks?

11. How devoted are the hawks to their mates and to their young? Does a hawk, having lost its mate, live alone ever after?

12. Describe the colors of the hen hawks and describe how you can tell the two species apart by the colors and markings of the tail.

13. What is the cry of the hawk? How can you tell the two species apart by this cry? Does the hawk give its cry only when on the wing?

14. Why should an eagle be considered so noble a bird and the hawk be so scorned? What difference is there between them in habits?

Yet, ere the noon, as brass the heaven turns,
The cruel sun smites with unerring aim,
The sight and touch of all things blinds and burns,
And bare, hot hills seem shimmering into flame!

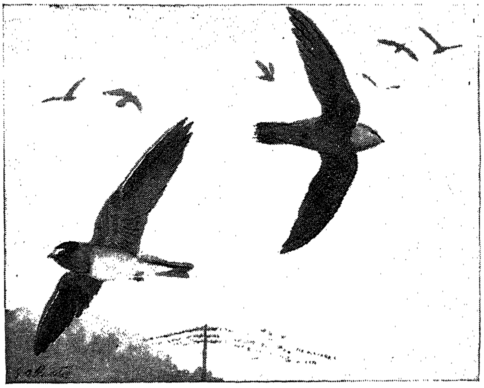
On outspread wings a hawk, far poised on high,
Quick swooping screams, and then is heard no more:
The strident shrilling of a locust nigh
Breaks forth, and dies in silence as before.

— "Summer Drought," J. P. Irvine

THE SWALLOWS AND THE CHIMNEY SWIFT

These friendly little birds spend their time darting through the air on swift wings, seeking and destroying insects which are foes to us and to our various crops. However, it is safe to assume that they are not thinking of us as they skim above our meadows and ponds, hawking our tiny foes; for like most of us, they are simply intent upon getting a living. Would that we might perform this necessary duty as gracefully as they!

In general, the swallows have a long, slender, graceful body, with a long tail which is forked or notched, except in the case of the eave swallow. The beak is short but wide where it joins the head; this enables the bird to open its mouth wide and gives it more scope in the matter of catching insects; the swift flight of the swallows enables them to catch insects on the wing. Their legs are short, the feet are weak and fitted for perching; it would be quite im-



L. A. Fuertes

Swallows and swifts

possible for a swallow to walk or hop like a robin or blackbird.

THE EAVE OR CLIFF SWALLOWS — These swallows build under the eaves of barns or in similar locations. In early times they built against the sides of cliffs; but when man came and built barns, they chose them for their dwelling sites. The nest is made of mud pellets and is somewhat globular in shape, with an entrance at one side. When the nest is on the side of a cliff or in an unprotected portion of a barn, a covered passage is built around the door, which gives the nest the shape of a gourd or retort; but when protected beneath the eaves the birds seem to think this vestibule is unnecessary. The mud nest is warmly lined with feathers and soft materials, and often there are many nests built so closely together that they touch. The eave swallow comes north about May 1, and soon after that may be seen along streams or other damp places gathering mud for the nests. It seems necessary for the bird to find clay mud in order to render the nest strong enough to support the eggs and nestlings. The eggs are white, blotched with reddish brown. The parents cling to the edge of the nest when feeding the young. Both the barn and eave swallows are blue above, but the eave swallow has the forehead cream white and the rump of pale brick-red, and its tail is square across the end as seen in flight. The barn swallow has a chestnut forehead and its outer tail feathers are long, making a distinct fork during flight, and it is not red upon the rump.

A. A. Allen

Nests of cliff swallows

Leonard K. Beyer

Barn swallow and nest

THE BARN SWALLOWS — These birds choose a barn where there is a hole in the gable or where the doors are kept open all the time. They build upon beams or rafters, making a cup-shaped nest of layers of pellets of mud, with grass between; it is well lined with feathers. The nest is usually the shape of half of a shallow cup which has been cut in two lengthwise, the cut side being plastered against the side of the rafter. Sometimes the nests are more or less supported upon a beam or rafter; the eggs are white and dotted with reddish brown. The barn swallows, aside from their constant twittering, have also a pretty song. Both parents work at building the nest and feeding the young; there are likely to be several pairs nesting in the same building. The parents continue to feed the young long after they have left the nest; often a whole family may be seen sitting on a telegraph wire or wire fence, the parents still feeding the well-grown youngsters. This species comes north in

This barn swallow's nest is well feathered

the latter part of April and leaves early in September. It winters as far south as Brazil.

The barn swallow has a distinctly tailor-made appearance; its red-brown vest and iridescent blue coat, with deeply forked "coat tails" give it an elegance of style which no other bird, not even the chic cedar waxwing, can emulate.

THE BANK SWALLOW — When we see a sandy bank apparently shot full of holes as by small cannon balls, we may know that we have found a tenement of bank swallows. These birds always choose the perpendicular banks of creeks or of railroad cuts or of sand pits for their nesting sites; they require a soil sufficiently soft to be tunneled by their weak feet, and yet not so loose as to cave in upon the nest. The tunnel may extend from one to four feet

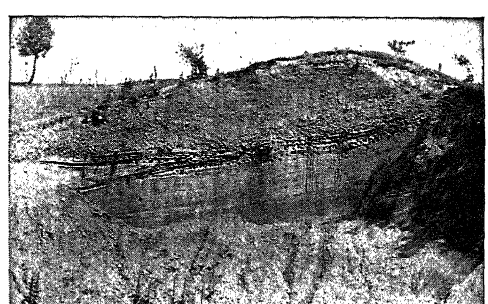
Leonard K. Beyer

The band of color across the breast is the distinguishing mark of the bank swallow

horizontally in the bank with just enough diameter to admit the body of the rather small bird. The nest is situated at the extreme end of the tunnel and is lined with soft feathers and grasses.

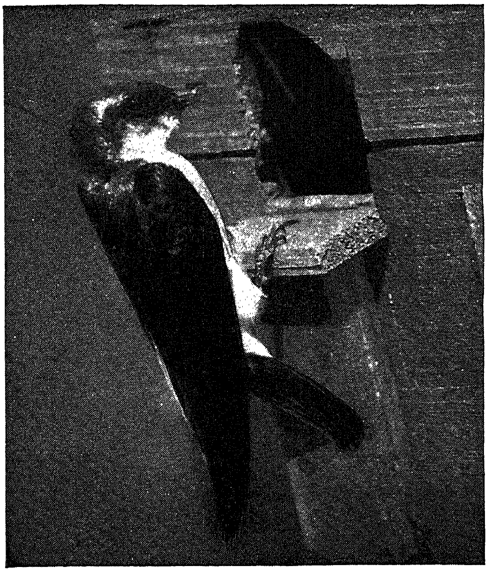
The bank swallows arrive late in April and leave early in September. They may be distinguished from the other species by their grayish color above; the throat and breast are white with a broad, brownish band across the breast; the tail is slightly forked. The rough-winged swallow, which is similar in habits to the bank swallow, may be distinguished from it by its gray breast which has no dark band.

THE TREE SWALLOW — This graceful little bird builds naturally in holes in trees, but readily accepts a box if it is provided. It begins to build soon after it comes north in late April, and it is well for us to encourage the tree swallows to live near



Leonard K. Beyer

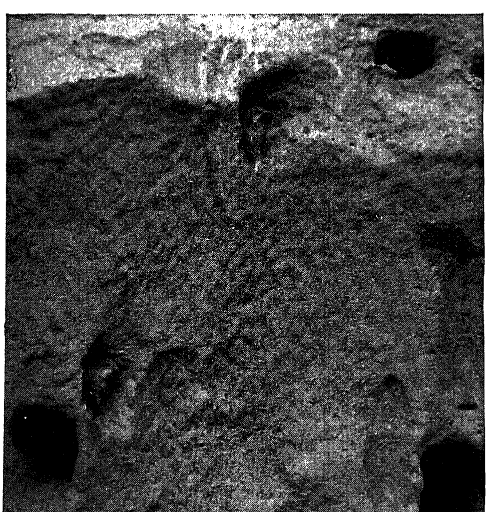
Nesting site of a colony of bank swallows



George Fiske, Jr.

A tree swallow

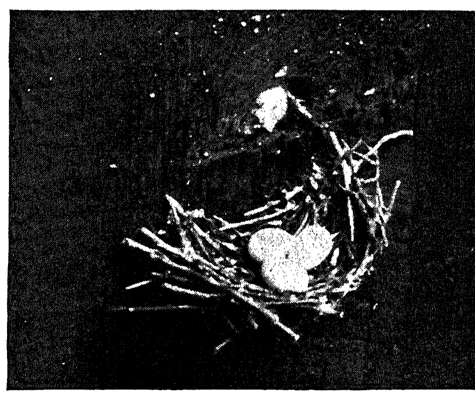
our houses by building houses for them and driving away the English sparrows. The tree swallows live upon many insects which annoy us and injure our gardens and damage our orchards; they are, therefore, much more desirable neighbors than the English sparrows. The tree swallows congregate in great numbers for the southern migration very early in the season, often in early August. They are likely to congregate in marshes, as are also the other swallows. In color the tree swallow has a green metallic back and head, and a pure white breast with no band across it; these peculiarities distinguish it from all other species.



Leonard K. Beyer

Two bank swallows at the entrances to their burrows

The Purple Martin — The martin is a larger bird than any other swallow, being eight inches in length, while the barn swallow does not measure quite seven. The male is shining, steel-blue above and below; the female is brownish above, has a gray throat, brownish breast and is white beneath. The martins originally nested in hollow trees but for centuries have been cared for by man. The Indians were wont to put out empty gourds for them to nest in; and as soon as America was settled by Europeans, martin boxes were built extensively. But when the English sparrows came, they took possession of the boxes, and the martins have to a large extent disappeared; this is a pity since they are beneficial birds, feeding upon insects which are injurious to our farms and gardens. They are also delightful birds to have around, and we may possibly induce them to come back to us by building houses for them and driving away the sparrows.



A. A. Allen

Nest of chimney swifts

The Chimney Swift

When the old-fashioned fireplaces went out of use and were walled up, leaving the great old chimneys useless, these sociable birds took possession of them.

Here they built their nests and reared their young, and twittered and scrambled about, awakened all sleepers in the neighborhood at earliest dawn, and in many ways made themselves a distinct part of family life. With the disappearance of these old chimneys and the growing use of the smaller chimney, the swifts have been more or less driven from their close association with people; and now their nests are often found in hay barns or other secluded buildings, although they still gather in chimneys when opportunity offers.

The chimney swifts originally built nests in hollow trees and caves; but with the coming of civilization they took possession of the chimneys disused during the summer, and here is where we know them best. The nests are shaped like little wall pockets; they are made of small sticks of nearly uniform size which are glued together and glued fast to the chimney wall by means of the saliva secreted in the mouth of the bird. After the nesting season, the swifts often gather in great flocks and live together in some large chimney; toward nightfall they may be seen circling about in great numbers and dropping into the mouth of the chimney, one by one, as if they were being poured into a funnel. In the morning they leave in reverse manner, each swift flying about in widening circles as it leaves the chimney. The swifts are never seen to alight anywhere except in hollow trees or chimneys or similar places; their tiny feet have sharp claws for clinging to the slightest roughness of the upright wall; the tail acts as a prop, each tail feather ending in a spine which is pressed against the chimney side when the bird alights, thus enabling it to cling more firmly. In this fashion the swifts roost, practically hung up against a wall.

The swift has a short beak and wide mouth which it opens broadly to engulf insects as it darts through the air. Chimney swifts have been known to travel at the rate of 110 miles an hour.

This bird should never be confused with the swallows, for when flying, its tail seems simply a sharp point, making the whole body cigar-shaped. This characteristic alone distinguishes it from the long-tailed swallows. In color it is sooty brown, with a gray throat and breast; the wings are long and narrow and apparently curved. The manner of flight and appearance in the air make it resemble the bat more than it does the swallow.

Suggested Reading — *Audubon Bird Leaflets* 13, 32, 33, and 49; *Bird Stories*, by Edith M. Patch (Cliff Swallow); *Bird Stories from Burroughs*, by John Burroughs (Chimney Swift); *First Lessons in Nature Study*, by Edith M. Patch (Cliff Swallow, Bank Swallow); *Holiday Pond*, by Edith M. Patch (Bank Swallow); *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting* (Bank Swallow), Book 2, *Outdoor Visits* (Bank Swallow, Tree Swallow), Book 3, *Surprises* (Tree Swallow), Book 5, *Science at Home* (Cliff Swallow); also, readings on pages 28–29.

LESSON 28

The Swallows and Swifts

Leading Thought — The swallows are very graceful birds and are exceedingly swift fliers. They feed upon insects which they catch upon the wing. There are five native swallows which are common — the eave, or cliff, the barn, the bank, the tree swallow, and the purple martin. The chimney swift, although often called so, is not a swallow; it is more nearly related to the hummingbird than to the swallows.

Method — The questions should be given as an outline for observation, and may be written on the blackboard or placed in the field notebook. The pupils should answer them individually and from field observation. We study the swifts and swallows together to teach the pupils to distinguish them apart.

Observations — 1. What is the general shape of the swallow? What is the color of the forehead, throat, upper breast, neck, rump, and tail?

2. Is the tail noticeably forked, especially during flight?

Leonard K. Beyer

Nest of bank swallows. The bank has been cut away so that the nest and eggs could be photographed

3. Describe the flight of the swallow. What are the purposes of its long, swift flight? How are the swallow's wings fitted for carrying the bird swiftly?

4. Describe the form of the beak of the swallow. How does it get its food? What is its food?

5. In what particular locations do you see the swallows darting about? At what time of day do they seem most active?

6. Describe the swallow's legs and feet and explain why they look so different from those of the robin and blackbird.

The Eave or Cliff Swallow

7. Where do the eave swallows build their nests? Of what material is the outside? The lining? Describe the shape of the nest and how it is supported.

8. How early in the spring do the eave swallows begin to make their nests? Where and by what means do they get the material for nest building? Are there a number of nests usually grouped together?

9. Describe the eave swallow's egg. Where do the parents sit when feeding the young? What is the note of the eave swallow?

10. What are the differences between the barn and the eave swallow in color and shape of tail?

The Barn Swallow

11. Where does the barn swallow place its nest? What is the shape of the nest? Of what material is it made?

12. What is the color of the eggs? Describe the feeding of the young and the sounds made by them and their parents. Do both parents work together to build the nest and feed the young?

13. Is there usually more than one nest in the same locality? When the young swallows are large enough to leave the nest, describe how the parents continue to care for them.

14. Have you ever heard the barn swallows sing? Describe their conversational notes.

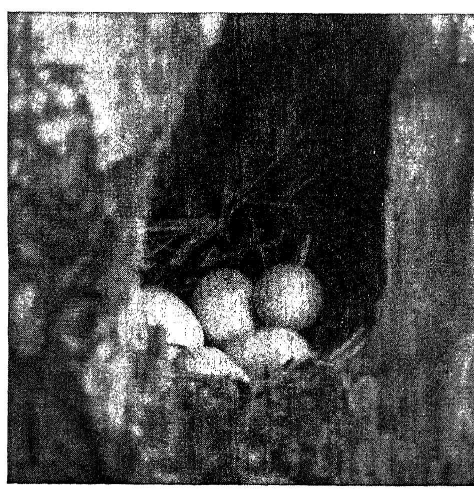
15. When do the barn swallows migrate and where do they go during the winter? How can you distinguish the barn swallow from the eave swallow?

The Bank Swallow

16. Where do the bank swallows build? What sort of soil do they choose?

17. How does a bank which is tenanted by these birds look?

18. How far do the bank swallows tunnel into the earth? What is the diameter of one of these tunnels? Do they extend straight or do they rise or deflect?



A. A. Allen

Nest and eggs of tree swallows

19. With what tools is the tunnel excavated? Where is the nest situated in the tunnel and how is it lined?

20. How can you distinguish this species from the barn and eave and tree swallows? At what time do the bank swallows leave us for migration south?

The Tree Swallow

21. Where does the tree swallow make its nest? How does its nest differ from that of the barn, eave, or bank swallow? When does it begin to build?

22. How can we encourage the tree swallow to build near our houses? Why is the tree swallow a much more desirable bird to have in birdhouses than the English sparrow?

23. Describe the peculiar migrating habits of the tree swallow. How can you tell this species from the barn, the eave, and the bank swallows?

The Purple Martin

24. Compare the purple martin with the swallows and describe how it differs in size and color.

25. Where did the martins build their nests before America was civilized? Where do they like to nest now? How do the purple martins benefit us and how can we induce them to come to us?

The Chimney Swift

26. Where do the chimney swifts build their nests? Of what materials is the nest made? What is its shape and how is it supported? Where does the chimney swift get the glue which it uses for nest building?

27. Describe how the chimney swifts enter their nesting place at night. Where and how do they perch? Describe the shape of the swift's tail and its use to the bird when roosting.

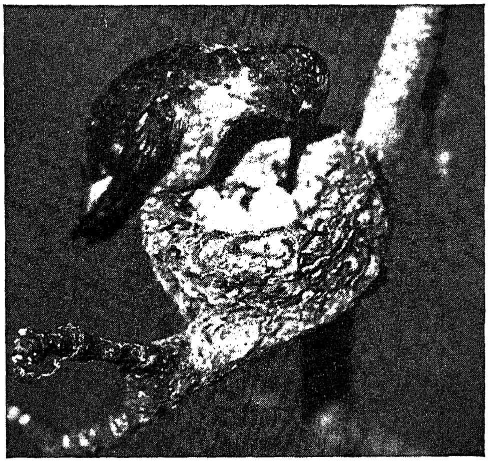
28. On what does the chimney swift feed and how does it procure this food? Describe how its beak is especially fitted for this.

29. How can you distinguish the chimney swift from the swallows? In what respect does the chimney swift resemble the swallows? In what respects does it differ from them?

THE HUMMINGBIRD

Formerly it was believed that this daintiest of birds found the nectar of flowers ample support for its active life; but the later methods of discovering what birds eat by examining the contents of their stomachs, show that the hummingbird is an insect eater of most ravenous appetite. Not only does it catch insects in mid air, but undoubtedly takes them while they are feasting on the nectar of the tubular flowers which the hummingbird loves to visit. Incidentally, the hummingbird carries some pollen for these flowers and may be counted as a friend in every respect, since usually the insects in the nectaries of those flowers with long tubular corollas are stealing nectar without giving in return any compensation to the flower by carrying its pollen. Such insects may be the smaller beetles, ants, and flies. The adaptations of the hummingbird's beak and long, double-tubed tongue, are especially for securing this mingled diet of insects and nectar. It is interesting to note that the young hummingbirds have the beak much shorter than the mature birds. The hummingbird's beak is exactly fitted to probe those flowers where the bird finds its food. The tongue has the outer edges curved over, making a tube on each side. These tubes are provided with minute brushes at the tips and thus are fitted both for sucking nectar and for sweeping up the insects.

The natural home of the hummingbird seems to have been in the American tropics. The male of our one species east of the Rocky Mountains has a ruby throat. This bird comes to us after a very long journey each year. One species on the Pa-

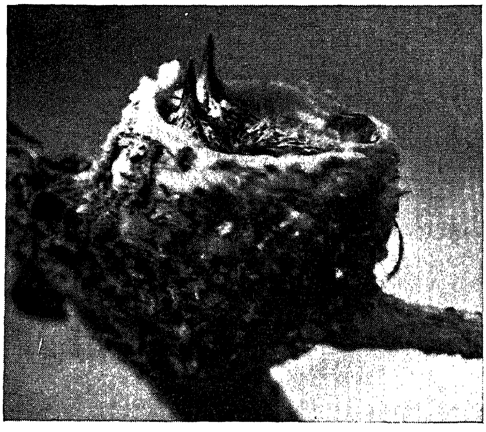


A. A. Allen

Ruby-throated hummingbird turning her eggs

cific Coast is known to travel three thousand miles to the north for the summer and back again in winter.

Hummingbirds are not supposed to sing, but to use their voices for squeaking when angry or frightened. However, I once had the privilege of listening to a true song by a hummingbird on the Pacific Coast. The midget was perched upon a twig and lifted up his voice with every appearance of ecstasy in pouring forth his lay. To my uncultured ear this song was a fine, shrill, erratic succession of squeaks, "as fine as a cambric needle," said my companion.



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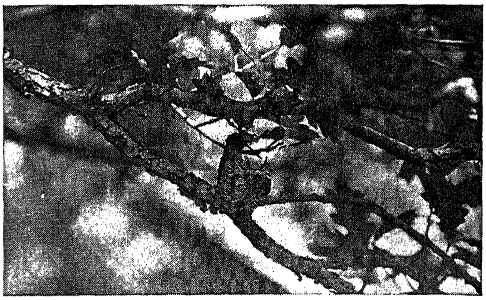
Two young hummingbirds. They remain in nest for about three weeks

The nest of the hummingbird is a most exquisite structure; it is about three-fourths of an inch in diameter on the inside and about half an inch deep. It is, in shape, a symmetrical cup; the outside is covered with lichens, so that it exactly resembles the branch on which it rests; the inside is lined with the down of plant seeds and plant fibers. The lichens are often fastened to the outside with the



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Not much larger than a walnut, the hummingbird's nest looks like a knot on a branch

silk web of spiders or caterpillars. The nest is usually saddled on a branch of a tree from ten to fifty feet above the ground. The eggs are two in number and white; they look like tiny beans. The young are black and look, at first glance, more like insects than like birds.

Suggested Reading — *American Bird Biographies*, by A. A. Allen; *Audubon Bird Leaflet* 56; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 5, *Science at Home*; also, readings on pages 28–29.

LESSON 29

The Hummingbird

Leading Thought — The hummingbird in flight moves its wings so rapidly that we cannot see them. It can hold itself poised above flowers while it thrusts its long beak into them for nectar and insects.

Method — Give the questions to the

pupils and let them make the observations when they have the opportunity.

Observations — 1. Where did you find the hummingbird? What flowers was it visiting? At what time of day? Can you tell whether it is a hummingbird or a hawkmoth which is visiting the flowers? At what time of day do the hawkmoths appear?

2. Did you ever see the hummingbird come to rest? Describe its actions while resting.

3. What are the colors of the back, throat, breast, and under parts? How do you distinguish the mother hummingbird from her mate?

4. How does the hummingbird act when extracting the nectar? How does it balance itself in front of a flower? Have you ever seen hummingbirds catch insects in the air? If so, describe how they did it.

5. Describe the hummingbird's nest. How large is it in diameter? What is the covering outside? With what is it lined?

THE RED-WINGED BLACKBIRD

The blackbirds are among our earliest visitors in the spring; they come in flocks and beset our leafless trees like punctuation marks, meanwhile squeaking like musical wheelbarrows. What they are, where they come from, where they are going and what they are going to do, are the questions that naturally arise at the sight of these sable flocks. It is not easy to distinguish grackles, cowbirds, and rusty blackbirds at a glance, but the redwing proclaims his identity from afar. The bright red epaulets, margined behind with pale yellow, make up a uniform which catches the admiring eye. The bird's glossy black plumage brings into greater contrast his bright decorations. No one who has seen his actions can doubt that he is fully aware of his beauty: he comes sailing down at the end of his strong, swift flight, and balances himself on some bending reed; then, dropping his long tail as if it were the crank of his music box, and holding both wings lifted to show his scarlet decorations, he sings his "quong-queree-ee." Little wonder that such a handsome, military-looking fellow should be able now and then to win more than his share of feminine admiration. But even though he become an entirely successful bigamist or even trigamist, he has proved himself to be a good protector of each and all of his wives and nestlings; however, he often has but one mate.

"The redwing flutes his O-ka-lee" is Emerson's graphic description of the sweet song of the redwing; he also has many other notes. He clucks to his mates and clucks more sharply when suspicious, and has one alarm note that is truly alarm-

Male and female red-winged blackbirds

ing. The male redwings come from the South in March; they appear in flocks, often three weeks before their mates arrive. The female looks as though she belonged to quite a different species. Al-

Nest and eggs of the red-winged blackbird

though her head and back are black, the black is decidedly rusty; it is quite impossible to describe her, she is so inconspicuously speckled with brown, black, whitish buff, and orange. Most of us never recognize her unless we see her with her spouse. She probably does most of the nest building, and her suit of salt, pepper, and mustard renders her invisible to the keen eyes of birds of prey. Only when she is flying does she show her blackbird characteristics — her tail being long and of obvious use as a steering organ; and she walks with long, stiff strides. The redwings are ever to be found in and about swamps and marshes. The nest is usually built in May; it is made of grasses and stalks of weeds and is lined with finer grass or reeds. It is bulky and is placed in low bushes or among the reeds. The eggs are pale blue, streaked and spotted with purple or black. The young resemble the mother in color, the males being obliged to wait a year for their epaulets. As to the food of the redwings here in the North, Mr. Forbush has said:

" Although the red-wings almost invariably breed in the swamp or marsh, they have a partiality for open fields and plowed lands; however, most of the blackbirds that nest in the smaller swamps adjacent to farm lands get a large share of their food from the farmer's fields. They forage about the fields and meadows when they first come north in the spring. Later, they follow the plow, picking up grubs, worms and caterpillars; and should there be an outbreak of canker-worms in the orchard, the blackbirds will fly at least half a mile to get canker-worms for their young. Wilson estimated that the red-wings of the United States would in four months destroy sixteen thousand two hundred

A. A. Allen

The mother arrives with food for her young

million larvæ. They eat the caterpillars of the gypsy moth, the forest tent-caterpillar, and other hairy larvæ. They are among the most destructive birds to weevils, click beetles, and wire-worms. Grasshoppers, ants, bugs, and flies form a portion of the red-wing's food. They eat comparatively little grain in Massachusetts although they get some from newly sown fields in spring, as well as from the autumn harvest; but they feed very largely on the seeds of weeds and wild rice in the fall. In the

South they join with the bobolink in devastating the rice fields, and in the West they are often so numerous as to destroy the grain in the fields; but here [in the North and East] the good they do far outweighs the injury, and for this reason they are protected by law."

SUGGESTED READING — *Audubon Bird Leaflet* 25; also, readings on pages 28–29.

LESSON 30

THE RED-WINGED BLACKBIRD

LEADING THOUGHT — The red-winged blackbird lives in the marshes where it builds its nest. However, it comes over to our plowed lands and pastures and helps the farmer by destroying many insects which injure the meadows, crops, and trees.

METHOD — The observations should be made by the pupils individually in the field. These birds may be looked for in flocks early in the spring, but the study should be made in May or June when they will be found in numbers in almost any swamp. The questions may be given to the pupils a few at a time or written in their field notebooks and the answers discussed when discovered.

OBSERVATIONS — 1. How can you distinguish the red-winged blackbird from all other blackbirds? Where is the red on his wings? Is there any other color besides black on the wings? Where? What is the color of the rest of the plumage of this bird?

2. What is there peculiar in the flight of the redwing? Is its tail long or short? How does it use its tail in flight? What is its position when the bird alights on a reed?

3. What is the song of the redwing? Describe the way he holds his wings and tail when singing, balanced on a reed or some other swamp grass. Does he show off his epaulets when singing? What note does he give when he is surprised or suspicious? When frightened?

4. When does the redwing first appear in the spring? Does he come alone or in flocks? Does his mate come with him? Where do the redwings winter? In what localities do the red-winged blackbirds live? Why do they live there? What is the color of the mother redwing? Would you know by her looks that she was a blackbird? What advantage is it to the pair that the female is so dull in color?

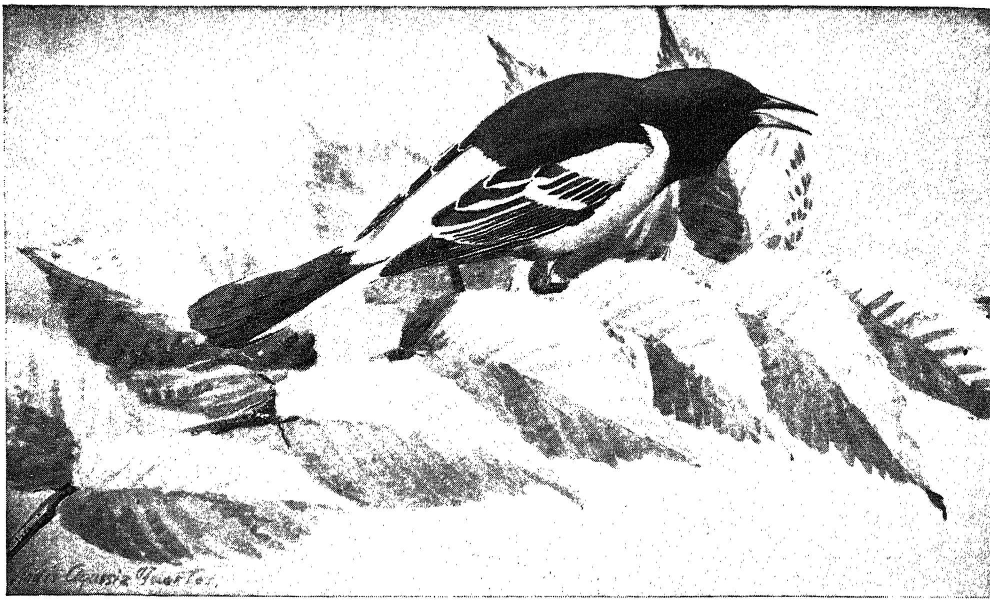
5. At what time do these birds nest? Where is the nest built? Of what material? How is it concealed? What is the color of the eggs?

6. Do the young birds resemble in color their father or their mother? Why is this an advantage?

7. Is the redwing ever seen in fields adjoining the marshes? What is he doing there? Does he walk or hop when looking for food? What is the food of the redwings? Do they ever damage grain? Do they not protect grain more than they damage it?

8. What great good do the redwings do for forest trees? For orchards?

9. At what time in the summer do the redwings disappear from the swamps? Where do they gather in flocks? Where is their special feeding ground on the way south for the winter?



L. A. Fuertes

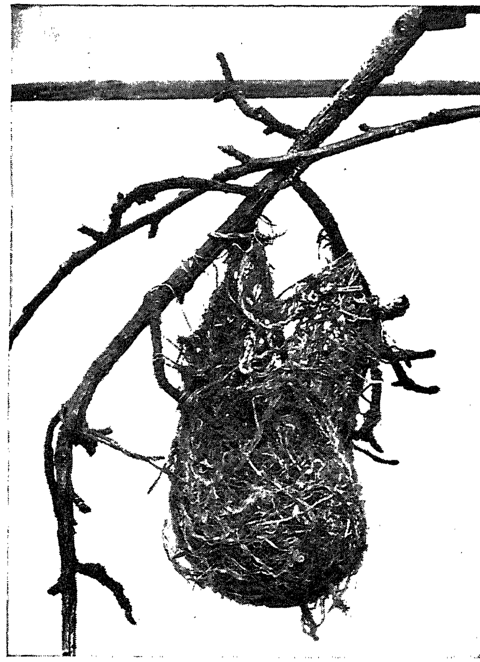
The Baltimore oriole

THE BALTIMORE ORIOLE

I know his name, I know his note,
That so with rapture takes my soul;
Like flame the gold beneath his throat,
His glossy cope is black as coal.
O Oriole, it is the song
You sang me from the cottonwood,
Too young to feel that I was young,
Too glad to guess if life were good.
— William Dean Howells

Dangling from the slender, drooping branches of the elm in winter, these pocket nests look like some strange persistent fruit; and, indeed, they are the fruit of much labor on the part of the oriole weavers, those skilled artisans of the bird world. Sometimes the oriole "For the summer voyage his hammock swings" in a sapling, placing it near the main stem and near the top; otherwise it is almost invariably hung at the end of branches and is rarely less than twenty feet from the ground. The nest is pocket-shaped, and usually about seven inches long, and four and a half inches wide at the largest part, which is the bottom. The top is attached to forked twigs at the Y so that the mouth or door will be kept open to allow the bird to pass in and out; when within, the weight of the bird causes the opening to contract somewhat and protects the inmate from prying eyes. Often the pocket hangs free so that the breezes may rock it, but in one case we found a nest with the bottom stayed to a twig by guy lines. The bottom is much more closely woven than the upper part for a very good reason, since the open meshes admit air to the sitting bird. The nest is lined with hair or other soft material, and although this is added last, the inside of the nest is woven first. The orioles like to build the framework of twine, and it is marvelous how they will loop this around a twig almost as evenly knotted as if crocheted; in and out of this net the mother bird with her long, sharp beak weaves bits of wood fiber, strong, fine grass, and scraps of weeds. The favorite lining is horsehair, which simply cushions the bottom of the pocket. Dr. Detwiler had a pet oriole which built her nest of his hair, which she pulled from his head; is it possible that orioles get their supply of horsehair in a similar way? If we put bright-colored twine or narrow ribbons in convenient places, the orioles will weave them into the nest, but the strings should not be long lest the birds become entangled. If the nest is strong the birds may use it a second year.

That Lord Baltimore found in new America a bird wearing his colors must have cheered him greatly; and it is well for us that this brilliant bird brings to our minds kindly thoughts of that tolerant, high-minded English nobleman. The oriole's head, neck, throat, and part of the back are black; the wings are black but the feathers are margined with white; the tail is black except that the ends of the outer feathers are yellow; all the rest of the bird is golden orange, a luminous color which makes him seem a splash of brilliant sunshine. The female, although marked much the same, has the back so dull and mottled that it looks olive-brown; the rump, breast, and under parts are yellow but by no means showy. The advantage of these quiet colors to the mother bird is obvious, since it is she that makes the nest and sits in it without attracting attention to its location. In fact, when she is sitting, her brilliant mate places himself far enough away to distract the attention of meddlers, yet near enough for her to see the flash of his breast in the sunshine and to hear his rich and cheering song. He is a good spouse and brings her the materials for the nest which she weaves in, hanging head downward from a twig and using her long sharp beak for a shuttle. And his glorious song is for her alone. Some hold that no two orioles have the



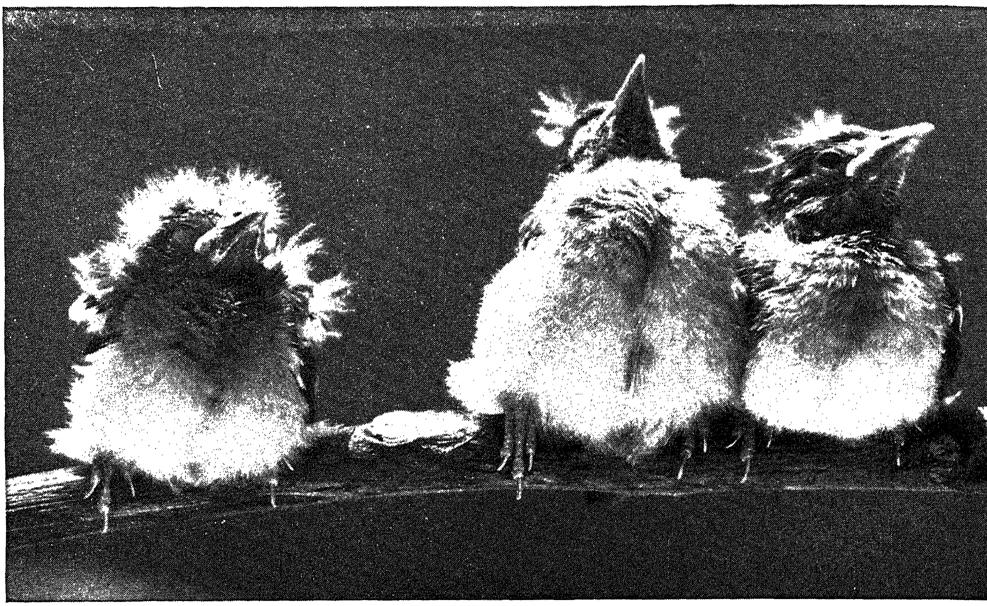
C. R. Crosby

An oriole's nest, anchored to the windward

same song, and I know of two individuals at least whose songs were sung by no other birds: one gave a phrase from the Waldvogel's song in *Siegfried;* the other whistled over and over, " Sweet birdie, hello, hello." The orioles can chatter and scold as well as sing.

The oriole is a brave defender of his nest and a most devoted father, working hard to feed his ever-hungry nestlings; we can hear these hollow mites peeping for more food, " Tee dee dee, tee dee dee," shrill and constant, if we stop for a moment under the nest in June. The young birds dress in the safe colors of the mother, the males not donning their bright plumage until the second year. A brilliant colored fledgling would not live long in a world where sharp eyes are in constant quest for little birds to fill empty stomachs.

The food of the oriole places it among our most beneficial birds, since it is always ready to cope with the hairy caterpillars avoided by most birds; it has learned to abstract the caterpillar from his spines and is thus able to swallow him minus his



Young orioles just out of the nest

" whiskers." The orioles are waging a great war against the terrible brown-tail and gypsy moths; they also eat click beetles and many other noxious insects. Once when we were breeding big caterpillars in the Cornell University Insectary, an oriole came in through the open windows of

Leonard K. Beyer

An orchard oriole

the greenhouse, and thinking he had found a bonanza proceeded to work it, carrying off our precious crawlers before we discovered what was happening.

The orioles winter in Central America and give us scarcely four months of their company. They do not usually appear before May and leave in early September.

Suggested Reading — *American Bird Biographies,* by A. A. Allen; *Audubon Bird Leaflet* 26; *Bird-House to Let,* by Mary F. Terrel; *Bird Stories from Burroughs,* by John Burroughs; *Nature and Science Readers,* by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; Pathways in Science,* by Gerald S. Craig and Co-authors, Book 3, *Our Wide, Wide World;* also, readings on pages 28–29.

LESSON 31

The Oriole

Leading Thought — The oriole is the most skillful of all our bird architects. It is also one of our prized song birds and is very beneficial to the farmer and the fruit grower because of the insect pests which it destroys.

Method — Begin during winter or early spring with a study of the nest, which may be obtained from the elms of the roadsides. During the first week in May, give the questions concerning the birds and their habits. Let the pupils keep the questions in their notebooks and answer them when they have opportunity. The observations should be summed up once a week.

Observations — 1. Where did you find the nest? On what species of tree? Was it near the trunk of the tree or the tip of the branch?

2. What is the shape of the nest? How long is it? How wide? Is the opening as large as the bottom of the nest? How is it hung to the twigs so that the opening remains open and does not pull together with the weight of the bird at the bottom? Is the bottom of the nest stayed to a twig or does it hang loose?

3. With what material and how is the nest fastened to the branches? Of what material is the outside made? How is it woven together? Is it more loosely woven at the top than at the bottom? How many kinds of material can you find in the outside of the nest?

4. With what is the nest lined? How far up is it lined? With what tool was the nest woven? If you put out bright-colored bits of ribbon and string do you think the orioles will use them? Why should you not put out long strings?

5. At what date did you first see the Baltimore oriole? Why is it called the Baltimore oriole? How many other names has it? Describe in the following way the colors of the male oriole: top of head, back, wings, tail, throat, breast, under parts. What are the colors of his mate? How would it endanger the nest and nestlings if the mother bird were as bright colored as the father bird?

6. Which weaves the nest, the father or the mother bird? Does the former assist in any way in nest building?

7. Where does the father bird stay and what does he do while the mother bird is sitting on the eggs?

8. What is the oriole's song? Has he more than one song? What other notes has he? After the young birds hatch, does the father bird help take care of them?

9. By the middle of June the young birds are usually hatched; if you know where an oriole nest is hung, listen and describe the call of the nestlings for food.

10. Which parent do the young birds resemble in their colors? Why is this a benefit?

11. What is the oriole's food? How is the oriole of benefit to us in ways in which other birds are not?

12. Do the orioles use the same nest two years in succession? How long does the oriole stay in the North? Where does it spend its winters?

Hush! 'tis he!
My oriole, my glance of summer fire,
Is come at last, and, ever on the watch,
Twitches the packthread I had lightly wound
About the bough to help his housekeeping, —
Twitches and scouts by turns, blessing his luck,
Yet fearing me who laid it in his way,
Nor, more than wiser we in our affairs,
Divines the Providence that hides and helps.
Heave, ho! Heave, ho! he whistles as the twine
Slackens its hold; once more, now! and a flash
Lightens across the sunlight to the elm
Where his mate dangles at her cup of felt.

— "Under the Willows," Lowell

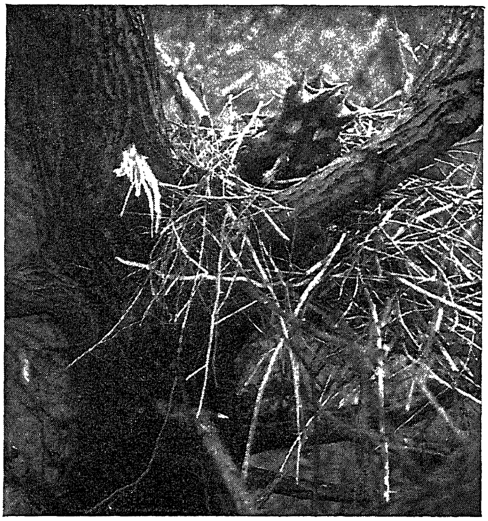
THE CROW

Thoreau says: " What a perfectly New England sound is this voice of the crow! If you stand still anywhere in the outskirts of the town and listen, this is perhaps the sound which you will be most sure to hear, rising above all sounds of human industry and leading your thoughts to some far-away bay in the woods. The bird sees the white man come and the Indian withdraw, but it withdraws not. Its untamed voice is still heard above the tinkling of the forge. It sees a race pass away, but it passes not away. It remains to remind us of aboriginal nature."

The crow is probably the most intelligent of all our native birds. It is quick to learn and clever in action, as many a farmer will testify who has tried to keep it out of corn fields with various devices, the harmless character of which the crow soon understood perfectly. Of all our birds, this one has the longest list of virtues and of sins, as judged from our standpoint; but we should listen to both sides of the case before we pass judgment. I find with crows, as with people, that I like some more than I do others. I do not like at all the cunning old crow which steals the suet I put on the trees in winter for the chickadees and nuthatches; and I have hired a boy with a shotgun to protect the eggs and nestlings of the robins and other birds in my neighborhood from the ravages of one or two cruel old crows that have developed the nest-hunting habit. On the other hand, I became a sincere admirer of a crow flock which worked in a field close to my country home, and I have been the chosen friend of several tame crows who were even more interesting than they were mischievous.

The crow is larger than any other of our common black birds; the northern raven is still larger, but is very rarely seen. Although the crow's feathers are black, yet in the sunlight a beautiful purple iridescence plays over the plumage, especially about the neck and back; it has a compact but not ungraceful body, and long, powerful wings; its tail is medium sized and is not notched at the end; its feet are long and strong; the track shows three toes directed forward and one long one directed backward. The crow does not sail through the air as does the hawk, but progresses with an almost constant flapping of the wings. Its beak is very strong and is used for tearing the flesh of its prey and for defense, and in fact for almost anything that a beak could be used for; its eye is all black and is very keen and intelligent. When hunting for food in the field, it usually walks, but sometimes hops. The raven and the fish crows are the nearest relatives of the American crow, and next to them the jays. We should hardly think that the blue jay and the crow were related to look at them, but when we come to study their habits, much is to be found in common.

The crow's nest is usually very large; it is made of sticks, of grape vines and bark, sod, horsehair, moss, and grasses. It is placed in trees or in tall bushes rarely less than twenty feet from the ground. The eggs are pale bluish green or nearly white with brownish markings. The young crows hatch in April or May. Both parents are devoted in the care of the young, and remain with them during most of the summer. I have often seen a mother crow feeding her young ones which were following her with obstreperous caws, although they were as large as she.



Young crows are a noisy lot

While the note of the crow is harsh when close at hand, it has a musical quality in the distance. Mr. Mathews says: "The crow when he sings is nothing short of a clown; he ruffles his feathers, stretches his neck, like a cat with a fish bone in her throat, and with a most tremendous effort delivers a series of hen-like squawks." But aside from his caw, the crow has some very seductive soft notes. I have held long conversations with two pet crows, talking with them in a high, soft tone, and finding that they answered readily in a like tone in a most responsive way. I have also heard these same tones among the wild crows when they were talking together; one note is a guttural tremolo, most grotesque.

Herbert E. Gray

A crow's nest and eggs

Crows gather in flocks for the winter; these flocks number from fifty to several hundred individuals, all having a common roosting place, usually in pine or hemlock forests or among other evergreens. They go out from these roosts during the day to get food, often making a journey of many miles. During the nesting season they scatter in pairs, and they do not gather again in flocks until the young are fully grown.

When crows are feeding in the fields there is usually, if not always, a sentinel posted on some high point so that he can give warning of danger. This sentinel is

Verne Morton

The story of a take-off. With the third wing beat the crow is away

an experienced bird and is keen to detect a dangerous from a harmless intruder. I once made many experiments with these sentinels; I finally became known to those of a particular flock and I was allowed to approach within a few yards of where the birds were feeding, a privilege not accorded to any other person in the neighborhood.

The crow is a general feeder and will eat almost any food; generally, however, it finds its food upon the ground. The food given to nestlings is very largely insects, and many pests are thus destroyed. The crows do harm to the farmer by pulling the sprouting corn and by destroying the eggs and young of poultry. They also do much harm by destroying the eggs and nestlings of other birds which are beneficial to the farmer; they also do some harm by distributing the seeds of poison ivy and other noxious plants. All these must be set down in the account against the crow, but on the credit side must be placed the fact that it does a tremendous amount of good work for the farmer by eating injurious insects, especially the grubs and cutworms which work in the ground, destroying the roots of grasses and grains. It also kills many mice and other rodents which are destructive to crops.

One of the best methods of preventing crows from taking sprouting corn is to treat the seed corn with some strong-smelling substance, such as tar.

If any of the pupils in your school have had any experience with tame crows they will relate interesting examples of the love of the crow for glittering objects. I once knew a tame crow which stole all of the thimbles in the house and buried them in the garden; he would watch for a thimble to be laid aside when the sewing was dropped, and would seize it almost immediately. This same crow persisted in taking the clothespins off the line and burying them, so that he was finally imprisoned on wash-days. He was fond of playing marbles with a little boy of the family. The boy would shoot a marble into a hole and then Billy, the crow, would take a marble in his beak and drop it into the hole. The bird seemed to understand the game and was highly indignant if the boy played out of turn and made shots twice in succession.

Suggested Reading — *Audubon Bird Leaflet* 77; *Bird Stories*, by Edith M. Patch; *Bird Stories from Burroughs*, by John Burroughs; *The Crow in its Relation to Agriculture*, by E. R. Kalmbach (U. S. Department of Agriculture, Farmers' Bulletin 1102); *Our Backdoor Neighbors*, by Frank C. Pellett; *The Pet Book*, by Anna B. Comstock; *The Stir of Nature*, by William H. Carr (Cleo and Mark); *Wild Animals I Have Known*, by Ernest Thompson Seton; also, readings on pages 28–29.

LESSON 32

The Crow

Leading Thought — The crow has the keenest intelligence of all our common birds. It does good work for us and also does damage. We should study its ways before we pronounce judgment, for in some localities it may be a true friend and in others an enemy.

Method — This work should begin in winter with an effort on the part of the boys to discover the food of the crows while snow is on the ground. This is a good time to study their habits and their roosts. The nests are also often seen in winter, although usually built in evergreens. The nesting season is in early April, and the questions about the nests should be given then. Let the other questions be given when convenient. The flight, the notes, the sentinels, the food, the benefit and damage may all be taken as separate topics.

The following topics may be given to correlate with work in English: "What a pet crow of my acquaintance did"; "Evidences of crow intelligence"; "A plea a crow might make in self-defense to the farmer who wished to shoot him"; "The best methods of preventing crows from stealing planted corn."

Observations — 1. How large is the crow compared with other black birds?

2. Describe its colors when seen in the sunlight.

3. Describe the general shape of the crow.

4. Are its wings long and slender or short and stout?

5. Is the tail long or short? Is it notched or straight across the end?

6. Describe the crow's feet. Are they large and strong or slender? How many toes does the track show in the snow or mud? How many are directed forward and how many backward?

7. Describe a crow's flight compared with that of the hawk.

8. Describe its beak and what it is used for.

9. What is the color of the crow's eye?

10. When hunting for food does the crow hop or walk?

11. Which are the crow's nearest relatives?

12. Where and of what material do the crows build their nests?

13. Describe the eggs. At what time of the year do the young crows hatch? Do both parents take care of and feed the young? How long do the parents care for the young after they leave the nest?

14. What are the notes of the crow? If you have heard one give any note besides "caw," describe it.

15. Where and how do crows live in winter? Where do they live in summer?

16. Do they post sentinels if they are feeding in the fields? If so, describe the action of the sentinel on the approach of people.

17. Upon what do the crows feed? What is fed to the nestlings?

18. How do the crows work injury to the farmer? How do they benefit the farmer? Do you think they do more benefit than harm to the farmer and fruit-grower?

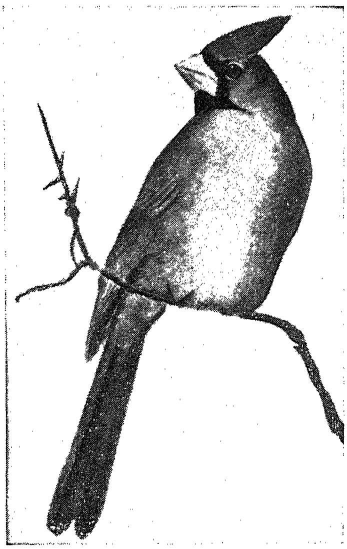
19. Have you known of instances of the crow's fondness for shining or glittering articles, like pieces of crockery or tin?

THE CARDINAL GROSBEAK

There never lived a Lord Cardinal who possessed robes of state more brilliant in color than the plumage of this bird. By the way, I wonder how many of us ever think when we see the peculiar red called cardinal, that it gained its name from the dress of this high functionary of the church? The cardinal grosbeak is the best name for the redbird because that describes it exactly, both as to its color and its chief characteristic, since its beak is thick and large; the beak is also red, which is a rare color in beaks, and in order to make its redness more emphatic it is set in a frame of black feathers. The use of such a large beak is unmistakable, for it is strong enough to crush the hardest of seed shells or to crack the hardest and driest of grains.

What cheer! What cheer!
That is the grosbeak's way,
With his sooty face and his coat of red

sings Maurice Thompson. Besides the name given above, this bird has been



After Audubon Leaflet 18

The cardinal grosbeak

called in different localities the redbird, Virginia redbird, crested redbird, winter redbird, Virginia nightingale, the red corn-cracker; but it remained for James Lane Allen to give it another name in his masterpiece, *The Kentucky Cardinal*.

The cardinal is a trifle smaller than the robin and is by no means slim and graceful, like the catbird or the scarlet tanager, but is quite stout and is a veritable chunk of brilliant color and bird dignity. The only bird that rivals him in redness is the scarlet tanager, which has black wings; the summer tanager is also a red bird, but is not so vermilion and is more slender and lacks the crest. The cardinal surely finds his crest useful in expressing his emotions; when all is serene, it lies back flat on the head, but with any excitement, whether of joy or surprise or anger, it lifts until it is as peaked as an old-fashioned nightcap. The cardinal's mate is of quiet color; her back is greenish gray and her breast buffy, while her crest, wings, and tail reflect in faint ways the brilliancy of his costume.

The redbird's song is a stirring succession of syllables uttered in a rich, ringing tone, and may be translated in a variety of ways. I have heard him sing a thousand times " tor-re'-do, tor-re'-do, tor-re'-do," but Dr. Dawson has heard him sing " che'-pew, che'-pew, we'-woo, we'-woo "; " bird-ie, bird-ie, bird-ie; tschew, tschew, tschew "; and " chit-e-kew, chit-e-kew; he-weet, he-weet." His mate breaks the custom of other birds of her sex and sings a sweet song, somewhat softer than his. Both birds utter a sharp note " tsip, tsip."

The nest is built in bushes, vines, or low trees, often in holly, laurel, or other low evergreens, and is rarely more than six or eight feet above the ground. It is made of twigs, weed stems, tendrils, the bark of the grapevine, and coarse grass; it is lined with fine grass and rootlets; it is rather loosely constructed but firm and is well hidden, for it causes these birds great anguish to have their nest discovered. Three or four eggs are laid, which are bluish white or grayish, dully marked with brown. The father cardinal is an exemplary husband and father; he cares for and feeds his mate tenderly and sings to her gloriously while she is sitting; and he works hard catching insects for the nestlings. He is also a brave defender of his nest and will attack any intruder, however large, with undaunted courage. The fledglings have the dull color of the mother and have dark-colored bills. Until the young birds are able to take care of themselves, their dull color somewhat protects them from the keen eyes of their enemies. If the male fledglings were the color of their father, probably not one would escape a tragic death. While the mother bird is hatching the second

Leonard K. Beyer

The cardinal builds its nest in thick bushes or vines brood, the father keeps the first brood with him and cares for them; often the whole family remains together during the winter, making a small flock. However, the flocking habit is not characteristic of these birds, and we only see them in considerable numbers when the exigencies of seeking food in the winter naturally bring them together.

The cardinals are fond of the shrubbery and thickets of river bottoms near grain fields, or where there is plenty of wild grass, and they only visit our premises when driven to us by winter hunger. Their food consists of the seeds of rank weeds, corn, wheat, rye, oats, beetles, grasshoppers, flies, and to some extent, wild and garden berries; but they never occur in sufficient numbers to be a menace to our crops. The cardinals may often be seen in the cornfields after the harvest, and will husk an overlooked ear of corn and crack the kernels with their beaks in a most dexterous manner. During the winter we may coax them to our grounds by scattering corn in some place not frequented by cats; thus, we may induce them to nest near us, since the cardinal is not naturally a migrant but likes to stay in one locality summer and winter. It has been known to come as far north as Boston and southern New York, but it is found in greatest numbers in our Southern states.

Suggested Reading — *Audubon Bird Leaflet* 18; also, readings on pages 28–29.

LESSON 33

The Cardinal Grosbeak

Leading Thought — The cardinal is the most brilliantly colored of all our birds, and one of our most cheerful singers. We should seek to preserve it as a beautiful ornament to our groves and grounds.

Method — This work must be done by personal observation in the field. The field notes should be discussed in school.

Observations — 1. Do you know the cardinal? Why is it so called?

2. How many names do you know for this bird?

Leonard K. Beyer

The cardinal sings a beautiful song

3. Is the cardinal as large as the robin? Is it graceful in shape?

4. Is there any color except red upon it? If so, where?

5. What other vividly red birds have we and how can we distinguish them from the cardinal?

6. Describe the cardinal's crest and how it looks when lifted. Why do you think it lifts it?

7. Describe its beak as to color, shape, and size. What work is such a heavy beak made for?

8. Is the cardinal's mate the same color as he? Describe the color of her head, back, wings, tail, breast.

9. Can you imitate the cardinal's song? What words do you think he seems to sing? Does his mate sing also? Is it usual for mother birds to sing? What other notes besides songs do you hear him utter?

10. Where does the cardinal usually build its nest? How high from the ground? Of what materials? Is it compact or bulky? How many eggs are there and what are their colors?

11. How does the father bird act while his mate is brooding? How does he help take care of the young in the nest?

12. How do the fledglings differ in color from their father? From their mother? Of what use to the young birds is their sober color?

13. What happens to the fledglings of the first brood while the mother is hatching the eggs of the second brood?

14. In what localities do you most often see the cardinals? Do you ever see them in flocks?

15. What is the food of the cardinals? What do they feed their nestlings?

16. How can you induce the cardinals to build near your home?

17. What do you know about the laws protecting birds? Why should such laws be observed?

Along the dust-white river road,
The saucy redbird chirps and trills;
His liquid notes resound and rise
Until they meet the cloudless skies,
And echo o'er the distant hills.

— Naylor

GEESE

To be called a goose should be considered most complimentary, for of all the birds the goose is probably the most intelligent. An observant lady who keeps geese on her farm assures me that no animal, not even dog or horse, has the intelligence of the goose. She says that these birds learn a lesson after a few repetitions, and surely her geese were patterns of obedience. While I was watching them one morning, they started for the brook via the cornfield; she called to them sharply, " No, no, you mustn't go that way! " They stopped and conferred; she spoke again and they waited, looking at her as if to make up their minds to this exercise of self-sacrifice; but when she spoke the third time they left the cornfield and took the other path to the brook. She could bring her geese into their house at any time of day by calling to them, " Home, home! " As soon as they heard these words, they would start and not stop until the last one was housed.

Canada geese in a field of grain

In ancient Greece maidens made pets of geese; and often there was such a devotion between the bird and the girl that when the latter died her statue with that of the goose was carved on her burial tablet. The loyalty of a pet goose came under the observation of Miss Ada Georgia. A lone gander was the special pet of a small boy in Elmira, New York, who took sole care of him. The bird obeyed commands like a dog but would never let his little master out of his sight if he could avoid it; occasionally he would appear in the school yard, where the pupils would tease him by pretending to attack his master at the risk of being so severely whipped with the bird's wings that it was a test of bravery among the boys so to challenge him. His fidelity to his master was extreme; once when the boy was ill in bed, the bird wandered about the yard honking disconsolately and refused to eat; he was driven to the side of the house where his master could look from the window and he immediately cheered up, took his food, and refused to leave his post beneath the window while the illness lasted.

The goose is a stately bird whether on land or water; its long legs give it good proportions when walking, and the neck, being so much longer than that of the duck, gives an appearance of grace and dignity. The duck on the other hand is beautiful only when on the water or on the wing; its short legs, placed far back and far out at the sides, make it a most ungraceful walker. The beak of the goose is harder in texture and is not flat like the duck's; no wonder the bird was a favorite with the ancient Greeks, for the high ridge from the beak to the forehead resembles the famous Grecian nose. The plumage of geese is very beautiful and abundant and for this reason they are profitable domestic birds. They are picked late in summer when the feathers are nearly ready to be molted; at this time the geese flap their wings often and set showers of loose feathers flying. A stocking or a bag is slipped over the bird's head and she is turned breast side up with her head firmly between the knees or under the arm of the picker. The tips of the feathers are seized with the fingers and come out easily; only the breast, the under parts, and the feathers beneath the wings are plucked. Geese do not seem to suffer while being plucked except through the temporary inconvenience and ignominy of having their heads thrust into a bag; their dignity is hurt more than their bodies.

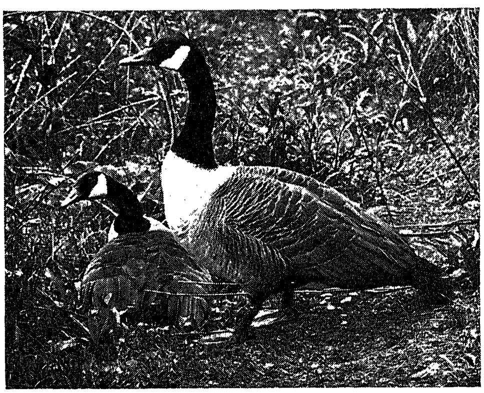
The wings of geese are very large and beautiful; although our domestic geese have lost their powers of flight to a great extent, yet they often stretch their wings and take little flying hops, teetering along as if they can scarcely keep on earth; this must surely be reminiscent of the old instinct for traveling in the skies. The tail of the goose is a half circle and is spread when flying; although it is short, it seems to be sufficiently long to act as a rudder. The legs of the goose are much longer than those of the duck; they are not set so far back toward the rear of the body, and therefore the goose is the much better runner of the two. The track made by the goose's foot is a triangle with two scallops on one side made by the webs between the three front toes; the hind toe is placed high up; the foot and the unfeathered portion of the leg, protected by scales, are used as oars when the bird is swimming. When she swims forward rapidly, her feet extend out behind her and act on the principle of a propeller; but when swimming around in the pond she uses them at almost right angles to the body. Although they are such excellent oars they are also efficient on land; when running, her body may waddle somewhat, but her head and neck are held aloft in stately dignity.

The Toulouse are our common gray geese; the Embdens are pure white with orange bill and bright blue eyes. The African geese have a black head with a large black knob on the base of the black bill; the neck is long, snakelike, light gray, with a dark stripe down the back; the wings and tail are dark gray; there is a dewlap at the throat. The brown Chinese geese have also a black beak and a black knob at the base of the bill. The neck is light brown with a dull yellowish stripe down the neck. The back is dark brown; breast, wings, and tail are grayish brown. The white Chinese are shaped like the brown Chinese, but the knob and bill are orange and the eyes light blue.

The Habits of Geese

Geese are monogamous and are loyal to their mates. Old-fashioned people declare that they choose their mates on Saint Valentine's Day, but this is a pretty myth; when once mated, the pair live together year after year until one dies; an interesting instance of this is one of the traditions in my own family. A fine pair of geese belonging to my pioneer grandfather had been mated for several years and had reared handsome families; but one spring a conceited young gander fell in love with the old goose, and as he was young and lusty, he whipped her legitimate lord and master and triumphantly carried her away, although she was manifestly disgusted with this change in her domestic fortunes. The old gander sulked and refused to be comforted by the blandishments of any young goose whatever. Later the old pair disappeared from the farmyard and the upstart gander was left wifeless. It was inferred that the old couple had run away with each other into the encompassing wilderness and much sympathy was felt for them because of this sacrifice of their lives for loyalty. However, this was misplaced sentiment, for later in the summer the happy pair was discovered in a distant "slashing" with a fine family of goslings, and all were brought home in triumph. The old gander, while not able to cope with his rival, was still able to trounce any of the animal marauders which approached his home and family.

The goose lines her nest with down and the soft feathers which she plucks from her breast. The gander is very devoted to his goose while she is sitting; he talks to her in gentle tones and is fierce in her defense. The eggs are about twice as large as those of the hen and have the ends more



A. A. Allen

A pair of Canada geese. While one broods the eggs the other stands guard

rounded. The period of incubation is four weeks. The goslings are beautiful little creatures, covered with soft down, and have large, bright eyes. The parents give them most careful attention from the first. One family which I studied consisted of the parents and eighteen goslings. The mother was a splendid African bird; she walked with dignified step, her graceful neck assuming serpentine curves; and she always carried her beak "lifted," which gave her an appearance of majestic haughtiness. The father was just a plebeian white gander, probably of Embden descent, but he was a most efficient protector. The family always formed a procession in going to the creek, the majestic mother at the head, the goslings following her and the gander bringing up the rear to be sure there were no stragglers; if a gosling strayed away or fell behind, the male went after it, pushing it back into the family circle. When entering the coop at night he pushed the little ones in gently with his bill; when the goslings took their first swim, both parents gently pushed them into the water, "rooted them in," as the farmer said. Any attempt to take liberties with the brood was met with bristling anger and defiance on the part of the gander; the mistress of the farm told me that he had whipped her black and blue when she tried to interfere with the goslings.

The gander and goose always show suspicion and resentment by opening the mouth wide and making a hissing noise, showing the whole round tongue in mocking defiance. When the gander attacks, he thrusts his head forward, even with or below the level of his back, seizes his victim firmly with his hard, toothed bill so that it cannot get away, and then with his strong wings beats the life out of it. I remember vividly a whipping which a gander gave me when I was a child, holding me fast by the blouse while he laid on the blows.

Geese feed much more largely upon land vegetation than do ducks; a good growth of clover and grass makes excellent pasture for them; in the water, they feed upon water plants but do not eat insects and animals to any extent.

Undoubtedly goose language is varied and expresses many things. Geese talk to each other and call from afar; they shriek in warning and in general make such a turmoil that people do not enjoy it. The goslings, even when almost grown, keep up a constant "pee wee, pee wee," which is nerve-racking. There is a good opportunity for some interesting investigations in studying out just what the different notes of the geese mean.

The goose is very particular about her toilet; she cleans her breast and back and beneath her wings with her bill; and she cleans her bill with her foot; she also cleans the top of her head with her foot and the under side of her wing with the foot of that side. When oiling her feathers, she starts the oil gland flowing with her beak, then rubs her head over the gland until it is well oiled; she then uses her head as a "dauber" to apply the oil to the feathers of her back and breast. When thus polishing her feathers, she twists the head over and over and back and forth to add to its efficiency.

The Jack Miner Migratory Bird Foundation, Inc.

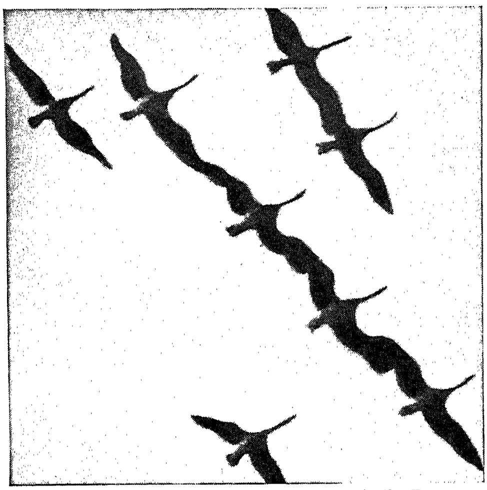
One corner of Jack Miner's Bird Sanctuary, Kingsville, Ontario, Canada, where Canada geese find food, shelter, and protection

WILD GEESE

There is a sound, that, to the weatherwise farmer, means cold and snow, even though it is heard through the hazy atmosphere of an Indian summer day; and that is the honking of wild geese as they pass on their southward journey. And there is not a more interesting sight anywhere in the autumn landscape than the wedge-shaped flock of these long-necked birds with their leader at the front apex. "The wild goose trails his harrow," sings the poet; but only the aged can remember the old-fashioned harrow which makes this simile graphic. The honking which reveals to us the passing flock, before our eyes can discern the birds against the sky, is the call of the wise old gander who is the leader, to those following him, and their return salute. He knows the way on this long thousand-mile journey, and knows it by instinct and in part by the topography of the country. If ever fog or storm hides the earth from his view, he is likely to become confused, to the dismay of his flock, which follows him to the earth with many lonely and distressful cries.

The northern migration takes place in April and May, and the southern from October to December. The journey is made with stops for rest and refreshment at certain selected places, usually some secluded pond or lake. The food of wild geese consists of water plants, seeds and corn, and some of the smaller animals living in water. Although the geese come to rest on the water, they go to the shore to feed. In California, the wild geese are dreaded visitors of the cornfields, and men with guns are employed regularly to keep them off.

The nests are made of sticks lined with down, usually along the shores of streams, sometimes on tree stumps and sometimes in deserted nests of the osprey. There are



A. R. Dugmore

Wild geese flying in even ranks

only four or five eggs laid and both parents are devoted to the young, the gander bravely defending his nest and family from the attacks of any enemies.

Although there are several species of wild geese on the Atlantic Coast, the one called by this name is usually the Canada goose. This bird is a superb creature, brown above and gray beneath, with head, neck, tail, bill, and feet of black. These black trimmings are highly ornamental and, as if to emphasize them, there is a white crescent-shaped " bib " extending from just back of the eyes underneath the head. This white patch is very striking, and gives one the impression of a bandage for sore throat. It is regarded as a call-color, and is supposed to help keep the flock together; the side tail-coverts are also white and may serve as another guide to follow.

Often some wounded or wearied bird of the migrating flock spends the winter in farmyards with domestic geese. One morning a neighbor of mine found that during the night a wild gander, injured in some way, had joined his flock. The stranger was treated with much courtesy by its new companions as well as by the farmer's family and soon seemed perfectly at home. The next spring he mated with one of the domestic geese. In the late summer, my neighbor, mindful of wild geese habits, clipped the wings of the gander so that he would be unable to join any passing flock of his wild relatives. As the migrating season approached, the gander became very uneasy; not only was he uneasy and unhappy always but he insisted that his wife share his misery of unrest. He spent days in earnest remonstrance with her and, lifting himself by his cropped wings to the top of the barnyard fence, he insisted that she keep him company on this, for webbed feet, uneasy resting place. Finally, after many days of tribulation, the two valiantly started south on foot. News was received of their progress for some distance and then they were lost to us. During the winter our neighbor visited a friend living eighteen miles to the southward and found in his barnyard the errant pair. They had become tired of migrating by tramping and had joined the farmer's flock; but we were never able to determine the length of time required for this journey.

Suggested Reading — *Audubon Bird Leaflet* 106; *Birds in the Wilderness*, by George M. Sutton; *Farm Animals*, by James G. Lawson; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*, Book 3, *Surprises*; *The Pet Book*, by Anna B. Comstock; also, readings on pages 28–29.

LESSON 34

Geese

Leading Thought — Geese are the most intelligent of the domesticated birds, and they have many interesting habits.

Method — This lesson should not be

given unless there are geese where the pupils may observe them. The questions should be given a few at a time and answered individually by the pupils after the observations are made.

OBSERVATIONS — 1. What is the chief difference between the appearance of a goose and a duck? How does the beak of the goose differ from that of the duck in shape and in texture? Describe the nostrils and their situation.

2. What is the difference in shape between the neck of the goose and that of the duck?

3. What can you say about the plumage of geese? How are geese "picked"? At what time of year? From what parts of the body are the feathers plucked?

4. Are the wings of the goose large compared with the body? How do geese exercise their wings? Describe the tail of the goose and how it is used.

5. How do the legs and feet of the goose differ from those of the duck? Describe the goose's foot. How many toes are webbed? Where is the other toe? What is the shape of the track made by the goose's foot? Which portions of the legs are used for oars? When the goose is swimming forward where are her feet? When turning around how does she use them? Does the goose waddle when walking or running as a duck does? Why? Does a goose toe in when walking? Why?

6. Describe the shape and color of the following breeds of domestic geese: The Toulouse, the Embden, the African, and the Chinese.

HABITS OF GEESE

1. What is the chief food of geese? What do they find in the water to eat? How does their food differ from that of ducks?

2. How do geese differ from hens in the matter of mating and nesting? At what time of year do geese mate? Does a pair usually remain mated for life?

3. Describe the nest and compare the eggs with those of hens. Describe the young goslings in general appearance. With what are they covered? What care do the parents give to their goslings? Describe how the parents take their family afield. How do they induce their goslings to go into the water for the first time? How do they protect them from enemies?

4. How does the gander or goose fight? What are the chief weapons? How is the head held when the attack is made?

5. How does the goose clean her feathers, wings, and feet? How does she oil her feathers? Where does she get the oil and with what does she apply it?

6. How much of goose language do you understand? What is the note of alarm? How are defiance and distrust expressed? How does a goose look when hissing? What is the constant note which the gosling makes?

7. Give such instances as you may know illustrating the intelligence of geese, their loyalty and bravery.

8. "The Canada Goose, its appearance, nesting habits, and migrations," would be an interesting topic for discussion.

1. Ring-necked Pheasants. *These birds, native to China, have been introduced into many other parts of the world. They were first brought to the United States in* 1881 *and since then have become common in many of the states. The cock is handsome and brightly colored, the hen an inconspicuous brown. These pheasants are found in fields and in hedgerows or brush-covered areas rather than in forested sections. They feed chiefly on the ground, eating weed seeds, insects, ungarnered grain, and wild or waste fruit. In winter, whenever the ground is covered with crusted snow or ice, it is hard for them to get food and many of them starve unless man feeds them. Another difficulty of theirs in winter is that their long tail feathers get loaded with snow and ice, which keeps them from going about after food and even from seeking shelter.* (*Photo by courtesy of* Country Life in America)

2. Wild Turkey. *This game bird was once common from New England southward and west to the Rocky Mountains. It has been exterminated in the North, but it is still found locally in the South and West. Because the wild turkey thrives upon a variety of foods and because it can adapt itself to varied conditions of climate, it is again being introduced in many sections of the country.* (*Photo by L. W. Brownell*)

3. Nest of the Ruffed Grouse. *The ruffed grouse, a much prized game bird, is native to the eastern and central United States. It is a very hardy bird, being able to withstand extreme cold, and to live on the buds and twigs of trees when insects, berries, and seeds are not available. In winter ruffed grouse take shelter at night in a "pocket" of snow or beneath brush; in summer they usually roost in trees. In appearance this bird is not unlike the dusky grouse (No.* 5). (*Photo by Marjorie Ruth Ross*)

4. Eastern Bobwhite *or* Quail. *Found in the eastern United States, except peninsular Florida, and as far west as Colorado, except New Mexico and southern Texas, bobwhite or quail are permanent residents. They like open fields with brushy fence-corners or low bushes near at hand for protection from storm and enemies. The pretty song is often translated* bob-white *or* buck-wheat. *The nest is made upon the ground under a bunch of grass or some bush, and in it are laid ten to eighteen white eggs. The family or covey will remain together until spring, and at night will squat close together in a circle with tails together and heads out ready to scatter in all directions at the slightest indication of danger. In winter when quail are in this formation, they may be covered with snow; and if a crust of sleet or ice which they are unable to break should form, the entire covey may smother or starve.* (*Photo by L. W. Brownell*)

5. Dusky Grouse. *A relative of the ruffed grouse, this species is found in the Rocky Mountain regions of the United States and Canada.* (*Photo by L. W. Brownell*)

6. A Woodcock on Its Nest. *Except in the Far West the woodcock is found widespread over the United States. It winters in the South. It lives largely on earthworms and grubs for which it probes moist soft earth with a long, sensitive bill. The courtship song-flights of the male are unique: with a call to his mate he rises into the air; by a series of loops he flies higher and higher until from a height of about two hundred feet he drops suddenly to a place on the ground very near where he started. The young quickly learn to fly, but until they do they are frequently carried from place to place by their mother who holds them between her legs with her feet.* (*Photo by Olin Sewall Pettingill, Jr.*)

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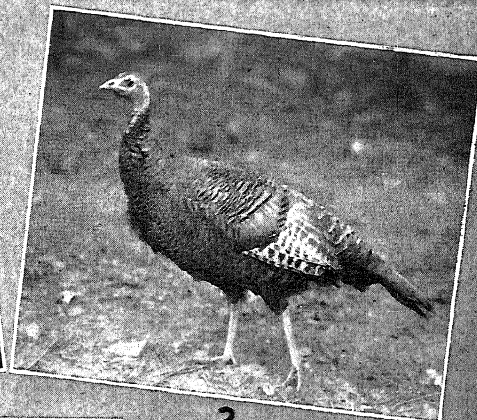

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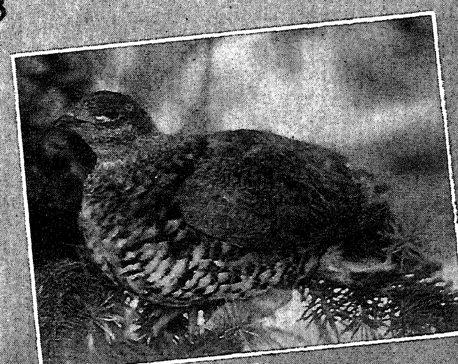

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The beginning of the strut. These gobblers are strutting before the camera, hidden by brush, in an endeavor to attract the hen turkey whose mating call the camera man is imitating

THE TURKEY

That the turkey and not the eagle should have been chosen for our national bird, was the conviction of Benjamin Franklin. It is a native of our country, it is beautiful as to plumage, and like the American Indian, it has never yielded entirely to the influences of civilization. Through the hundreds of years of domestication it still retains many of its wild habits. In fact, it has many qualities in common with the red man. Take for instance its sun dance, which anyone who is willing to get up early enough in the morning and who has a flock of turkeys at hand can witness. Miss Ada Georgia made a pilgrimage to witness this dance and describes it thus: "While the dawn was still faint and gray, the long row of birds on the ridge-pole stood up, stretched legs and wings and flew down into the orchard beside the barnyard and began a curious, high-stepping, 'flip-flop' dance on the frosty grass. It consisted of little, awkward, up-and-down jumps, varied by forward springs of about a foot, with lifted wings. Both hens and males danced, the latter alternately strutting and hopping and all 'singing,' the hens calling a 'Quit, quit,' the males accompanying with a high-keyed rattle, sounding like a hard wood stick drawn rapidly along a picket fence. As the sun came up and the sky brightened, the exhibition ended suddenly when 'The Captain,' a great thirty pound gobbler and leader of the flock, made a rush at one of his younger brethren who had dared to be spreading a tail too near to his majesty."

The bronze breed resembles most closely our native wild turkey and is therefore chosen for this lesson. The colors and markings of the plumage form the bronze turkey's chief beauty. Reaching from the skin of the neck halfway to the middle of the back is a collar of glittering bronze with greenish and purple iridescence, each feather tipped with a narrow jet band. The remainder of the back is black except that each feather is edged with bronze. The breast is like the collar and at its center is a tassel of black bristles called the beard which hangs limply downward when the birds are feeding; but when the gobbler stiffens his muscles to strut, this beard is thrust proudly forth. Occasionally the hen turkeys have a beard. The long quills, or primaries, of the wings are barred across with bands of black and white; the secondaries are very dark, luminous brown, with narrower bars of white. Each feather of the fan-shaped tail is banded with black and brown and ends with a black bar tipped with white; the tail-coverts are lighter brown but also have the black margin edged with white. The colors of the hen are like those of the gobbler except that the bronze brilliance of breast, neck, and wings is dimmed by the faint line of white which tips each feather.

The heads of all are covered with a warty wrinkled skin, bluish white on the crown, grayish blue about the eyes, and the other parts are red. Beneath the throat is a hanging fold called the wattle, and above the beak a fleshy pointed knob called the caruncle, which on the gobbler is prolonged so that it hangs over and below the beak. When the bird is angry these carunculated parts swell and grow more vivid in color, seeming to be gorged with blood. The color of the skin about the head is more extensive and brilliant in the gobblers than in the hens. The beak is slightly curved, short, stout, and sharp-pointed, yellowish at the tip and dark at the base.

The eyes are bright, dark hazel with a thin red line of iris. Just back of the eye is the opening of the ear, seemingly a mere hole, yet leading to a very efficient ear, upon which every smallest sound impinges.

The legs of the young turkeys are nearly black, fading to a brownish gray when mature. The legs and feet are large and stout, the middle toe of the three front ones being nearly twice the length of the one on either side; the hind toe is the shortest of the four. On the inner side of the gobbler's legs, about one-third the bare space above the foot, is a wicked-looking spur which is a most effective weapon. The wings are large and powerful; the turkey flies well for such a large bird and usually roosts high, choosing trees or the ridge-pole of the barn for this purpose.

In many ways the turkeys are not more than half domesticated. They insistently prefer to spend their nights out of doors instead of under a roof. They are also great wanderers and thrive best when allowed to forage in the fields and woods for a part of their food.

The gobbler is the most vainglorious bird known to us; when he struts to show his flock of admiring hens how beautiful he is, he lowers his wings and spreads the stiff primary quills until their tips scrape the ground, lifting meanwhile into a semicircular fan his beautiful tail feathers; he protrudes his chest, and raises the iridescent plumage of his neck like a ruff to make a background against which he throws back his red, white, and blue decorated head. He moves forward with slow and mincing steps and calls attention to his grandeur by a series of most aggressive "gobbles." But we must say for the gobbler that although he is vain he is also a brave fighter. When beginning a fight he advances with wings lowered and sidewise as if guarding his body with the spread wing. The neck and the sharp beak are outstretched and he makes the attack so suddenly that it is impossible to see whether he strikes with both wing and beak or only with the latter, as with fury he pounces upon his adversary apparently striving to rip his neck open with his spurs.

Turkey hens usually begin to lay in April in this latitude (southern New York) and much earlier in more southern states. At nesting time each turkey hen strays off alone, seeking the most secluded spot she can find to lay the large, oval, brown-speckled eggs. Silent and sly, she slips away to the place daily, by the most roundabout ways, and never moving in the direction of the nest when she thinks herself observed. Sometimes the sight of any person near her nest will cause her to desert it. The writer has spent many hours when a child, sneaking in fence corners and behind stumps and tree trunks, stalking turkeys' nests. Incubation takes four weeks. The female is a most persistent sitter and care should be taken to see that she gets a good supply of food and water at this time. Good sound corn or wheat is the best food for her at this period. When sitting she is very cross and will fight most courageously when molested on her nest.

Turkey nestlings are rather large, with long, bare legs and scrawny, thin necks; they are very delicate during the first six weeks of their lives. Their call is a plaintive "peep, weep," and when a little turkey feels lost its cry is expressive of great fear and misery. But if the mother is freely ranging she does not seem to be much affected by the needs of her brood; she will fight savagely for them if they are near her, but if they stray, and they usually do, she does not seem to miss or hunt for them, but strides serenely on her way, keeping up a constant crooning "kr-rit, kr-rit," to encourage them to follow. As a consequence, the chicks are lost, or get draggled and chilled by struggling through wet grass and leaves that are no obstacle to the mother's strong legs, and thus many die. If the mother is confined in a coop it should be so large and roomy that she can move about without trampling on the chicks, and it should have a dry floor, since dampness is fatal to the little ones.

For the first week the chicks should be fed five times a day, and for the next five weeks they should have three meals a day. They should be given only just about enough to fill each little crop and none should be left over to be trodden under their awkward little feet. Their quarters should be kept clean and free from vermin.

Suggested Reading — *Farm Animals*, by James G. Lawson; also, readings on pages 28–29.

LESSON 35

Turkeys

Leading Thought — The turkey is a native of America. It was introduced into Spain from Mexico about 1518, and since then has been domesticated. However, there are still in some parts of the country flocks of wild turkeys. It is a beautiful bird and has interesting habits.

Method — If the pupils could visit a flock of turkeys, the lesson would be given to a better advantage. If this is impossible, ask the questions a few at a time and let those pupils who have opportunities for observing the turkeys give their answers before the class.

Observations — 1. Of what breed are the turkeys you are studying: Bronze, Black, Buff, White Holland, or Narragansett?

2. What is the general shape and size of the turkey? Describe its plumage, noting every color which you can see in it. Does the plumage of the hen turkey differ from that of the gobbler?

3. What is the covering of the head of the turkey, what is its color and how far does it extend down the neck of the bird? Is it always the same color; if not, what causes the change? Is the head covering alike in shape and size on the male and the female? What is the part called that hangs from the front of the throat below the beak? From above the beak?

4. What is the color of the beak? Is it short or long, straight or curved? Where are the nostrils situated?

5. What is the color of the turkey's eyes? Do you think it is a keen-sighted bird?

6. Where are the ears? Do they show as plainly as a chicken's ears do? Are turkeys quick of hearing?

7. Do turkeys scratch like hens? Are they good runners? Describe the feet and legs as to shape, size, and color. Has the male a spur on his legs, and if so, where is it situated? For what is it used?

8. Can turkeys fly well? Are the wings small or comparatively large and strong for the weight of the body? Do turkeys prefer high or low places for perching when they sleep? Is it well to house and confine them in small buildings and parks as is done with other fowls?

9. Tell, as nearly as you can discover by close observation, how the gobbler sets

each part of his plumage when he is "showing off" or strutting. What do you think is the bird's purpose in thus exhibiting his fine feathers? Does the "king of the flock" permit any such action by other gobblers in his company?

10. Are turkeys timid and cowardly or independent and brave, ready to meet and fight anything which they think is threatening to their comfort and safety?

11. When turkeys fight, what parts of their bodies seem to be used as weapons? Does the male "gobble" during a fight, or only as a challenge or in triumph when victorious? Do the hen turkeys ever fight, or only the males?

12. How early in the spring does the turkey hen begin to lay? Does she nest about the poultry yard and the barns or is she likely to seek some secret and distant spot where she may hide her eggs? Describe the turkey's egg, as well as you can, as to color, shape, and size. Can one tell it by the taste from an ordinary hen's egg? About how many eggs does the turkey hen lay in her nest before she begins to "get broody" and want to sit?

13. How many days of incubation are required to hatch the turkey chick? Is it as downy and pretty as other little chicks? How often should the young chicks be fed, and what food do you think is best for them? Are turkey chicks as hardy as other chicks?

14. Is the turkey hen generally a good mother? Is she cross or gentle when sitting and when brooding her young? Is it possible to keep the mother turkey as closely confined with her brood as it is with the mother hen? What supplies should be given to her in the way of food, grits, dust-baths, etc.?

BIRDS OF MARSH AND SHORE

1. Shoveller, Spoonbill, or Broadbill. *The range of the shoveller extends from Alaska in summer to Colombia, South America, in winter. With its uniquely long, broad bill, this shallow-water "dabbler" gathers up water and ooze; by means of the comblike teeth with which the bill is equipped it strains out the insects and vegetable matter which are its favorite food. (Photo by L. W. Brownell)*

2. The Mallard. *The range of the mallard in North America extends in summer south of the Arctic circle, east to Hudson Bay, and south to Lower California and Texas. In winter it is found from the Aleutian Islands south to Panama. Being a "dabbler" the mallard generally feeds in shallow water, but it is very adaptable as to food and environment. From the economic standpoint it is the most important duck in the world, since it is the ancestor of most domestic ducks, is widely distributed, and produces meat of good quality. (Photo by L. W. Brownell)*

3. Lesser Scaup Ducks. *This is one of the most common ducks in the open waters of rivers, larger lakes and bays, and along seacoasts. Its food, consisting chiefly of insects, crustaceans, water snails, tadpoles, and aquatic plants, it secures by diving. In the Gulf states, the lesser scaup is often called the "raft duck" because of the great numbers that collect into flocks and move about on the water. These rafts are sometimes a mile long. (Photo by S. A. Grimes)*

4. Pied-billed Grebe on Its Nest. *The summer range of this grebe is from southern Canada to the southern United States; its winter range extends to Mexico and Cuba. It moves south when ice forms on northern streams, and returns when it breaks up in spring. Its food consists chiefly of aquatic animals and some water plants. To escape danger it dives rather than flies. This grebe, like others, often carries its young on its back, thus hiding them from observers; the mother can even dive with the young and when she comes again to the surface keep them still concealed. (Photo by Olin Sewall Pettingill, Jr.)*

5. Spotted Sandpiper Approaching Its Nest. *The sandpiper (also called* tip-up *or* tip-tail*), said to be the most widely and commonly distributed shore bird in North America, is found in regions about both fresh and salt water. Although it can swim and dive readily, its food consists chiefly of grasshoppers, cutworms, grubs, and pests of cultivated lands. The nest, a hollow in the ground, may be along shores or even in cultivated fields far from water; it is built by the united efforts of the pair. (Photo by L. W. Brownell)*

6. Chicks of Wilson's Plover. *These newly hatched chicks were picked up on a sandy beach and "posed" in a shell. (Photo by Olin Sewall Pettingill, Jr.)*

7. Wilson's Plover at Its Nest. *(See also No. 6.) Wilson's plover is found in the coastal regions of southern North America and Central America. It feeds on the tiny sea creatures that the falling tide leaves strewn along mud flats and sandy beaches. The nest, usually placed above high water on a sandy beach, is a hollowed out place in the sand. The young and eggs blend so with the sand as to be almost unnoticeable. In the one pictured here, note one egg beneath the female, one in front of her, and newly hatched chick behind her. (Photo by S. A. Grimes)*

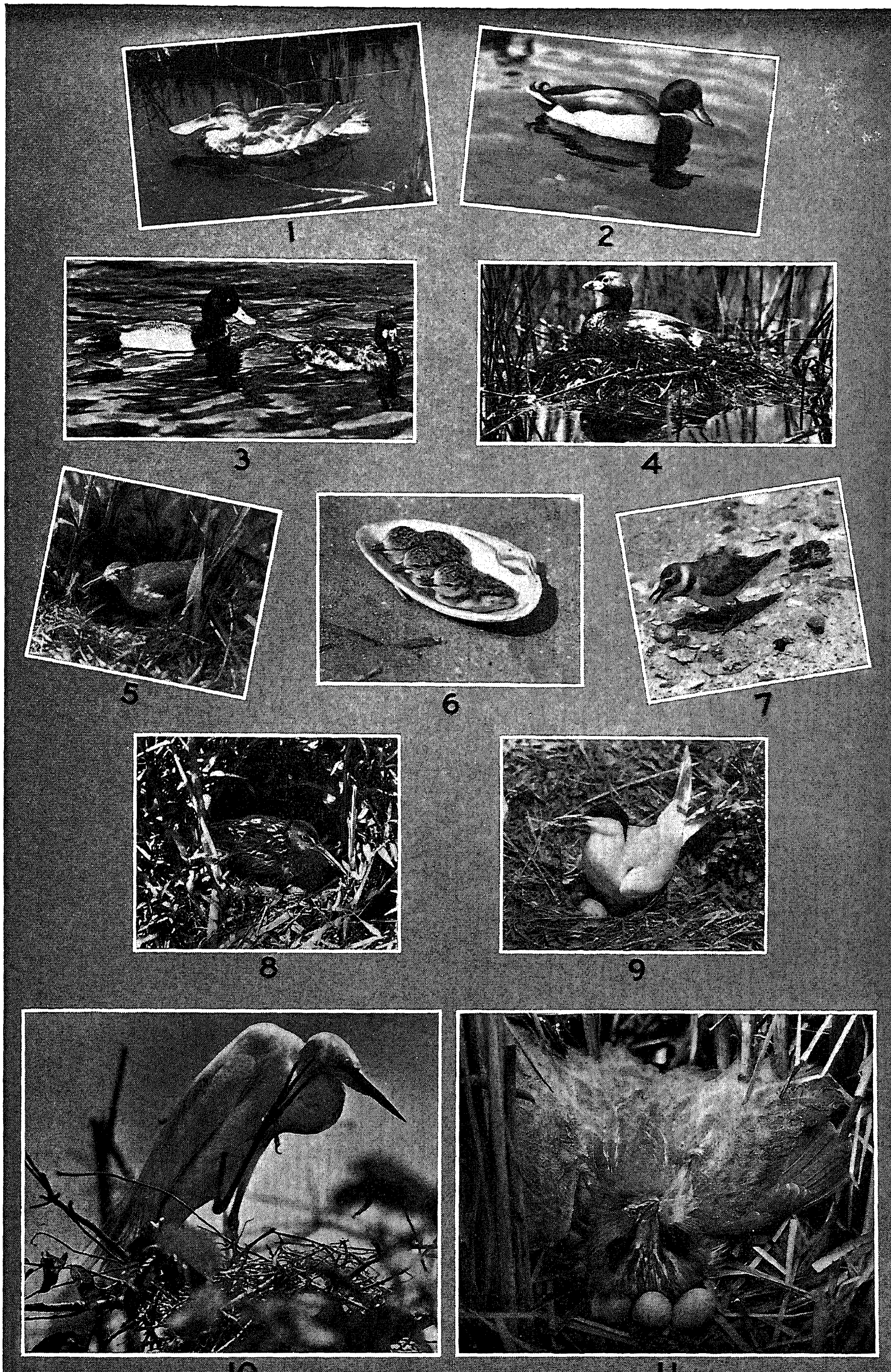
8. King Rail on Its Nest. *The range of this bird is in the central and southern portions of the eastern half of the United States. Its food consists largely of insects of cultivated lands, which it secures from the edges of swampy areas in uplands. Rails are found chiefly in grassy marshes. The legs are strong and the wings are weak, and hence when pursued they will run or hide, but will fly only as a last resort. (Photo by S. A. Grimes)*

9. The Common Tern at Its Nest. *Terns live in both the Eastern and Western Hemispheres.*

Terns nest in colonies, usually on the open sand of an island beach. They can be distinguished from gulls by their more pointed bills, narrower wings, and by their habit of diving or swimming to catch their food, which consists of small fish, aquatic worms, and insects. (Photo by S. A. Grimes)

10. American Egret, Great White Egret, or White Heron. *The summer range of this egret is chiefly from the southern United States south to Patagonia. In late summer it migrates northward to Maine. Its winter range is Colorado, Texas, and South Carolina southward. The egrets and other herons are commonly found about the shores of lakes, rivers, or bays. They usually nest in flocks. Once in danger of extinction, they are now under protection and are increasing in numbers. (Photo by S. A. Grimes)*

11. An American Bittern on the Defensive. *This inhabitant of the marshes ranges in summer across the North American continent from central Canada to the southern United States. In winter it is found from the southern United States to Panama. When approached bitterns fall into a rigid pose which they hold until the intruder retires or frightens them into flight. The cry of this bird is most arresting and unusual. It is compared to the sound of driving a stake or the sound of a pump in action. Frogs, snakes, small fish, mice, and insects comprise its food. (Photo by S. A. Grimes)*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FISHES

It remains yet unresolved whether the happiness of a man in this world doth consist more in contemplation or action. Concerning which two opinions I shall forebear to add a third by declaring my own, and rest myself contented in telling you that both of these meet together, and do most properly belong to the most honest, ingenious, quiet and harmless art of angling. And first I tell you what some have observed, and I have found to be a real truth, that the very sitting by the riverside is not only the quietest and the fittest place for contemplation, but will invite an angler to it.

— Isaak Walton

Dear, human, old Isaak Walton discovered that nature-study, fishing, and philosophy were akin and as inevitably related as the three angles of a triangle. And yet it is surprising how little the fish have been used as subjects for nature lessons. Every brook and pond is a treasure to the teacher who will find what there is in it and who knows what may be got out of it.

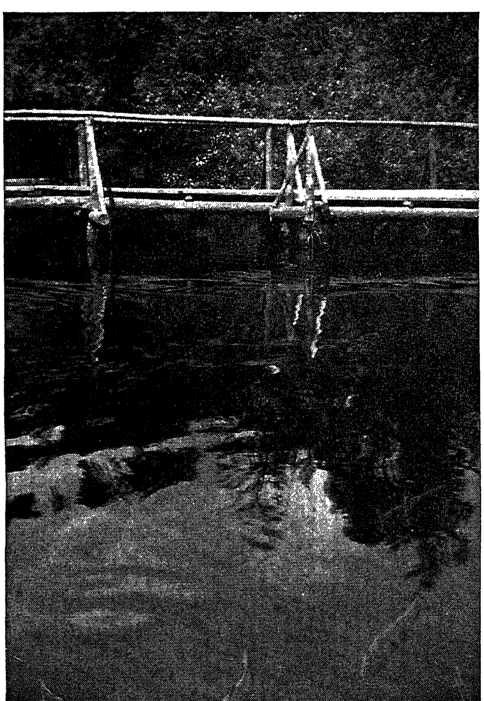
Almost any of the fishes found in a brook or pond may be kept in an aquarium for a few days of observation in the schoolroom. A large water pail or a bucket does very well if there is no glass aquarium. The water in an aquarium should be changed whenever it becomes foul. The practice should be established, once for all, of putting these finny prisoners back into the identical body of water from which they were taken. Much damage has been done by liberating fish in bodies of water where they do not belong. Many fish have cannibalistic traits: black bass, for instance, if they are either the newcomers or the original inhabitants, will be likely to attack and destroy other fish. Besides, even if the new home provides suitable living conditions for the newcomers, they may upset the balance existing among the various forms of plant and animal life already there.

Suggested Reading — *The Book of Fishes*, by J. O. LaGorce; *Cold-blooded Vertebrates*, by Samuel F. Hildebrand, Charles W. Gilmore, and Doris M. Cochran, Vol. 8 of Smithsonian Scientific Series; *The Complete Aquarium Book*, by W. T. Innes; *Field Book of Ponds and Streams*, by Ann H. Morgan; *A History of Fishes*, by J. R. Norman; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals; Our Great Outdoors: Reptiles, Amphibians and Fishes*, by C. W. G. Eifrig; *Young Folks' Book of Fishes*, by Ida M. Mellen. See also *Bibliography*.

THE GOLDFISH

Once upon a time, if stories are true, there lived a king called Midas, whose touch turned everything to gold. Whenever I see goldfish, I wonder if, perhaps, King Midas were not a Chinese and if he perchance did not handle some of the little fish in Orient streams. But common man has learned a magic as wonderful as that of King Midas, although it does not act so immediately, for it is through his agency in selecting and breeding that we have gained these exquisite fish for our aquaria. In the streams of China the goldfish, which were the ancestors of these effulgent creatures, wore safe green colors like the shiners in our brooks; and if any goldfish escape from our fountains and run wild, their progeny return to their native olive-green color. There are many of such dull-colored goldfish in the lakes and rivers of our country. It is almost inconceivable that one of the brilliant-colored fishes, if it chanced to escape into our ponds, should escape the fate of being eaten by some larger fish attracted by such glittering bait.

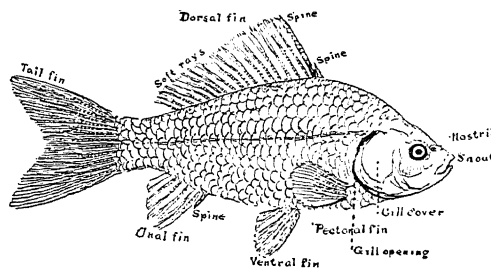
The goldfish, as we see it in the aquarium, is brilliant orange above and pale lemon-yellow below; there are many specimens that are adorned with black patches. And as if this fish were bound to imitate the precious metals, there are individuals which are silver instead of gold; they are oxidized silver above and polished silver below. The goldfish are closely related to the carp and can live in waters that are stale. If water plants and scavengers, such as water snails, are kept in the aquarium, the water does not become foul. The water, then, need not be changed; but unless the aquarium is covered, it will be necessary to add water to replace that which evaporates. Goldfish should not be



Helen F. Hill

Fish in a hatchery pond

fed too lavishly. An inch square of one of the sheets of prepared fish food we have found a fair daily ration for five medium sized fish; these fish are more likely to

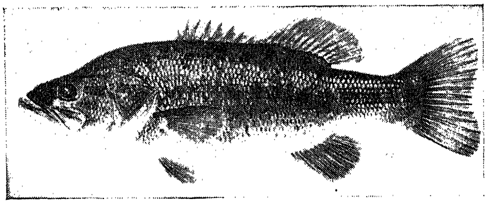


Goldfish with parts named

die from overfeeding than from starving. Goldfish are naturally long-lived; Miss Ada Georgia kept them until seven years old in a school aquarium; and there is on record one goldfish that lived nine years.

Too often the wonderful common things are never noticed because of their commonness; and there is no better instance of this than the form and movements of a fish. It is an animal in many ways similar to animals that live on land; but its form and structure are such that it is perfectly adapted to live in water all its life; there are none of the true fishes which live portions of their lives on land as do the frogs. The first peculiarity of the fish is its shape. Looked at from above, the broader part of the body is near the front end, which is rounded or pointed so as to cut the water readily. The long, narrow, hind portion of the body with the tail acts as a propeller in the sense that it pushes the body forward; this movement is not at all similar to the action of an airplane propeller or a ship's screw. Seen from the side, the body is a smooth, graceful oval and this form is especially adapted to move through the water swiftly, as can be demonstrated to the pupil by cutting a model of the fish from wood and trying to move it through the water sidewise.

Normally, the fish has seven fins, one along the back called the dorsal, one at the end of the tail called the tail or caudal fin, one beneath the rear end of the body called the anal, a pair on the lower side

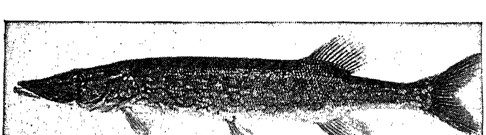


N. Y. State Conservation Dept.

Large-mouthed black bass
Aplites salmoides

of the body called the ventrals, and a pair just back of the gill openings called the pectorals. All these fins play their own parts in the movements of the fish. The dorsal fin is usually higher in front than behind and can be lifted or shut down like a fan. This fin when it is lifted gives the fish greater height and it can be twisted to one side or the other and thus be made a factor in steering. The anal fin on the lower side acts in a similar manner. The tail fin is the propeller and sends the body forward by pressing backward on the water, first on one side and then on the other, being used like a scull. The tail fin varies in shape very much in different species. In the goldfish it is fanlike, with a deeply notched hind edge, but in some it is rounded or square. The paired fins correspond anatomically to our arms and legs, the pectorals representing the arms, the ventrals the legs.

Fishes' eyes have no eyelid but the eyeball is movable, and this often gives the impression that the fish winks. Fishes are necessarily nearsighted since the lens of the eye has to be spherical in order to see in the water. The sense of smell is located in a little sac to which the nostril leads; the nostrils are small and often partitioned and may be seen on either side of the snout. The nostrils of a fish have no connection whatever with breathing.

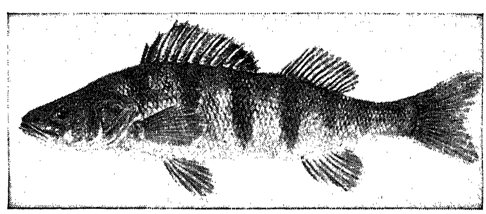


N. Y. State Conservation Dept.

A chain pickerel
Esox niger

The tongue of the fish is very bony or gristly and immovable. Very little sense of taste is developed in it. The shape, number, and position of the teeth vary according to the food habits of the fish. The commonest teeth are fine, sharp, and short and are arranged in pads, as seen in the bullhead. Some fish have blunt teeth suitable for crushing shells. Some herbivorous fishes have sharp teeth with serrated edges, while those living upon crabs and snails have incisor-like teeth. In some species we find several types of teeth; in others, such as goldfish or minnows in general, the teeth may be entirely absent. The teeth are borne not only on the jaws but also in the roof of the mouth, on the tongue, and in the throat.

The ear of the fish has neither outside form nor opening and is very imperfect in comparison with that of man. Extending along the sides of the body from head to tail is a line of modified scales containing small tubes connecting with nerves; this is called the lateral line and it is believed that it is in some way connected with the fish's senses, perhaps with the sense of hearing.



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A yellow perch
Perca flavescens

The covering of fishes varies: most fish, such as the yellow perch and black bass, are sheathed in an armor of scales; others, such as the bullhead, have only a smooth skin. All fish are covered with a slimy substance which somewhat reduces friction as they swim through the water.

In order to understand how the fish breathes we must examine its gills. In front, just above the entrance to the gullet, are several bony ridges which bear two rows of pinkish fringes; these are the gill arches and the fringes are the gills. The gills are filled with tiny bloodvessels, and as the water passes over them, the impurities of the blood pass out through the thin skin of the gills and the life-giving oxygen passes in. Since most fish cannot make use of air unless it is dissolved in water, it is very important that the water in the aquarium provide a sufficient surface area to enable the fish to secure air. The gill arches also bear a series of bony processes called gill-rakers. Their function is to prevent the escape of food through the gills while it is being swallowed, and they vary in size according to the food habits of the fish. We note that the fish in the aquarium constantly opens and closes the mouth; this action draws the water into the throat and forces it out over the gills and through the gill openings; this, then, is the act of breathing.

Suggested Reading—*Goldfish Culture for Amateurs*, by A. E. Hodge and Arthur Derham; *Goldfish, Their Care in Small Aquaria and Ponds*, by E. C. Fearnow (Document 980, Bureau of Fisheries, Washington, D. C.); *The Pet Book*, by Anna B. Comstock; also, readings on page 144.

LESSON 36

A Study of the Fish

Leading Thought — A fish lives in the water where it must breathe, move, and find its food. The water world is quite different from the air world and the fish have developed forms, senses, and habits which fit them for life in the water.

Method — The goldfish is used as a subject for this lesson because it is so conveniently kept where the children may see it. However, a shiner or other minnow would do as well.

Before the pupils begin the study, place the diagram shown on p. 145 on the blackboard, with all the parts labeled; thus the pupils will be able to learn the parts of the fish by consulting it, and not be compelled to commit them to memory arbitrarily. It would be well to associate the goldfish with a geography lesson on China.

Observations — 1. Where do fish live?

2. What is the shape of a fish when seen from above? Where is the widest part? What is its shape seen from the side? Think if you can in how many ways the shape of the fish is adapted for moving swiftly through the water.

3. How many fins has the fish? Make a sketch of the goldfish with all its fins and name them from the diagram on the blackboard.

4. How many fins are there in all? Four of these fins are in pairs; where are they situated? What are they called? Which pair corresponds to our arms? Which to our legs?

5. Describe the pectoral fins. How are they used? Are they kept constantly moving? Do they move together or alternately? How are they used when the fish swims backward?

6. How are the ventral fins used? How do they assist the fish when swimming?

7. Observe a dorsal fin and an anal fin. How are these used when the fish is swimming?

8. With what fin does the fish push itself through the water? Make a sketch of the tail. Note if it is square, rounded, or notched at the end.

9. Watch the goldfish swim and describe the action of all the fins while it is in motion. In what position are the fins when the fish is at rest?

10. What is the nature of the covering of the fish? Are the scales large or small? In what direction do they seem to overlap? Of what use to the fish is this scaly covering?

11. Can you see a line which extends from the upper part of the gill opening, along the side to the tail? This is called the lateral line. Do you think it is of any use to the fish?

12. Note carefully the eyes of the fish. Describe the pupil and the iris. Are the eyes placed so that the fish can see in all directions? Can they be moved so as to see better in any direction? Does the fish wink? Has it any eyelids? Do you know why fish are nearsighted?

13. Can you see the nostrils? Is there a little wartlike projection connected

with the nostril? Do you think fishes breathe through their nostrils?

14. Describe the mouth of the fish. Does it open upward, downward, or directly in front? What sort of teeth have fish? How does the fish catch its prey? Does the lower or upper jaw move in the process of eating?

15. Is the mouth kept always in motion? Do you think the fish is swallowing water all the time? Do you know why it does this? Can you see a wide opening along the sides of the head behind the gill cover? Does the gill cover move with the movement of the mouth? How does a fish breathe?

16. What are the colors of the goldfish above and below? What would happen to our beautiful goldfish if they were put in a brook with other fish? Why could they not hide? Do you know what happens to the colors of the goldfish when they run wild in our streams and ponds?

17. Can you find in books or cyclopedias where the goldfish came from? Are they gold and silver in color in the streams where they are native? Do you think that they had originally the long, slender, swallow-tails which we see sometimes in goldfish? How have the beautiful colors and graceful forms of the gold and silver fishes been developed?

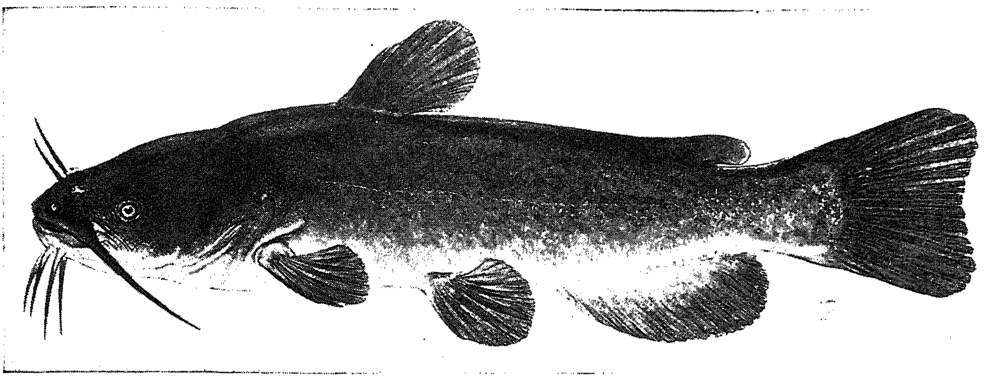
I have my world, and so have you,
A tiny universe for two,
A bubble by the artist blown,
Scarcely more fragile than our own,
Where you have all a whale could wish,
Happy as Eden's primal fish.
Manna is dropt you thrice a day
From some kind heaven not far away,
And still you snatch its softening crumbs,
Nor, more than we, think whence it comes.
No toil seems yours but to explore
Your cloistered realm from shore to shore;
Sometimes you trace its limits round,
Sometimes its limpid depths you sound,
Or hover motionless midway,
Like gold-red clouds at set of day;
Erelong you whirl with sudden whim
Off to your globe's most distant rim,
Where, greatened by the watery lens,
Methinks no dragon of the fens
Flashed huger scales against the sky,
Roused by Sir Bevis or Sir Guy;
And the one eye that meets my view,
Lidless and strangely largening, too,
Like that of conscience in the dark,
Seems to make me its single mark.
What a benignant lot is yours
That have an own All-out-of-doors,
No words to spell, no sums to do,
No Nepos and no parlyvoo!
How happy you, without a thought
Of such cross things as Must and Ought —
I too the happiest of boys
To see and share your golden joys!

— "THE ORACLE OF THE GOLDFISHES," LOWELL

THE BULLHEAD

The bull-head does usually dwell and hide himself in holes or amongst stones in clear water; and in very hot days will lie a long time very still and sun himself and will be easy to be seen on any flat stone or gravel; at which time he will suffer an angler to put a hook baited with a small worm very near into his mouth; and he never refuses to bite, nor indeed, to be caught with the worst of anglers. — ISAAK WALTON

When one looks a bullhead in the face one is glad that it is not a real bull, for its barbels give it an appearance quite fit for the making of a nightmare; and yet from the standpoint of the bullhead, how truly beautiful those fleshy feelers are! For without them how could it feel its way about searching for food in the mud? Two of these barbels stand straight up; the two largest ones stand out on each



State of New York Conservation Department

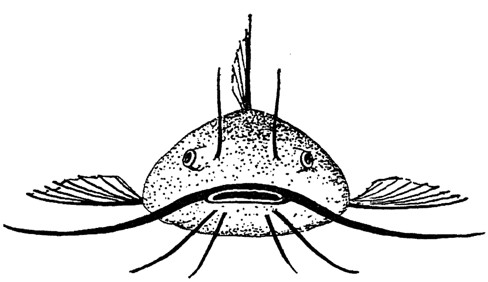
Common bullhead
Ameiurus nebulosus

side of the mouth, and two pairs of short ones adorn the lower lip, the smallest pair at the middle.

As the fish moves about, it is easy to see that the large barbels at the side of the mouth are of the greatest use; it keeps them in a constantly advancing movement, feeling of everything it meets. The upper ones stand straight up, keeping watch for whatever news there may be from above; the two lower ones spread apart and follow rather than precede the fish, seeming to test what lies below. The upper and lower pairs seem to test things as they are, while the large side pair deal with what is going to be. The broad mouth seems to be formed for taking in all things eatable, for the bullhead lives on almost anything alive or dead that it discovers as it noses about in the mud. Nevertheless, it has its notions about its food, for I have repeatedly seen one draw material into its mouth through its breathing motion and then spew it out with a vehemence one would hardly expect from such a phlegmatic fish.

Although it has feelers which are very efficient, it also has perfectly good eyes which it uses to excellent purpose; note how promptly it moves to the other side of the aquarium when we are trying to study it. The eyes are not large; the pupils are black and oval and are rimmed with a narrow band of shiny pale yellow. The eyes are prominent so that when moved backward and forward they gain a view of the enemy in the rear or at the front while the head is motionless. It seems strange to see such a pair of pale yellow, almost white eyes in such a dark body.

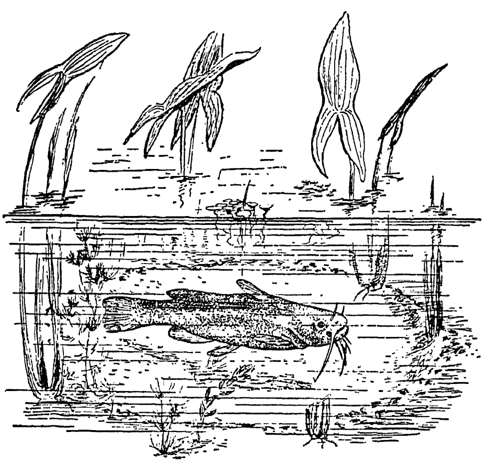
The general shape of the front part of the body is flat, in fact, it is shaped decidedly like a tadpole; this shape is especially fitted for groping about muddy



bottoms. The flat effect of the body is emphasized by the gill covers opening below rather than at the sides, every pulsation widening the broad neck. The pectoral fins also open out on the same plane as the body, although they can be turned at an angle if necessary; they are thick and fleshy and the sharp tips of their spines offer punishment to whosoever touches them. The dorsal fin is far forward and not large; it is usually raised at a threatening angle.

Near the tail there is a little fleshy dorsal fin which stands in line with the body, and one wonders what is its special use. The ventral fins are small. The anal fin is far back and rather strong, and this with the long, strong tail gives the fish good motor power; it can swim very rapidly if occasion requires.

The bullhead is mud-colored and has no scales. The skin is very thick and leathery so that it is always removed before the fish is cooked. The bullhead burrows deep into the mud in the fall and remains there all winter; when the spring freshets come, it emerges and is hungry for fresh meat.



Bullhead guarding his nest

The family life of the bullheads and other catfishes seems to be quite ideal. Dr. Theodore Gill tells us that bullheads make their nests by removing stones and gravel from a more or less irregularly circular area in shallow water, and on sandy or gravelly ground. The nest is somewhat excavated, both parents removing the pebbles by sucking them into the mouth and carrying them off for some distance. After the eggs are laid, the male watches over and guards the nest and seems to have great family responsibilities. He is the more active of the two in stirring and mixing the young fry after they are hatched. Smith and Harron describe the process thus: " With their chins on the bottom, the old fish brush the corners where the fry were banked, and with the barbels all directed forward, and flexed where they touch the bottom, thoroughly agitate the mass of fry, bringing the deepest individuals to the surface. This act is usually repeated several times in quick succession.

" The nests are usually made beneath logs or other protecting objects and in shallow water. The paternal care is continued for many days after the birth of the young. At first these may be crowded together in a dense mass, but as time passes they disperse more and more and spread around the father. Frequently, especially when the old one is feeding, some — one or more — of the young are taken into the mouth, but they are instinctively separated from the food and spit out. At last the young swarm venture farther from their birthplace, or perhaps they are led away by their parents."

SUGGESTED READING — *Along the Brook*, by Raymond T. Fuller; *Backyard Exploration*, by Paul G. Howes; *The Pet Book*, by Anna B. Comstock; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 144.

LESSON 37

THE BULLHEAD, OR HORNED POUT

LEADING THOUGHT — The bullhead lives in mud bottoms of streams and ponds and is particularly adapted for life in such locations.

METHOD — A small bullhead may be placed in a small aquarium jar. At first let the water be clear and add a little pond weed so as to observe the natural tendency of the fish to hide. Later add mud and gravel to the aquarium and note the behavior of the fish.

OBSERVATIONS — 1. What at the first glance distinguishes the bullhead from other fish? Describe these strange " whiskers " growing about the mouth; how many are there and where are they situated? Which are the longest pair? Can the fish move them in any direction at will?

2. Where do we find bullheads? On what do they feed? Would their eyes help them to find their food in the mud? How do they find it?

3. Explain, if you can, why the bullhead has barbels, or feelers, while the trout and bass have none.

4. What is the shape of the mouth?

5. What is the general shape of the body? What is its color? Has it any scales?

6. Why should the bullhead be so flat horizontally while the sunfish is so flat in the opposite direction?

7. Describe the bullhead's eyes. Are they large? What is their color? Where are they placed?

8. Describe the dorsal fin, giving its comparative size and position. Do you see another dorsal fin? Where is this peculiar fin and how does it differ from all of the others?

9. Describe the tail fin. Does it seem long and strong? Is the bullhead a good swimmer?

10. Is the anal fin large or small as compared with that of the goldfish?

11. How do the pectoral fins move as compared with those of the sunfish? Why is the position of the pectoral and dorsal fins of benefit to this fish?

12. How does the bullhead inflict wounds when it is handled? Tell how these spines may protect it from its natural enemies.

13. When is the best season for fishing for bullheads? Does the place where they are found affect the flavor of their flesh? Why?

14. What is the spawning season? Do you know about the nests the bullheads build and the care they give their young?

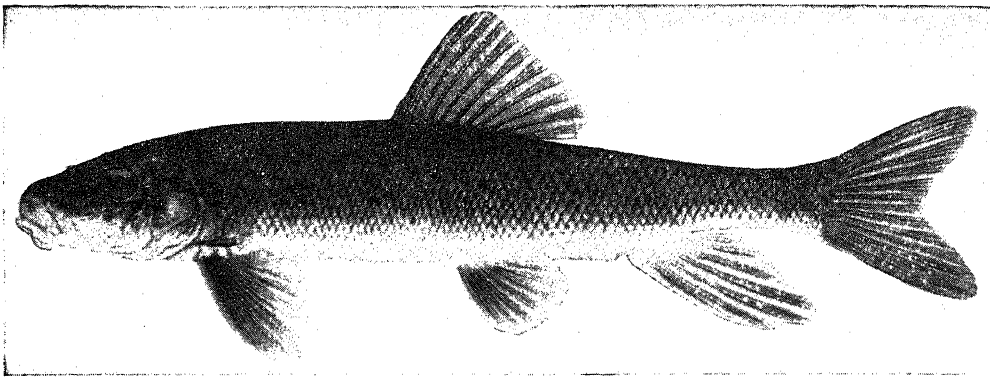
15. Write an essay on the nest-making habits of the bullheads and the care given the young by the parents.

And what fish will the natural boy naturally take? In America, there is but one fish which enters fully into the spirit of the occasion. It is a fish of many species according to the part of the country, and of as many sizes as there are sizes of boys. This fish is the horned pout, and all the rest of the species of Ameiurus. Horned pout is its Boston name. Bullhead is good enough for New York; and for the rest of the country, big and little, all the fishes of this tribe are called catfish. A catfish is a jolly blundering sort of a fish, a regular Falstaff of the ponds. It has a fat jowl, and a fat belly, which it is always trying to fill. Smooth and sleek, its skin is almost human in its delicacy. It wears a long mustache, with scattering whiskers of other sort. Meanwhile it always goes armed with a sword, three swords, and these it has always on hand, always ready for a struggle on land as well as in the water. The small boy often gets badly stuck on these poisoned daggers, but, as the fish knows how to set them by a muscular twist, the small boy learns how, by a like untwist, he may unset and leave them harmless.

The catfish lives in sluggish waters. It loves the millpond best of all, and it has no foolish dread of hooks when it goes forth to bite. Its mouth is wide. It swallows the hook, and very soon it is in the air, its white throat gasping in the untried element. Soon it joins its fellows on the forked stick, and even then, uncomfortable as it may find its new relations, it never loses sight of the humor of the occasion. Its large head and expansive forehead betoken a large mind. It is the only fish whose brain contains a Sylvian fissure, a piling up of tissue consequent on the abundance of gray matter. So it understands and makes no complaint. After it has dried in the sun for an hour, pour a little water over its gills, and it will wag its tail, and squeak with gratitude. And the best of all is, there are horned pouts enough to go around.

The female horned pout lays thousands of eggs, and when these hatch, she goes about near the shore with her school of little fishes, like a hen with myriad chicks. She should be respected and let alone, for on her success in rearing this breed of "bullying little rangers" depends the sport of the small boy of the future.

— "FISH STORIES," CHARLES FREDERICK HOLDER AND DAVID STARR JORDAN



State of New York Conservation Department

The common sucker
Catostomus commersonnii

THE COMMON SUCKER

He who loves to peer down into the depths of still waters, often sees upon the sandy, muddy, or rocky bottom several long, wedge-shaped sticks lying at various angles one to another. But if he thrust down a real stick, behold, these inert, water-logged sticks move off deftly! And then he knows that they are suckers. He may drop a hook baited with a worm in front of the nose of one, and if he waits long enough before he pulls up he may catch this fish, not by its gills but by the pit of its stomach; for it not only swallows the hook completely but tries to digest it along with the worm. Its food is made up of soft-bodied insects and other small water creatures; it is also a mud eater and manages to make a digestive selection from the organic material of silt. For this latter reason it is not a desirable food fish, although its flesh varies in flavor with the locality where it is found. The suckers taken when the waters are cold, are tasty but somewhat more bony than most fishes, while those taken from warm waters are very inferior in flavor and often unpalatable.

Seen from above, the sucker is wedge-shaped, being widest at the eyes; seen from the side it has a flat lower surface and an ungracefully rounded contour above, which tapers only slightly toward the tail. The profile of the face gives the impression of a Roman nose. The young specimens have an irregular scale-mosaic pattern of olive-green blotches on a paler ground color, while the old ones are quite brown above and on the sides. The suckers differ from most other fishes in having the markings of the back extend down the sides almost to the belly. This is a help in concealing the fish, since its sides show from above quite as distinctly as its back because of its peculiar form. The scales are rather large and are noticeably larger behind than in the region of the head. Like other fish it is white below.

The dorsal fin is placed about midway the length of the fish as measured from nose to tail. The tail is long and strong and deeply notched; the anal fin extends back to where the tail begins. The ventral fins are small and are directly opposite the hind half of the dorsal fin. The pectorals are not large but are strong and are placed low down. The sucker has not a lavish equipment of fins, but its tail is strong and it can swim swiftly; it is also very excitable; in its efforts to escape, it will jump from the aquarium more successfully than any other fish. When resting on the bottom, it is supported by its extended pectoral and ventral fins, which are strong although not large.

The eyes are fairly large but the iris is not shiny; they are placed so that the fish can easily see above it as well as at the sides; the eyes move so as to look up or down and are very well adapted to serve a fish that lives upon the bottom. The nostrils are divided, the partition projecting until it seems a tubercle on the face. The mouth opens below and looks like the puckered opening of a bag. The lips are thick but are very sensitive; it is by projecting these lips, in a way that reminds one of a very short elephant's trunk, that it is enabled to reach and find its food in the mud or gravel; so although the sucker's mouth is not a beautiful feature, it is doubly useful. The sucker has the habit of remaining motionless for long periods of time. It breathes very slowly and appears sluggish; it never seizes its food with any spirit but simply slowly engulfs it; and for this reason it is considered poor game. It is only in the spring when they may be speared through the ice that there is any fun in catching suckers; it is at this season of the year that they move upstream to shallow riffles to spawn. Even so lowly a creature as the sucker seems to respond to influences of the springtime, for at that period the male has a faint rosy stripe along his sides. In the winter these fish retire to the depths of the rivers or ponds.

There are many species of suckers and they vary in size from six inches to three feet in length. They inhabit all sorts of waters, but they do not like a strong current and are, therefore, found in still pools. The common sucker (*Catostomus commersonii*), which is the subject of this lesson, sometimes attains the length of twenty-two inches and the weight of five pounds. The ones under observation were about eight inches long, and proved to be the acrobats of the aquarium, since they were likely at any moment to jump out; several times I found one on the floor.

Suggested Reading — *Along the Brook*, by Raymond T. Fuller; *Backyard Exploration*, by Paul G. Howes; also, readings on page 144.

LESSON 38

The Common Sucker

Leading Thought — The sucker is especially adapted by shape for lying on the bottom of ponds under still water where its food is abundant.

Method — If still-water pools along rivers or lakesides are accessible, it is far more interesting to study a sucker in its native haunts, as an introduction to the study of its form and colors when it is in the aquarium.

Observations — 1. Where do you find suckers? How do you catch them? Do they take the hook quickly? What is the natural food of the sucker?

2. What is the shape of this fish's body when seen from above? From the side? What is the color above? On the sides? Below? Does the sucker differ from most other fishes in the coloring along its sides? What is the reason for this? What do suckers look like on the bottom of the pond? Are they easily seen?

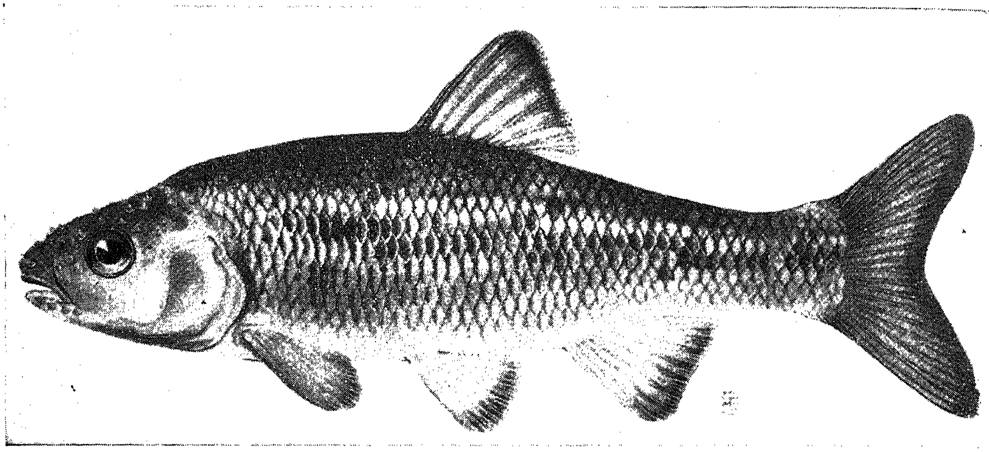
3. Describe or sketch a sucker, showing the position, size, and shape of the fins and tail. Are its scales large or small? How does it use its fins when at rest? When moving? Is it a strong swimmer? Is it a high jumper?

4. Describe the eyes; how are they especially adapted in position and in movement to the needs of a fish that lives on the bottom of streams and ponds?

5. Note the nostrils. Are they used for breathing?

6. Where is the mouth of the sucker situated? What is its form? How is it adapted to get food from the bottom of the stream and from crevices in the rocks?

7. Tell all you know about the habits of the suckers. When do you see them first in the spring? Where do they spend the winter? Where do they go to spawn? How large is the largest one you have ever seen? Why is their flesh sometimes considered poor in quality as food? Is there a difference in the flavor of their flesh depending upon the temperature of the water in which they live?



State of New York Conservation Department

Common shiner or redfin
Notropis cornutus

THE SHINER

This is a noteworthy and characteristic lineament, or cipher, or hieroglyphic, or type of spring. You look into some clear, sandy bottomed brook where it spreads into a deeper bay, yet flowing cold from ice and snow not far off, and see indistinctly poised over the sand on invisible fins, the outlines of the shiner, scarcely to be distinguished from the sands behind it as if it were transparent. — Thoreau

There are many species of shiners and it is by no means easy to recognize them or to distinguish them from chub, dace, and other minnows, since all these belong to one family; they all have the same arrangement of fins and live in the same water; and the plan of this lesson can with few changes be applied to any of them.

Never were seen more exquisite colors than shimmer along the sides of the common shiner (*Notropis cornutus*). It is pale olive-green above, just a sunny brook-color; this is bordered at the sides by a line of iridescent blue-purple, while the shining silver scales on the sides below flash and glimmer with the changing hues of the rainbow. Most of the other minnows are darker than the shiners.

The body of the shiner is ideal for slipping through the water. Seen from above it is a narrow wedge, rounded in front and tapering to a point behind; from the side, it is long, oval, lance-shaped. The scales are large and beautiful, and the lateral line looks like a series of dots embroidered at the center of the diamond-shaped scales.

The dorsal fin is placed just back of the center of the body and is not very large; it is composed of soft rays, the first two being stiff and unbranched. The tail is long, large, graceful and deeply notched. The anal fin is almost as large as the dorsal. The ventral pair is placed on the lower side, opposite the dorsal fin; the pectorals are set at the lower margin of the body, just behind the gill openings. The shiner and its relatives use the pectoral fins to aid in swimming, and keep them constantly in motion when moving through the water. The ventrals are moved only now and then and evidently help in keeping the balance. When the fish moves rapidly forward, the dorsal fin is raised so that its front edge stands at right angles to the body and the ventral and anal fins are expanded to their fullest extent. But when the fish is lounging, the dorsal, anal, and ventral fins are more or less closed, although the tip of the dorsal fin swings with every movement of the fish.

The eyes are large, the pupils being very large and black; the iris is pale yellow and shining; the whole eye is capable of much movement forward and back. The nostril is divided by a little projecting partition which looks like a tubercle. The mouth is at the front of the head; to see the capabilities of this mouth, watch the shiner yawn, if the water of the aquarium becomes stale. Poor fellow! He yawns just as we do in the effort to get more oxygen.

The shiners are essentially brook fish although they may be found in larger bodies of water. They lead a precarious existence, for the larger fish eat them in all their stages. They hold their own only by laying countless numbers of eggs. They feed chiefly on water insects, algæ, and fish eggs, including their own. They are pretty and graceful little creatures and may be seen swimming up the current in the middle of the brook. They often occur in schools or flocks, especially when young.

Suggested Reading — *Backyard Exploration*, by Paul G. Howes; *The Pet Book*, by Anna B. Comstock; also, readings on page 144.

LESSON 39

The Shiner

Leading Thought — The shiners are among the most common of the little fish in our small streams. They are beautiful in form and play an important part in the life of our streams.

Method — Place in the aquarium shiners and as many as possible of the other species of small fish found in our creeks and brooks. The aquarium should stand where the pupils may see it often. The following questions may be asked, giving the children time for the work of observation.

Observations — 1. What is the shape of the shiner's body when seen from above? When seen from the side? Do you think that its shape fits it for moving rapidly through the water?

2. What is the coloring above? On the sides? Below?

3. Are the scales large and distinct, or very small? Can you see the lateral line? Where are the tiny holes which make this line placed in the scales?

4. Describe or sketch the fish, showing position, relative size, and shape of all the fins and the tail.

5. Describe the use and movements of each of the fins when the fish is swimming.

6. Describe the eyes. Do they move?

7. Describe the nostrils. Do you think each one is double?

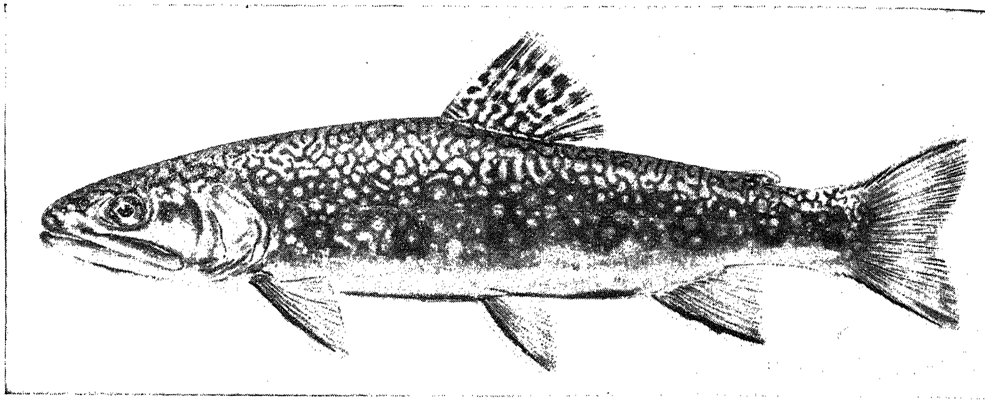
8. Does the mouth open upward, downward, or forward? Have you ever seen the shiner yawn? Why does it yawn? Why do you yawn?

9. Where do you find the shiners living? Do they haunt the middle of the stream or the edges? Do you ever see them in flocks or schools?

MINNOWS

How silent comes the water round that bend;
Not the minutest whisper does it send
To the o'er-hanging sallows; blades of grass
Slowly across the chequer'd shadows pass,
Why, you might read two sonnets, ere they reach
To where the hurrying freshnesses aye preach
A natural sermon o'er their pebbly beds;
Where swarms of minnows show their little heads,
Staying their wavy bodies 'gainst the streams,
To taste the luxury of sunny beams
Tempered with coolness. How they ever wrestle
With their own sweet delight, and ever nestle
Their silver bellies on the pebbly sand!
If you but scantily hold out the hand,
That very instant not one will remain;
But turn your eye, and there they are again.
The ripples seem right glad to reach those cresses,
And cool themselves among the em'rald tresses;
The while they cool themselves, they freshness give,
And moisture, that the bowery green may live.

— John Keats



State of New York Conservation Department

The brook trout
Salvelinus fontinalis

THE BROOK TROUT

Up and down the brook I ran, where beneath the banks so steep,
Lie the spotted trout asleep. — WHITTIER

But they were probably not asleep, as Mr. Whittier might have observed if he had cast a fly near one of them. There is in the very haunts of the trout a suggestion of where it gets its vigor and wariness: the cold, clear streams where the water is pure; brooks that wind in and out over rocky and pebbly beds, here shaded by trees and there dashing through the open — it makes us feel vigorous even to think of such streams. Under the overhanging bank or in the shade of some fallen log or shelving rock, the brook trout hides where he may see all that goes on in the world above and around him without being himself seen. Woe to the unfortunate insect that falls upon the surface of the water in his vicinity or even flies low over it, for the trout will easily jump far out of the water to seize its prey It is this habit of taking the insect upon and above the water's surface which has made trout fly-fishing the sport that it is. Man's ingenuity is fairly matched against the trout's cunning in this contest. I know of one old trout that has kept fishermen in the region around on the *qui vive* for years; and up to date he is still alive, making a dash now and then at a tempting bait, showing himself enough to tantalize his would-be captors with his splendid size, but always retiring at the sight of the line.

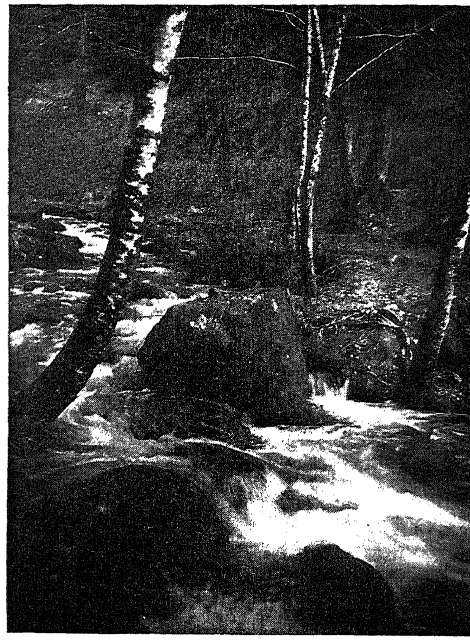
The brook trout varies much in color, depending upon the soil and the rocks of the streams in which it lives. Its back is marbled with dark olive or black, making it just the color of shaded water. This marbled coloration also marks the dorsal and the tail fins. The sides, which vary much in color, are marked with beautiful vermilion spots, each placed in the center of a larger, bluish spot. In some instances the lower surface is reddish, in others whitish. All the fins on the lower side of the body have the front edges creamy or yellowish white, with a darker streak behind.

The trout's head is quite large and somewhat blunt. The large eye is a little in front of the middle of the head. The dorsal fin is at about the middle of the body, and when raised is squarish in outline. Behind the dorsal fin and near the tail is the little, fleshy adipose fin, so called because its tissue is more or less adipose in nature. The tail is fan-shaped, slightly notched at the end and is large and strong.

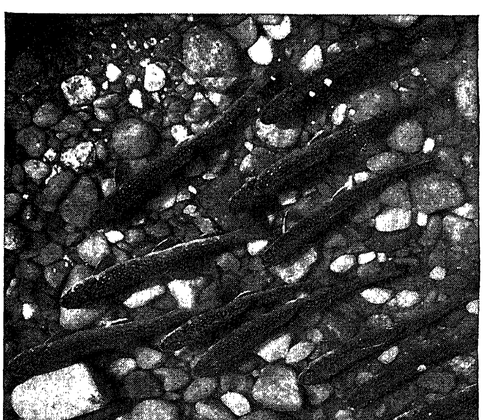
The anal fin is rather large, being shaped much like the dorsal fin, only slightly smaller. The ventral fins are directly below the dorsal fin and a little behind its middle. The pectorals are low down, being below and just behind the gill arches.

In size the brook trout may reach fourteen inches, but the majority of those caught are seldom longer than seven or eight inches. It does not flourish in water which is warmer than 70° Fahrenheit, and prefers a temperature of about 50° Fahrenheit. It must have the pure water of mountain streams and cannot endure the water of rivers which is polluted by mills or the refuse of cities. Where it has access to streams that flow into the ocean, it forms the salt-water habit, going out to sea and remaining there during the winter. Such specimens become very large.

The trout can lay eggs when about six inches in length. The eggs are laid from September until late November in most parts of the United States. One small mother trout lays from 400 to 600 eggs, but the large-sized ones lay more. The period of hatching depends upon the temperature of the water. In depositing their eggs the trout seek water with a gravelly bottom, often where some spring enters into a stream. The nest is shaped by the tail of the fish, the larger stones being carried away in the mouth. To make the precious eggs secure they are covered with gravel.



Where the trout live



Verne Morton

When resting on a stream bed trout face into the current

Strict laws have been enacted by almost all of our states to protect the brook trout and preserve it in our streams. While it is true that brook trout spawn when five to six inches in length, the legal size in most states is six to seven inches; this gives them a chance to spawn at least about once before being caught. It is the duty of every decent citizen to abide by these laws and to see to it that his neighbors observe them. The teacher cannot emphasize enough to the child the moral value of being law-abiding. There should be in every school in the Union children's clubs which should have for their purpose civic honesty and the enforcement of laws which affect the city, village, or township.

Almost any stream with suitable water may be stocked with trout from the national or the state hatcheries, but what is the use of this expense if the game laws are not observed and these fish are caught before they reach maturity, as is so often the case?

SUGGESTED READING — *Along the Brook*, by Raymond T. Fuller; *Backyard Explora-*

tion, by Paul G. Howes; *Mountain Neighbors*, by Edith M. Patch and Carroll L. Fenton (Rainbow Trout); *The Watchers of the Trails*, by Charles G. D. Roberts; also, readings on page 144.

LESSON 40

The Brook Trout

Leading Thought — The brook trout have been exterminated in many streams in our country largely because the game laws were passed too late to save them; and because of misuse of our waters. The trout is one of the most cunning and beautiful of our common fishes and the most delicious for food. Many mountain streams in our country could be well stocked with brook trout.

Method — For this lesson secure a trout from a fisherman at the opening of trout season. In some states, a permit is required before a trout may be legally kept in captivity, unless it is a legally captured specimen and is kept only during fishing season.

Observations — 1. In what streams are the brook trout found? Must the water be warm or cold? Can the trout live in impure water? Can it live in salt water?

2. Do the trout swim about in schools or do they live solitary? Where do they like to hide?

3. With what kind of bait are trout caught? Why do they afford such excellent sport for fly-fishing? Can you tell what the food of the trout is?

4. What is the color of the trout above? What colors along its sides? What markings make the fish so beautiful? What is its color below? Has the trout scales? Do you see the lateral line?

5. What is the general shape of the brook trout? Describe the shape, position, and color of the dorsal fin. Describe the little fin behind the dorsal. Why is it unlike the other fins? What is the shape of the tail fin? Is it rounded, square, or crescent-shaped across the end? What is the position and size of the anal fin compared with the dorsal? What are the colors on the ventral fins and where are these fins placed in relation to the dorsal fin? What color are the pectoral fins and how are they placed in relation to the gill arches?

6. Describe the trout's eyes. Do you think the trout is keen-sighted?

7. When and where are the eggs laid? Describe how the nest is made. How are the eggs covered and protected?

8. Could a trout live in the streams of your neighborhood? Can you get state aid in stocking the streams?

9. What are the game laws concerning trout fishing? When is the open season? How long must the trout be to be taken legally? If you are a good citizen what do you do about the game laws?

10. Write a story telling all you know about the wariness, cunning, and strength of the brook trout.

TROUT

It is well for anglers not to make trout, of all fishes, the prime objective of a day's sport, as no more uncertain game loves the sunlight. Today he is yours for the very asking; tomorrow, the most luscious lure will not tempt him. One hour he defies you, the next, gazes at you from some ensconcement of the fishes, and knows you not, as you pass him, casting, by.

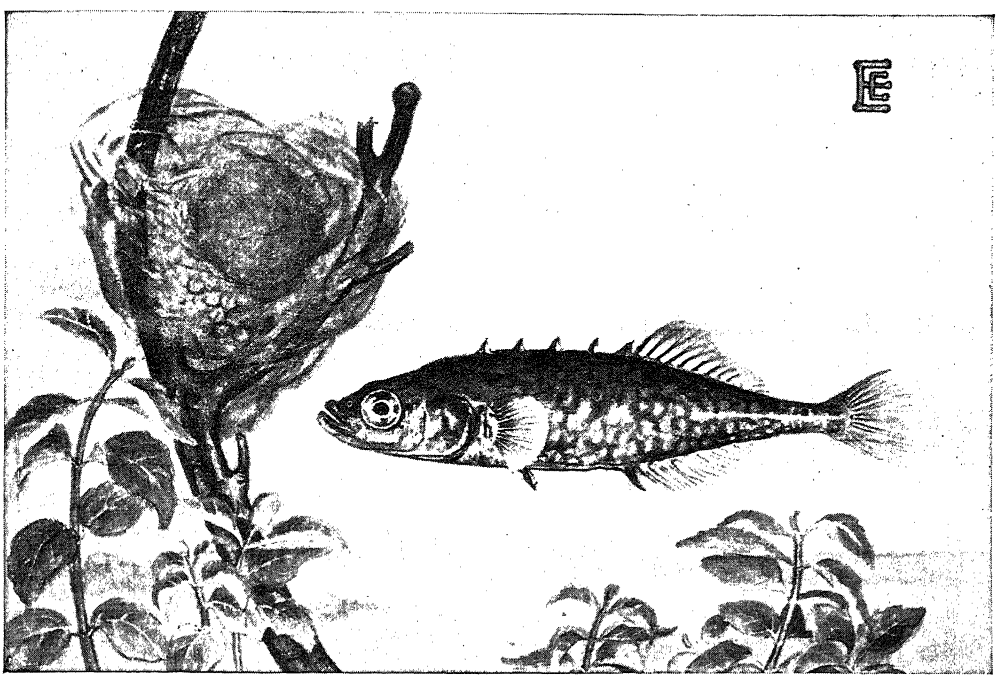
I believe I accumulated some of this angling wisdom years ago, in a certain trout domain in New England, where there were streams and pools, ripples, cascades and drooping trees; where everything was fair and promising to the eyes for trout; but it required superhuman patience to lure them, and many a day I scored a blank. Yet on these very days when lures were unavailing, the creel empty save for fern leaves, I found they were not for naught; that the real fishing day was a composite of the weather, the wind, even if it was from the east, the splendid colors of forest trees, the blue tourmaline of the sky that topped the stream amid the trees, the flecks of cloud mirrored on the surface. The delight of anticipation, the casting, the play of the rod, the exercise of skill, the quick turns in the stream opening up new vistas, the little openings in the forest, through which were seen dis-

tant meadows and nodding flowers — all these went to make up the real trout fishing, the actual catch being but an incident among many delights.

Just how long one could be content with mere scenery in lieu of trout, I am not prepared to say; if pushed to the wall, I confess that when fishing I prefer trout to scenic effects. Still, it is a very impracticable and delightful sentiment with some truth to it, the moral being that the angler should be resourceful, and not be entirely cast down on the days when the wind is in the east.

I am aware that this method of angling is not in vogue with some, and would be deemed fanciful, indeed inane, by many more; yet it is based upon a true and homely philosophy, not of today, the philosophy of patience and contentment. "How poor are they that have not patience," said Othello. It is well to be content with things as we find them, and it is well to go a-fishing, and not to catch fish alone, but every offering the day has to give. This should be an easy matter for the angler, as Walton tells us that Angling is somewhat like poetry; men are to be born so.

— "Fish Stories," Holder and Jordan



State of New York Conservation Department

Brook stickleback and nest
Eucalia inconstans

THE STICKLEBACK

This is certainly the most sagacious of the Lilliputian vertebrates; scarcely more than an inch in length when full-grown, it gazes at you with large, keen, shining-rimmed eyes, takes your measure and darts off with a flirt of the tail that says plainly, "Catch me if you can." The sticklebacks are delightful aquarium pets because their natural home is in still water sufficiently stagnant for algæ to grow luxuriously; thus we but seldom need to change the water in the aquarium, which, however, should be well stocked with water plants and have gravel at the bottom.

When the stickleback is not resting, he is always going somewhere and he knows just where he is going and what he is going to do, and earthquakes shall not deter him. He is the most dynamic creature in all creation, I think, except perhaps the dragon fly, and he is so ferocious that if he were as large as a shark he would destroy all other fishes. His ferocity is frightful to behold as he seizes his prey and shakes it as a terrier does a rat.

Well is this fish named stickleback, for along the ridge of its back are sharp, strong spines — five of them in our tiny brook species. These spines may be laid back flat or they may be erected stiffly, making an efficient saw which does great damage to fish many times larger than the stickleback. When we find the minnows in the aquarium losing their scales, we may be sure they are being raked off by this sawback; and if the shiner or sunfish undertakes to make a stickleback meal, there is only one way to do it, and that is to catch the quarry by the tail, since he is too alert to be caught in any other way. But swallowing a stickleback tail first is a dangerous performance, for the sharp spines rip open the throat or stomach of the captor. Dr. Jordan says that the sticklebacks of the Puget Sound region are called "salmon killers" and that they well earn the name; these fierce midgets unhesitatingly attack the salmon, biting off pieces of their fins and also destroying their spawn.

As seen from the side, the stickleback is slender and graceful, pointed like an arrow at the front end, and with the body behind the dorsal fin forming a long and slender pedicel to support the beautifully rounded tail fin. The dorsal fin is placed well back and is triangular in shape; the anal fin makes a similar triangle opposite it below and has a sharp spine at its front edge. The color of the body varies with the light; when the stickleback is floating among the water weeds, the back is greenish mottled with paler green, but when the fish is down on the gravel, it is much darker. The lateral line is marked by a silver stripe.

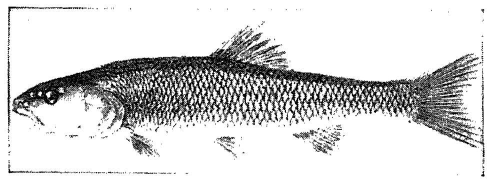
If large eyes count for beauty, then the stickleback deserves "the apple," for its eyes are not only large but gemlike, with a broad iris of golden brown around the black pupil. I am convinced that the stickleback has a keener vision than most fish; it can move its eyes backward and forward rapidly and alertly. The mouth opens almost upward and is a wicked little mouth, in both appearance and action.

When swimming, the stickleback darts about rapidly, its dorsal and anal fins extended, its spines all abristle, and its tail lashing the water with strong strokes. When the fish wishes to lift itself through the water, it seems to depend entirely upon its pectoral fins and these are also used for balancing. Its favorite position is hanging motionless among the pond weeds, with the tail and the dorsal and ventral fins partially closed; it usually rests upon the pectoral fins which are braced against some stem; in one case I saw the ventrals and pectorals used together to clasp a stem and hold the fish in place. In moving backward the pectorals do the work, with a little beckoning motion of the tail occasionally. When resting upon the bottom of the aquarium, it closes its fins and makes itself quite inconspicuous. It can dig with much power, accomplishing this by a comical auger-like motion; it plunges head first into the gravel and then, by twisting the body and tail around and around, it soon forms a hiding place.

But it is as house builder and father and home protector that the stickleback shines. In the early spring he builds him a nest made from the fine green algæ called frog-spittle. This would seem too delicate a material for the house construction, but he is a clever builder. He fastens his filmy walls to some stems of reed or grass, using as a platform a supporting stem; the ones which I have especially studied were fastened to grass stems. The stickleback has a little cement plant of his own, supposed to be situated in the kidneys, which at this time of year secretes the glue for building purposes. The glue is waterproof. It is spun out in fine threads or in filmy masses through an opening near the anal fin. One species weights his platform with sand which he scoops up from the bottom, but I cannot detect that our brook stickleback does this. In his case, home is his sphere literally, for he builds a spherical house about the size of a glass marble, three-quarters of an inch in diameter. It is a hollow sphere; he cements the inside walls so as to hold them back and give room, and he finishes his pretty structure with a circular door at the side. When finished, the nest is like a bubble made of threads of down, and yet it holds together strongly.

In the case of the best-known species, the male, as soon as he has finished his bower to his satisfaction, goes a-wooing; he selects some lady stickleback, and in his own way tells her of the beautiful nest he has made and convinces her of his ability to take care of a family. He certainly has fetching ways, for he soon conducts her to his home. She enters the nest through the little circular door, lays her eggs within it, and then, being a flighty creature, she sheds responsibilities and flits off carefree. He follows her into the nest, scatters the fertilizing milt over the eggs, and then starts off again and rolls his golden eyes on some other lady stickleback and invites her also to his home. She comes without any jealousy because she was not first choice; she also enters the nest and lays her eggs and then swims off unconcernedly. Again he enters the nest and drops more milt upon the eggs and then fares forth again, a still energetic wooer. If there was ever a justified polygamist, he is one, since it is only the cares and responsibilities of the home that he desires. He only stops wooing when his nest holds as many eggs as he feels equal to caring for. He now stands on guard by the door, and with his winnowing pectoral fins sets up a current of water over the eggs; he drives off all intruders with the most vicious attacks, and keeps off many an enemy simply by a display of reckless fury; thus he stands guard until the eggs hatch and the tiny little sticklebacks come out of the nest and float off, attaching themselves by their mouths to the pond weeds until they become strong enough to scurry around in the water.

Some species arrange two doors in this spherical nest so that a current of water can flow through and over the eggs. Mr. Eugene Barker, who has made a special study of the little brook sticklebacks of the Cayuga Basin, has failed to find more than one door to their nests. Mr. Barker made a most interesting observation on this stickleback's obsession for fatherhood. He placed in the aquarium two nests, one of which was still guarded by its loyal builder, who allowed himself to be caught



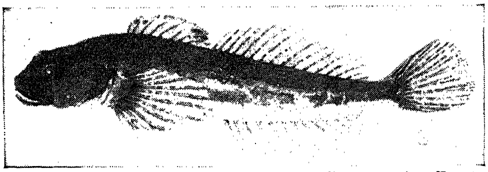
N. Y. State Conservation Dept.

Horned dace
Semotilus atromaculatus

rather than desert his post; the little guardian soon discovered the unprotected nest and began to move the eggs from it to his own, carrying them carefully in his mouth. This addition made his own nest so full that the eggs persistently crowded out of the door, and he spent much of his time nudging them back with his snout. We saw this stickleback fill his mouth with algæ from the bottom of the aquarium and holding himself steady a short distance away, apparently blow the algæ at the nest from a distance of half an inch; we wondered if this was his method of laying on his building materials before he cemented them.

The eggs of this species are white and shining like minute pearls, and seem to be fastened together in small packages with gelatinous matter. The mating habits of this species have not been thoroughly studied; therefore, here is an opportunity for investigation on the part of the boys and girls. The habits of other species of sticklebacks have been studied more than have those of the brook stickleback.

Suggested Reading — *Pathways in Science*, by G. S. Craig and Co-authors, Book 3, *Our Wide, Wide World; The Pet Book*, by Anna B. Comstock; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 144.



N. Y. State Conservation Dept.

A sculpin
Cottus cognatus

LESSON 41

The Stickleback

Leading Thought — The stickleback is the smallest of our common fish. It lives in stagnant water. The father stickleback builds his pretty nest of algæ and watches it very carefully.

Method — To find sticklebacks go to a pond of stagnant water which does not dry up during the year. If it is partly shaded by bushes, so much the better. Take a dip net and dip deeply; carefully examine all the little fish in the net by putting them in a Mason jar of water so that you can see what they are like. The stickleback is easily distinguished by the five spines along its back. If you collect these fish as early as the first of May and place several of them in the aquarium with plenty of the algæ known as frog-spittle and other water plants they may perhaps build a nest for you. They may be fed upon bits of meat or liver chopped very fine or upon earthworms cut into small sections.

Observations — 1. How did the stickleback gets its name? How many spines has it? Where are they situated? Are they always carried erect? How are these spines used as weapons? How do they act as a means of protection to the stickleback?

2. Describe or make a sketch showing the shape and position of the dorsal, the anal, the ventral, and the pectoral fins. What is the shape of the tail? What is the general shape of the fish?

3. What is the color of the sticklebacks? Is the color always the same? What is the color and position of the lateral line?

4. Describe the eyes. Are they large or small? Can they be moved? Do you think they can see far?

5. Describe the mouth. Does it open upward, straight ahead, or downward?

6. When the stickleback is swimming, what are the positions and motions of the dorsal, anal, tail, and pectoral fins? Can you see the ventral pair? Are they extended when the fish is swimming?

7. When resting among the pond weed of the aquarium what fins does the stickleback use for keeping afloat? How are the other fins held? What fins does it use to move backward? Which ones are used when it lifts itself from the bottom to the top of the aquarium? How are its fins placed when it is at rest on the bottom?

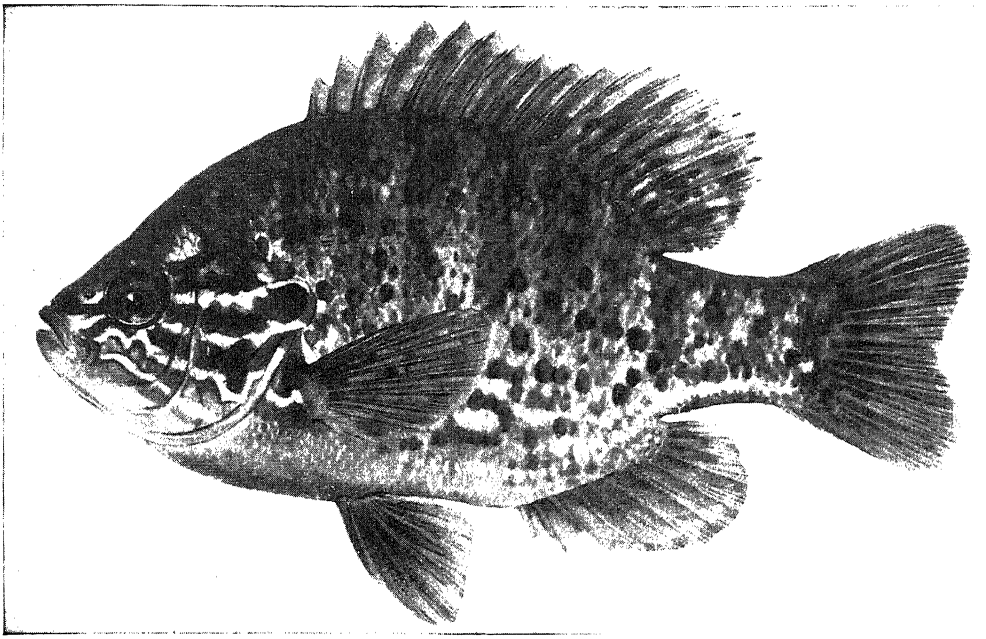
8. Drop a piece of earthworm or some liver or fresh meat cut finely into the aquarium and describe the action of the sticklebacks as they eat it. How large is a full-grown stickleback?

9. In what kind of ponds do we find sticklebacks? Do you know how the stickleback nest looks? Of what is it built? How is it supported? Is there one door or two? Does the father or mother stickleback build the nest? Are the young in the nest cared for? At what time is the nest built?

THE SUNFISH

This little disc of gay color has won many popular names. It is called pumpkinseed, tobacco box, and sunfish because of its shape, and it is also called bream and pondfish. I have always wondered that it was not called chieftain also, for when it raises its dorsal fin with its saw crest of spines, it looks like the headdress of an Indian chief; and surely no warrior ever had a greater enjoyment in a battle than does this indomitable little fish.

The sunfish lives in the eddies of our



State of New York Conservation Department

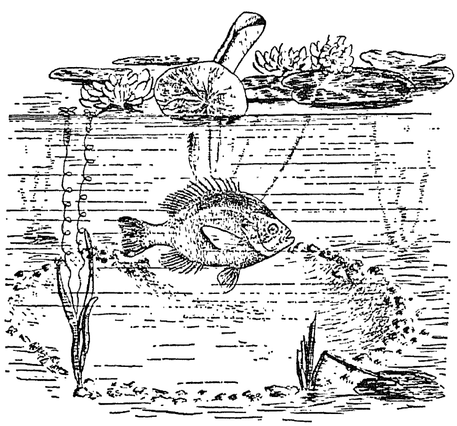
Sunfish or pumpkinseed
Eupomotis gibbosus

clear brooks and ponds. It is a near relative of the rock bass and also of the black bass and it has, according to its size, just as gamy qualities as the latter. I once had a sunfish on my line which made me think I had caught a bass and I do not know whether I or the mad little pumpkinseed was the more disgusted when I discovered the truth. I threw him back in the water, but his fighting spirit was up and he grabbed my hook again within five minutes, which showed that he had more courage than wisdom; it would have served him right if I had fried him in a pan, but I never could make up my mind to kill a fish for the sake of one mouthful of food.

Perhaps of all its names, "pumpkinseed" is the most graphic, for it resembles this seed in the outlines of its body when seen from the side. Looked at from above, it has the shape of a powerful craft with smooth, rounded nose and gently swelling and tapering sides; it is widest at the eyes and this is a canny arrangement, for these great eyes turn alertly in every direction; and thus placed they are able to discern the enemy or the dinner coming from any quarter.

The dorsal fin is a most militant looking organ. It consists of ten spines, the hind one closely joined to the hind dorsal fin, which is supported by the soft rays. The three front spines rise successively, one above another, and all are united by the membrane, the upper edge of which is deeply toothed. The hind dorsal fin is gracefully rounded and the front and hind fin work independently of each other, the latter often winnowing the water when the former is laid flat. The tail is strong and has a notch in the end; the anal fin has three spines on its front edge and ten soft rays. Each ventral fin also has a spine at the front edge and is placed below and slightly behind the pectorals. The pectoral fins, I have often thought, are the most exquisite and gauzelike in texture of all the fins I have ever seen; they are kept almost constantly in motion and move in such graceful flowing undulations that it is a joy to look at them.

The eye of the sunfish is very large and quite prominent; the large black pupil is surrounded by an iris that has shining lavender and bronze in it, but is more or less clouded above; the young ones have a pale silver iris. The eyes move in every direction and are eager and alert in their expression. The mouth is at the front of the body but it opens upward. The gill opening is prolonged backward at the upper corner, making an earlike flap; this, of course, has nothing to do with the fish's ears, but it is highly ornamental, as it is



Male sunfish guarding his nest

greenish-black in color, bordered by iridescent, pale green, with a brilliant orange spot on its hind edge. The colors of the sunfish are too varied for description and too beautiful to reduce to mere words. There are dark, dull, greenish or purplish cross-bands worked out in patterns of scale-mosaic, and between them are bands of pale, iridescent green, set with black-edged orange spots. But just as we have described his colors our sunfish darts off and all sorts of shimmering, shining blue, green and purple tints play over his body; and as he settles down into another corner of the aquarium, his colors seem much paler and we have to describe him over again. The body below is brassy yellow.

The beautiful colors which the male sunfish dons in spring, he puts at once to practical use. Professor Reighard says that when courting and trying to persuade his chosen one to come to his nest and there deposit her eggs, he faces her, with his gill covers puffed out, the scarlet or orange spot on the ear-flap standing out bravely, and his black ventral fins spread wide to show off their patent-leather finish. Thus does he display himself before her and intimidate her; but he is rarely allowed to do this in peace. Other males as brilliant as he arrive on the scene and he must forsooth stop parading before his lady love in order to fight his rival, and he fights with as much display of color as he courts. In the sunfish duel, however, the participants do not seek to destroy each other but to intimidate each other. The vanquished one retires. Professor Gill says: "Meanwhile the male has selected a spot in very shallow water near the shore, and generally in a mass of aquatic vegetation, not too large or close together to entirely exclude the light and heat of the sun, and mostly under an overhanging plant. The choice is apt to be in some general strip of shallow water close by the shore which is favored by many others so that a number of similar nests may be found close together, although never encroaching on each other. Each fish slightly excavates and makes a saucer-like basin in the chosen area which is carefully cleared of all pebbles. Such are removed by violent jerks of the caudal fin or are taken up by the mouth and carried to the circular boundary of the nest. An area of fine, clean sand or gravel is generally the result, but not infrequently, according to Dr. Reighard, the nest bottom is composed of the rootlets of water plants. The nest has a diameter of about twice the length of the fish."

On the nest thus formed, the sunfish belle is invited to deposit her eggs, which as soon as laid fall to the bottom and become attached to the gravel at the bottom of the nest by the viscid substance which surrounds them. Her duty is then done and she departs, leaving the master in charge of his home and the eggs. If truth be told, he is not a strict monogamist. Professor Reighard noticed one of these males which reared in one nest two broods laid at quite different times by two females. For about a week, depending upon the temperature, the male is absorbed in his care of the eggs and defends his nest with much ferocity; but after the eggs have hatched he considers his duty done and lets his progeny take care of themselves as best they may.

Sunfish are easily taken care of in an aquarium, but each should be kept by himself, as they are likely to attack any smaller fish and are most uncomfortable neighbors. I have kept one of these beautiful, shimmering pumpkinseeds for nearly a year by feeding him every alternate day with an earthworm; the unfortunate worms are kept stored in damp soil in an iron kettle during the winter. When I threw one of them into the aquarium the sunfish would seize it and shake it as a terrier shakes a rat; but this was perhaps to make sure of his hold. Once he attempted to take a second worm directly after the first; but it was a doubtful proceeding, and the worm reappeared as often as a prima donna, waving each time a frenzied farewell to the world.

Suggested Reading—*Along the Brook,* by Raymond T. Fuller; *Backyard Exploration,* by Paul G. Howes; *The Pet Book,* by Anna B. Comstock; also, readings on page 144.

LESSON 42

The Sunfish

Leading Thought — The pumpkinseeds are very gamy little fishes which seize the hook with much fierceness. They live in the still waters of our streams or in ponds and build nests in the spring, in which the eggs are laid and which they defend valiantly.

Method — The common pumpkinseed in the jar aquarium is all that is necessary for this lesson. However, it will add much to the interest of the lesson if the boys who have fished for pumpkinseeds will tell of their experiences. The children should acquire from this lesson an interest in nesting habits of the sunfishes.

Observations — 1. Where are the sunfish found? How do they act when they take the hook?

2. What is the general shape of the sunfish's body as seen from above? As seen from the side? Why is it called pumpkinseed?

3. Describe the dorsal fin. How many spines has it? How many soft rays? What is the difference in appearance between the front and hind dorsal fin? Do the two act together or separately? Describe the tail fin. Describe the anal fin. Has it any spines? If so, where are they? Where are the ventral fins in relation to the pectorals? What is there peculiar about the appearance and movements of the pectoral fins?

4. Describe the eye of the sunfish. Is it large or small? Is it placed so that the fish can see on each side? Does the eye move in all directions?

5. Describe the position of the mouth. In which direction does it open?

6. What is the color of the upper portion of the gill opening or operculum? What is the general color of the sunfish? Above? Below? Along the sides? What markings do you see?

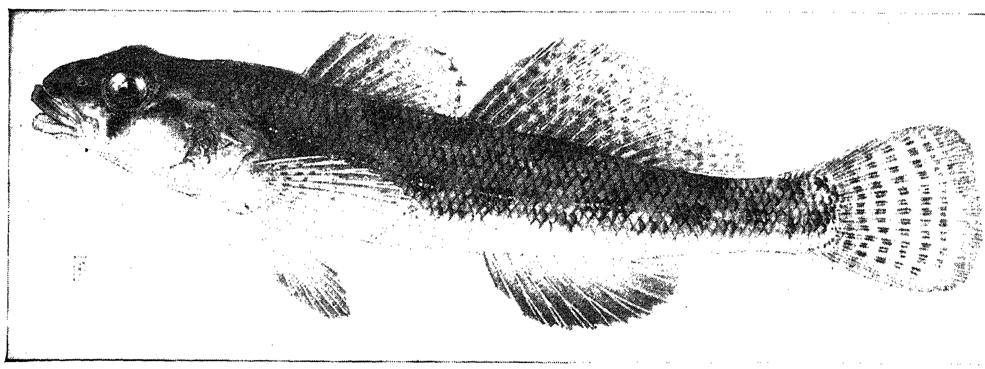
7. Where does the sunfish make its nest? Does the father or mother sunfish make the nest? Does one or both protect it? Describe the nest.

8. How many names do you know for the sunfish? Describe the actions of your sunfish in the aquarium. How does he act when eating an earthworm?

The lamprey is not a fish at all, only a wicked imitation of one which can deceive nobody. But there are fishes which are unquestionably fish — fish from gills to tail, from head to fin, and of these the little sunfish may stand first. He comes up the brook in the spring, fresh as " coin just from the mint," finny arms and legs wide spread, his gills moving, his mouth opening and shutting rhythmically, his tail wide spread, and ready for any sudden motion for which his erratic little brain may give the order. The scales of the sunfish shine with all sorts of scarlet, blue, green, and purple and golden colors. There is a black spot on his head which looks like an ear, and sometimes grows out *in a long black flap, which makes the imitation still closer. There are many species of the sunfish, and there may be half a dozen of them in the same brook, but that makes no difference; for our purposes they are all one.*

They lie poised in the water, with all fins spread, strutting like turkey-cocks, snapping at worms and little crustaceans and insects whose only business in the brook is that the fishes may eat them. When the time comes, the sunfish makes its nest in the fine gravel, building it with some care — for a fish. When the female has laid her eggs the male stands guard until the eggs are hatched. His sharp teeth and snappish ways, and the bigness of his appearance when the fins are all displayed, keep the little fishes away. Sometimes, in his zeal, he snaps at a hook baited with a worm. He then makes a fierce fight, and the boy who holds the rod is sure that he has a real fish this time. But when the sunfish is out of the water, strung on a willow rod, and dried in the sun, the boy sees that a very little fish can make a good deal of a fuss.

— David Starr Jordan



State of New York Conservation Department

Johnny darter
Boleosoma nigrum

THE JOHNNY DARTER

We never tired of watching the little Johnny, or Tessellated darter (Boleosoma nigrum); although our earliest aquarium friend, (and the very first specimens showed us by a rapid ascent of the river weed how " a Johnny could climb trees,") he has still many resources which we have never learned. Whenever we try to catch him with the hand we begin with all the uncertainty that characterized our first attempts, even if we have him in a two-quart pail. We may know him by his short fins, his first dorsal having but nine spines, and by the absence of all color save a soft, yellowish brown, which is freckled with darker markings. The dark brown on the sides is arranged in seven or eight W-shaped marks, below which are a few flecks of the same color. Covering the sides of the back are the wavy markings and dark specks which have given the name of the " Tessellated Darter "; but Boleosoma is a preferred name, and we even prefer " boly " for short. In the spring the males have the head jet black; and this dark color often extends on the back part of the body, so that the fish looks as if he had been taken by the tail and dipped into a bottle of ink. But with the end of the nuptial season this color disappears and the fish regains his normal, strawy hue.

His actions are rather bird-like; for he will strike attitudes like a tufted titmouse and he flies rather than swims through the water. He will, with much perseverance, push his body between a plant and the sides of the aquarium and balance himself on a slen-

der stem. Crouching catlike before a snail shell, he will snap off a horn which the unlucky owner pushes timidly out. But he is also less dainty and seizing the animal by the head, he dashes the shell against the glass or stones until he pulls the body out or breaks the shell. — David Starr Jordan

The johnny darters are, with the sticklebacks, the most amusing little fish in the aquarium. They are well called darters since their movements are so rapid when they are frightened that the eye can scarcely follow them; and there is something so irresistibly comical in their bright, saucy eyes, placed almost on top of the head, that no one could help calling one of them "Johnny." A "johnny" will look at you from one side, and then as quick as a flash, will flounce around and study you with the other eye and then come toward you head-on so that he may take you in with both eyes; he seems just as interested in the Johnny out of the jar as is the latter in the johnny within.

The johnny darter has a queerly shaped body for a fish, for the head and shoulders are the larger part of him — not that he suddenly disappears into nothingness; by no means! His body is long and very slightly tapering to the tail; along his lateral line he has a row of olive-brown W's worked out in scale-mosaic; and he has some other scale-mosaics also following a pattern of angular lines and making blotches along his back. The whole upper part of his body is pale olive, which is a good imitation of the color of the brook.

The astonished and anxious look on the johnny darter's face comes from the peculiar position of the eyes, which are set in the top of his forehead; they are big, alert eyes, with large black pupils, surrounded by a shining, pale yellow line at the inner edge of the green iris; and as the pupil is not set in the center of the eye, the iris above being wider than below, the result is an astonished look, as from raised eyebrows. The eyes move, often so swiftly that it gives the impression of winking. The eyes, the short snout, and the wide mouth give johnny a decidedly froglike aspect.

Although he is no frog, yet johnny darter seems to be in a fair way to develop something to walk upon. His pectoral fins are large and strong and the ventral pair are situated very close to them; when he rests upon the gravel he supports himself upon one or both of these pairs of fins. He rests with the pectoral fins outspread, the sharp points of the rays taking hold of the gravel like toenails and thus giving him the appearance of walking on his fins; if you poke him gently, you will find that he is very firmly planted on his fins so that you can turn him around as if he were on a pivot. He also uses the pectorals for swimming and jerks himself along with them in a way that makes one wonder if he could not swim well without any tail at all. The tail is large and almost straight across the end and is a most vigorous pusher. There are two dorsal fins. The front one has only spiny rays; when the fin is raised it appears almost semicircular in shape. The second dorsal fin is much longer, and when lifted stands higher than the front fin; its rays are all soft except the front one. As soon as the johnny stops swimming he shuts the front dorsal fin so that it can scarcely be detected; when he is frightened, his body lies motionless on the bottom; this act always reminds one of the "freezing" habit of the rabbit. But johnny does not stay scared very long; he lifts his head up inquisitively, stretching up as far as he is able on his feet, that is, his paired fins, in such a comical way that one can hardly realize he is a fish.

The tail and the dorsal fin of the johnny darter are marked with silver dots which give them an exquisite spun-glass look; they are as transparent as gauze.

The johnny darters live in clear, swift streams where they rest on the bottom, with the head upstream. Dr. Jordan has said they can climb up water weed with their paired fins. I have never observed them doing this but I have often seen one walk around the aquarium on his fins as if they were little fan-shaped feet; and when swimming he uses his fins as a bird uses its wings. There are many species of darters, some of them the most brilliantly colored of all our fresh-water fishes. The darters are perchlike in form.

Dr. Jordan says of the breeding habits of the darters: "On the bottom, among the stones, the female casts her spawn. Neither she nor the male pays any further attention to it, but in the breeding season the male is painted in colors as beautiful as those of the wood warblers. When you go to the brook in the spring you will find him there, and if you catch him and turn him over on his side you will see the colors that he shows to his mate, and which observation shows are most useful in frightening away his younger rivals. But do not hurt him. Put him back in the brook and let him paint its bottom with colors of a rainbow, a sunset or a garden of roses. All that can be done with blue, crimson and green pigments, in fish ornamentation, you will find in some brook in which the darters live."

Suggested Reading—*Along the Brook*, by Raymond T. Fuller; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*; *The Pet Book*, by Anna B. Comstock; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 144.

LESSON 43

Johnny Darter

Leading Thought — The johnny darter naturally rests upon the bottom of the stream. It uses its two pairs of paired fins somewhat as feet in a way interesting to observe.

Method — Johnny darters may be caught in nets with other small fish and placed in the aquarium. Place one or two of them in individual aquaria where the pupils may observe them at their leisure. They do best in running water.

Observations — 1. Describe or sketch the johnny darter from above. From the side. Can you see the W-shaped marks along its side? How is it colored above?

2. How are the pectoral fins placed? Are they large or small? How are they used in swimming? Where are the ventral fins placed? How are the ventrals and dorsals used together? When resting on the bottom how are the pectoral fins used?

3. What is there peculiar about the dorsal fins of the johnny darter? When he is resting, what is the attitude of the dorsal fins? What is the difference in shape of the rays of the front and hind dorsal fins?

4. When resting on the bottom of the aquarium how is the body held? On what does it rest? In moving about the bottom slowly why does it seem to walk? How does it climb up water weed?

5. When frightened how does it act? Why is it called a darter? What is the attitude of all the fins when the fish is moving swiftly?

6. What is the shape of the tail?

7. What is there peculiar about the eyes of the johnny? Describe the eyes and their position. What is there in the life of the fish that makes this position of the eyes advantageous?

8. Where do we find the johnny darters? In what part of the stream do they live? Are they usually near the surface of the water or at the bottom?

To my mind, the best of all subjects for nature-study is a brook. It affords studies of many kinds. It is near and dear to every child. It is an epitome of the nature in which we live. In miniature, it illustrates the forces which have shaped much of the earth's surface. It reflects the sky. It is kissed by the sun. It is rippled by the wind. The minnows play in the pools. The soft weeds grow in the shallows. The grass and the dandelions lie on its sunny banks. The moss and the fern are sheltered in the nooks. It comes from one knows not whence; it flows to one knows not whither. It awakens the desire to explore. It is fraught with mysteries. It typifies the flood of life. It goes on forever.

In other words, the reason why the brook is such a perfect nature-study subject is the fact that it is the central theme *in a scene of life. Living things appeal to children.*

Nature-study not only educates, but it educates nature-ward; and nature is ever our companion, whether we will or no. Even though we are determined to shut ourselves in an office, nature sends her messengers. The light, the dark, the moon, the cloud, the rain, the wind, the falling leaf, the fly, the bouquet, the bird, the cockroach — they are all ours.

If one is to be happy, he must be in sympathy with common things. He must live in harmony with his environment. One cannot be happy yonder nor to-morrow: he is happy here and now, or never. Our stock of knowledge of common things should be great. Few of us can travel. We must know the things at home.

Nature-love tends toward naturalness, and toward simplicity of living. It tends country-ward. One word from the fields is worth two from the city. "God made the country."

I expect, therefore, that much good will come from nature-study. It ought to revolutionize the school life, for it is capable of putting new force and enthusiasm into the school and the child. It is new, and therefore, is called a fad. A movement is a fad until it succeeds. We shall learn much, and shall outgrow some of our present notions, but nature-study has come to stay. It is in much the same stage of development that manual-training and kindergarten work were twenty-five years ago. We must take care that it does not crystallize into science-teaching on the one hand, nor fall into mere sentimentalism on the other.

I would again emphasize the importance of obtaining our fact before we let loose the imagination, for on this point will largely turn the results — the failure or the success of the experiment. We must not allow our fancy to run away with us. If we hitch our wagon to a star, we must ride with mind and soul and body all alert. When we ride in such a wagon, we must not forget to put in the tail-board.

— "The Nature-Study Idea,"
L. H. Bailey

AMPHIBIANS

Especially during early spring, one is likely to see many frogs, toads, and salamanders about ponds and other shallow water. These animals are harmless creatures; they do not bite and their chief method of defense is to escape to some place of concealment.

While there are exceptions to the general rule, and great variations in the life habits of these animals, it may be said that they are fitted to spend certain periods of their lives on land and other periods in water. In general, the immature stages are passed in or quite near water and the young are commonly called tadpoles. Of course, this means that the males and females of most species must return each year to the ponds, streams, or pools for the purpose of mating. Eggs are laid at once and usually hatch within a few days; the length of time varies according to the species and the weather conditions.

To this entire group of cold-blooded animals the term *amphibian* is applied; this term was selected because it really means "double life" — these animals live part of their lives on land and part in or quite near water. The presence or absence of a tail, during adult life, divides the amphibians into two more or less natural groups, *the tailed and the tailless amphibians.*

Suggested Reading — *Along Nature's Trails,* by Lillian C. Athey; *Backyard Exploration,* by Paul G. Howes; *Field Book of Ponds and Streams,* by Ann H. Morgan; *Our Great Outdoors, Reptiles, Amphibians and Fishes,* by C. W. G. Eifrig; *Out-of-Doors, A Guide to Nature,* by Paul B. Mann and George T. Hastings; *Reptiles and Amphibians; Their Habits and Adaptations,* by Thomas Barbour; *The Stir of Nature,* by William H. Carr. (See also the *Bibliography* in the back of this book.)

THE TAILLESS AMPHIBIANS

This group includes the frogs and toads. In attaining the adult stage these animals lose their tadpole tails; but we do not mean that the tail drops from the body; rather let us say that it is absorbed by the body before the animal reaches the adult stage.

THE COMMON TOAD

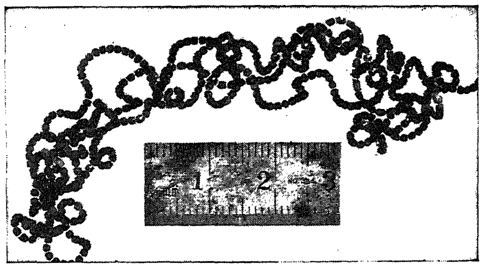
The toad hopped by us with jolting springs. — Akers

Whoever has not had a pet toad has missed a most entertaining experience. Toad actions are surprisingly interesting; one of my safeguards against the blues is the memory of the thoughtful way one of my pet toads rubbed and patted its stomach with its little hands after it had swallowed a June bug. Toads do not make warts upon attacking hands, neither do they rain down nor are they found in the bedrock of quarries; but they do have a most interesting history of their own, which is not at all legendary, and which is very like a life with two incarnations.

Tadpoles

The mother toad lays her eggs in May and June in ponds, or in the still pools, along streams; the eggs are laid in long strings of jelly-like substance, and are dropped upon the pond bottom or attached to water weeds; when first deposited, the jelly is transparent and the little black eggs can be plainly seen; but after a day or two, bits of dirt accumulate upon the jelly, obscuring the eggs. At first the eggs are spherical, like tiny black pills; but as they begin to develop, they elongate and finally the tadpoles may be seen wriggling in the jelly mass, which affords them efficient protection. After four or five days, the tadpoles usually work their way out and swim away; at this stage, the only way to detect the head is by the direction of the tadpole's progress, since it naturally goes head first. However, the head soon becomes decidedly larger, although at first it is not provided with a mouth; it has, instead, a V-shaped elevation where the mouth should be, which forms a sucker secreting a sticky substance. By means of this substance the tadpole attaches itself to water weeds, resting head up. When the tadpoles are two or three days old, we can detect little tassels on either side of

The toad in various stages of development from the egg to the adult



A. A. and A. H. Wright

Eggs of the spadefoot toad, Bufo compactilis. *Some toads lay as many as* 8,000 *eggs in a season*

the throat, which are the gills by which the little creature breathes; the blood passes through these gills, and is purified by coming in contact with the air which is mixed in the water. About ten days later, these gills disappear beneath a membrane which grows down over them; but they are still used for breathing, simply having changed position from the outside to the inside of the throat. The water enters the nostrils to the mouth, passes through an opening in the throat and flows over the gills and out through a little opening at the left side of the body; this opening or breathing-pore can be easily seen in the larger tadpoles; and when the left arm develops, it is pushed out through this convenient orifice.

When about ten days old, the tadpole has developed a small, round mouth which is constantly in search of something to eat, and at the same time is constantly opening and shutting to take in air for the gills; the mouth is provided with horny jaws for biting off pieces of plants. As the tadpole develops, its mouth gets larger and wider and extends back beneath the eyes, with a truly toadlike expansiveness.

At first, the tadpole's eyes are even with the surface of the head and can scarcely be seen, but later they become more prominent and bulge like the eyes of the adult toad.

The tail of the tadpole is long and flat, surrounded by a fin, and so is an organ for swimming. It strikes the water, first this side and then that, making most graceful curves, which seem to originate

A. A. and A. H. Wright

Eggs of Hammond's spadefoot, Scaphiopus hammondii. *Although it looks so like our common toad, the spadefoot belongs to a different genus; it lays its eggs in cylindrical masses on submerged twigs or grass*

near the body and multiply toward the tip of the tail. This movement propels the tadpole forward, or in any direction. The tail is very thin when seen from above; and it is amusing to look at a tadpole from above, and then at the side; it is like squaring a circle.

There is a superstition that tadpoles eat their tails; and in a sense this is true, because the material that is in the tail is absorbed into the growing body; but the last thing a right-minded tadpole would do would be to bite off its own tail. However, if some other tadpole should bite off the tail or a growing leg, these organs conveniently grow anew.

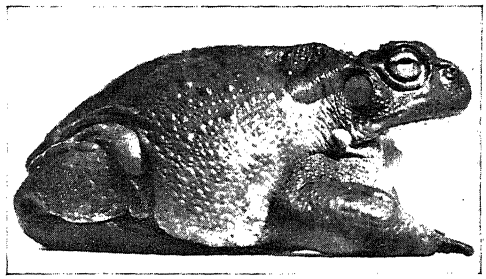
When the tadpole is a month or two old, depending upon the species, its hind legs begin to show; they first appear as mere buds which finally push out completely. The feet are long and are provided with five toes, of which the fourth is the longest; the toes are webbed so that they may be used to help in swimming. Two weeks later the arms begin to appear, the left one pushing out through the breathing-pore. The " hands " have four fingers and are not webbed; they are used in the water for balancing, while the hind legs are used for pushing, as the tail becomes smaller.

As the tadpole grows older, not only does its tail become shorter but its actions change. It now comes often to the surface of the water in order to get more air for its gills, although it lacks the frog tadpole's nice adjustment of the growing lungs and the disappearing gills. At last, some fine rainy day, the little creature feels that it is finally fitted to live the life of a land animal. It may not be a half inch in length, with big head, attenuated body, and stumpy tail, but it swims to the shore, lifts itself on its front legs, which are scarcely larger than pins, and walks off, toeing in, with a very grownup air; and at this moment the tadpole attains toadship. Numbers of tadpoles come out of the water together, hopping hither and thither with all of the eagerness and vim of untried youth. It is through issuing thus in hordes from the water that they gain the reputation of being rained down, when they really were rained up. It is quite impossible for a beginner to detect the difference between the toad and the frog tadpole; usually those of the toads are black, while those of the frogs are otherwise colored, though this is not an invariable distinction. The best way to distinguish the two is to get the eggs and develop the two families separately.

The Adult Toad

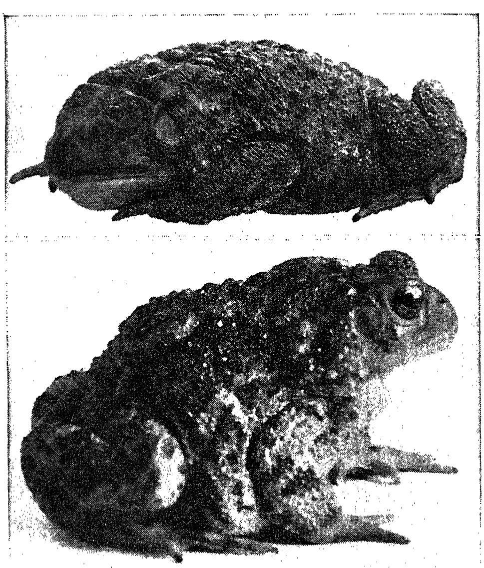
The general color of the common American toad is extremely variable. It may be yellowish brown, with spots of lighter color, and with reddish or yellow warts. There are likely to be four irregular spots of dark color along each side of the middle of the back, and the under parts are light-colored, often somewhat spotted. The throat of the male toad is black and he is not so bright in color as is the female. The warts upon the back are glands, which secrete a substance disagreeable for the animal seeking toad dinners. This is especially true of the glands in the elongated swellings above and just back of the ear, which are called the parotid glands; these give forth a milky, poisonous substance when the toad is seized by an enemy, although the snakes do not seem to mind it. Some people have an idea that the toad is slimy, but this is not true; the skin is perfectly dry. The toad feels cold to the hand because it is a cold-blooded animal, which means an animal with blood the temperature of the surrounding atmosphere; the blood of the warm-blooded animal has a temperature of its own, which it maintains whether the surrounding air is cold or hot.

The toad's face is well worth study; its eyes are elevated and very pretty, the pupil being oval and the surrounding iris shining like gold. The toad winks in a wholesale fashion, the eyes being pulled down into the head; the eyes are provided with nictitating lids, which rise from below, and are similar to those found in birds. When a toad is sleeping, its eyes do not bulge but are drawn in, so as to lie even with the surface of the head. The two



A. A. and A. H. Wright

The giant toad, Bufo alvarius. *This huge toad of the Southwest is from* $3\frac{1}{4}$ *to* $6\frac{1}{2}$ *inches long. If molested it will secrete a fluid which is strong enough to paralyze a dog*



S. H. Gage

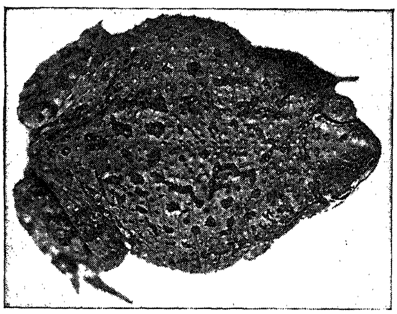
A common toad, Bufo americanus, *as he appears in winter sleep and after awakening in the spring*

tiny nostrils are black and are easily seen; the ear is a flat, oval spot behind the eye and a little lower down; in the common species it is not quite so large as the eye; this is really the eardrum, since there is no external ear like ours. The toad's mouth is wide and its jaws are horny; it does not need teeth since it swallows its prey whole.

The toad is a jumper, as may be seen from its long, strong hind legs, the feet of which are also long and strong and are armed with five toes that are somewhat webbed. The "arms" are shorter and there are four "fingers" to each "hand"; when the toad is resting, its front feet toe-in in a comical fashion. If a toad is removed from an earth or moss garden, and put into a white wash-bowl, in a few hours it will change to a lighter hue, and vice versa. This is part of its protective color, making it inconspicuous to the eyes of its enemy. It prefers to live in cool, damp places, beneath sidewalks or porches, etc., and its warty upper surface resembles the surrounding earth. If it is disturbed, it will seek to escape by long leaps, and acts frightened; but if very much frightened, it flattens out on the ground, and looks so nearly like a clod of earth that it may escape even the keen eyes of its pursuer. When seized by the enemy, it will sometimes "play possum," acting as if it were dead; but when actually in the mouth of the foe, it emits terrified and heart-rending cries.

The toad's tongue is attached to the

lower jaw, at the front edge of the mouth; it can thus be thrust far out, and since it secretes a sticky substance over its surface, any insects which it touches adhere, and are drawn back into the mouth and swallowed. It takes a quick eye to see this tongue fly out and make its catch. The tadpole feeds mostly upon vegetable matter, but the toad lives entirely upon small animals, usually insects; it is not particular as to what kind of insects, but because of the situations which it haunts, it usually feeds upon those which are injurious to grass and plants. Indeed, the toad is really the friend of the gardener and the farmer, and has been most ungratefully treated by those whom it has befriended. If you doubt that a toad is an animal of judgment, watch it when it finds an earthworm and set your doubts at rest! It will walk around the squirming worm, until it can seize it by the head, apparently knowing well that the horny hooks extending backward from the segments of the worm are likely to rasp the throat if swallowed the wrong way. If the worm prove too large a mouthful, the toad promptly uses its hands in an amusing fashion to stuff the wriggling morsel down its throat. When swallowing a large mouthful, it closes its eyes; but whether this aids the process, or is merely an expression of bliss, we have not determined. The toad never drinks by taking in water through the mouth, but absorbs it through the skin; when it wishes to drink, it stretches itself out in shallow water and thus satisfies its thirst; it will waste away and die in a short time, if kept in a dry atmosphere.



A. A. and A. H. Wright

The little green toad, Bufo debilis. *This small amphibian, resembling a lichen in appearance, is about 1½ inches long. It lives in grassy flat lands from Kansas and Colorado south into northern Mexico*

The toad burrows in the earth by a method of its own, hard to describe. It kicks backward with its strong hind legs, and in some mysterious way, the earth soon covers all excepting its head; then, if an enemy comes along, back goes the head, the earth caves in around it, and where is your toad! It remains in its burrow or hiding place usually during the day, and comes out at night to feed. This habit is an advantage, because snakes are then safely at home and, too, there are many more insects to be found at night. The sagacious toads have discovered that the vicinity of street lights is swarming with insects, and there they gather in numbers. In winter they burrow deeply in the ground and go to sleep, remaining dormant until the warmth of spring awakens them; then they come out, and the mother toads seek their native ponds there to lay eggs for the coming generation. They are excellent swimmers; when they are swimming rapidly, the front legs are laid backward along the sides of the body, so as to offer no resistance to the water; but when they are moving slowly, the front legs are used for balancing and for keeping afloat.

The song of the toad is a pleasant, crooning sound, a sort of guttural trill; it is made when the throat is puffed out almost globular, thus forming a vocal sac; the sound is made by the air drawn in at the nostrils and passed back and forth from the lungs to the mouth over the vocal chords, the puffed-out throat acting as a resonator.

The toad has no ribs by which to inflate the chest, and thus draw air into the lungs, as we do when we breathe; it is obliged to swallow the air instead and thus force it into the lungs. This movement is shown in the constant pulsation, in and out, of the membrane of the throat.

As the toad grows, it sheds its horny

skin, which it swallows; as this process is usually done strictly in private, the ordinary observer sees it but seldom. One of the toad's nice common qualities is its enjoyment in having its back scratched gently.

The toad has many enemies; chief among these is the snake and only less so are crows and also birds of prey.

Suggested Reading — *The Frog Book*, by Mary C. Dickerson; *Handbook of Frogs and Toads*, by Anna A. and Albert H. Wright; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 2, *By the Roadside*; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; *Science Stories*, by Wilbur L. Beauchamp and Co-authors, Book 1; also, readings on page 170.

LESSON 44

The Tadpole Aquarium

Leading Thought — The children should understand how to make the tadpoles comfortable and thus be able to rear them.

Materials — A tin or agate pan, a deep earthenware wash-bowl, a glass dish, or a wide-mouthed glass jar.

Things to Be Done — 1. Go to some pond where tadpoles live.

2. Take some of the small stones on the bottom and at the sides of the pond, lifting them very gently so as not to disturb what is growing on their surface. Place these stones on the bottom of the pan, building up one side higher than the other, so that the water will be more shallow on one side than on the other; a stone or two should project above the water.

3. Take some of the mud and leaves from the bottom of the pond, being careful not to disturb them, and place upon the stones.

4. Take some of the plants found growing under water in the pond and plant them among the stones.

5. Carry the pan thus prepared back to the schoolhouse and place it where the sun will not shine directly upon it.

6. Bring a pail of water from the pond and pour it very gently in at one side of the pan, so as not to disarrange the plants; fill the pan nearly to the brim.

7. After the mud has settled and the water is perfectly clear, remove some of the tadpoles which have hatched in the glass aquarium and place them in the "pond." Not more than a dozen should be put in a pan of this size, since the amount of food and microscopic plants which are on the stones in the mud will afford food for only a few tadpoles.

8. Every week add a little more mud from the bottom of the pond or another stone covered with slime, which is probably some plant growth. More water from the pond should be added to replace that evaporated.

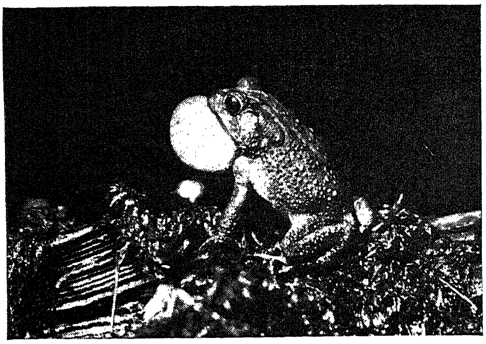
9. Care should be taken that the tadpole aquarium be kept where the sun will not shine directly upon it for any length of time, because if the water gets too warm the tadpoles will die.

10. Remove the "skin" from one side of a tulip leaf, so as to expose the pulp of the leaf, and give to the tadpoles every day or two. Bits of hard-boiled egg should be given now and then.

Toads' Eggs and Tadpoles

Leading Thought — The toads' eggs are laid in strings of jelly in ponds. The eggs hatch into tadpoles which are creatures of the water, breathing by gills, and swimming with a long fin. The tadpoles gradually change to toads, which are air-breathing creatures, fitted for life on dry land.

Method — The eggs of toads may be found in almost any pond about the first of May and may be scraped up from the bottom in a scoop-net. They should be placed in the aquarium where the children can watch the stages of development. Soon after they are hatched, a dozen or so should be selected and placed in the tadpole aquarium and the others put back into the stream. The children should ob-



F. Harper and A. A. Wright

Southern toad, Bufo terrestris. *When the male is croaking his throat is puffed out as in the picture. The color of the Southern toads varies from red or gray to black, and in size they range in length from 1½ inches to 3½ inches. They are found from North Carolina to Florida and west to the Mississippi River*

serve the tadpoles every day, watching carefully all the changes of structure and habit which take place. If properly fed, the tadpoles will be ready to leave the water in July as tiny toads.

Observations — 1. Where were the toads' eggs found and on what date? Were they attached to anything in the water or were they floating free? Are the eggs in long strings? Do you find any eggs laid in jelly-like masses? If so, what are they? How can you tell the eggs of toads from those of frogs?

2. Is the jelly-like substance in which the eggs are placed clear or discolored? What is the shape and the size of the eggs? A little later how do they look? Do the young tadpoles move about while they are still in the jelly mass?

3. Describe how the little tadpole works its way out from the jelly covering. Can you distinguish then which is head and which is tail? How does the tadpole act at first? Where and how does it rest?

4. Can you see with the aid of a lens the little fringes on each side of the neck? What are these? Do these fringes disappear a little later? Do they disappear on both sides of the neck at once? What becomes of them? How does the tadpole breathe? Can you see the little hole on the left side, through which the water used for breathing passes?

5. How does the tail look and how is it used? How long is it in proportion to the body? Describe the act of swimming.

6. Which pair of legs appears first? How do they look? When they get a little larger are they used as a help in swimming? Describe the hind legs and feet.

7. How long after the hind legs appear before the front legs or arms appear? What happens to the breathing-pore when the left arm is pushed through?

8. After both pairs of legs are developed what happens to the tail? What becomes of it?

9. When the tadpole is very young can you see its eyes? How do they look as it grows older? Do they ever bulge out like toads' eyes?

10. As the tadpole gains its legs and loses its tail how does it change in its actions? How does it swim now? Does it come oftener to the surface? Why?

11. Describe the difference between the front and the hind legs and the front and the hind feet on the fully grown tadpole. If the tail or a leg is bitten off by some other creature will it grow again?

LESSON 45

The Toad

Leading Thought — The toad is colored so that it resembles the soil and thus often escapes the observation of its enemies. It lives in damp places and eats insects, usually hunting them at night. It has powerful hind legs and is a vigorous jumper.

Method — Make a moss garden in a glass aquarium jar thus: Place some stones or gravel in the bottom of the jar and cover with moss. Cover the jar with a wire screen. The moss should be deluged with water at least once a day and the jar should be placed where the direct sunlight will not reach it. In this jar, place the toad for study.

Observations — 1. Describe the general color of the toad above and below. How does the toad's back look? Of what use are the warts on its back?

2. Where is the toad usually found?

Does it feel warm or cold to the hand? Is it slimy or dry? The toad is a cold-blooded animal; what does this mean?

3. Describe the eyes and explain how their situation is of special advantage to the toad. Do you think it can see in front and behind and above all at the same time? Does the bulge of the eyes help in this? Note the shape and color of the pupil and iris. How does the toad wink?

4. Find and describe the nostrils. Find and describe the ear. Note the swelling above and just back of the ear. Do you know the use of this?

5. What is the shape of the toad's mouth? Has it any teeth? Is the toad's tongue attached to the front or the back part of the mouth? How is it used to catch insects?

6. Describe the "arms and hands." How many "fingers" on the "hand"? Which way do the fingers point when the toad is sitting down?

7. Describe the legs and feet. How many toes are there? What is the relative length of the toes and how are they connected? What is this web between the toes for? Why are the hind legs so much larger than the front legs?

8. Will a toad change color if placed upon different colored objects? How long does it take it to do this? Of what advantage is this to the toad?

9. Where does the toad live? When it is disturbed how does it act? How far can it jump? If very frightened does it flatten out and lie still? Why is this?

10. At what time does the toad come out to hunt insects? How does it catch the insect? Does it swallow an earthworm head or tail first? When swallowing an earthworm or large insect, how does it use its hands? How does it act when swallowing a large mouthful?

11. How does the toad drink? Where does it remain during the day? Describe how it burrows into the earth.

12. What happens to the toad in the winter? What does it do in the spring? Is it a good swimmer? How does it use its legs in swimming?

13. How does the toad look when croaking? What sort of noise does it make?

14. Describe the action of the toad's throat when breathing. Did you ever see a toad shed its skin?

15. What are the toad's enemies? How does it act when caught by a snake? Does it make any noise? Is it swallowed head or tail first? What means has it of escaping or defending itself from its enemies?

16. How is the toad of great use to the farmer and gardener?

In the early years we are not to teach nature as science, we are not to teach it primarily for method or for drill: we are to teach it for loving — and this is nature-study. On these points I make no compromise.

— L. H. Bailey

THE SPRING PEEPER OR PICKERING'S HYLA

Ere yet the earliest warbler wakes, of coming spring to tell,
From every marsh a chorus breaks, a choir invisible,
As if the blossoms underground, a breath of utterance had found. — Tabb

Associated with the first songs of robin and bluebird, is the equally delightful chorus of the spring peepers, yet how infrequently do most of us see a member of this invisible choir! There are some creatures which are the quintessence of the slang word "cute," which, interpreted, means the perfection of Lilliputian proportions, permeated with undaunted spirit. The chickadee is one of these, and the spring peeper is another. I confess to a thrill of delight when the Pickering's hyla lifts itself on its tiny front feet, twists its head knowingly, and turns on me the full gaze of its bronze-rimmed eyes. This is one of the tiniest froglets of them all, being little more than an inch long when fully grown; it wears the Greek cross in

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The spring peeper, Hyla crucifer. *Here is shown the characteristic St. Andrew's cross on the peeper's back. This small frog, measuring ¾ inch to 1½ inches in length will be found from Manitoba to Maine and southward*

darker color upon its back, with some stripes across its long hind legs, which join the pattern on the back when the frog is " shut up," as the boys say.

The reason we see so little of spring peepers is that they are protected from discovery by their color. They have the chameleon power of changing color to match their background. This change can be effected in twenty minutes; the darker lines forming the cross change first, giving a mottled appearance which is at once protective. I have taken three of these peepers, all of them pale yellowish brown with gray markings, and have placed one upon a fern, one on dark soil, and one on the

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The note of the male spring peeper is a shrill, clear call and while it is being given his throat expands into a large bubble

purple bud of a flower. Within half an hour, each matched its surroundings so closely that the casual eye would not detect them. The song of the Pickering's hyla is a resonant chirp, very stirring when heard nearby; it sounds somewhat like the note of a water bird. How such a small creature can make such a loud noise is a mystery. The process, however, may be watched at night by the light of a flashlight or lantern, as none of the peepers seem to pay any attention to an artificial light; the thin membrane beneath the throat swells out until it seems almost

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The green tree frog, Hyla cinerea cinerea. *These frogs, 1½ to 2½ inches long are bright green in color with a straw-colored stripe along each side. On the tips of their toes are discs which enable them to cling to vertical surfaces. The green tree frogs are found from Virginia to Texas and up the Mississippi River to Illinois*

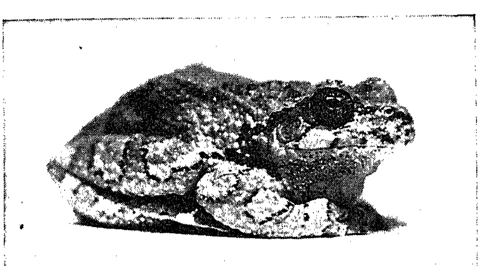
large enough to balloon the little chap off his perch. No wonder that, with such a sounding-sac, the note is stirring.

The spring peepers have toes and fingers ending in little round discs which secrete at will a substance by means of which they can cling to vertical surfaces, even to glass. In fact, the time to study these wonderful feet is when the frog is climbing up the sides of the glass jar. The fingers are arranged as follows: two short inside ones, a long one, and another short one outside. The hind feet have three shorter inside toes quite far apart, a long one at the tip of the foot and a shorter one outside. When climbing a smooth surface like glass, the toes are spread wide apart, and there are other little clinging discs on their lower sides, although not so large as those at the tips. It is by means of these sticky, disclike toes that the animals hold themselves upon the tree trunks or other upright objects.

The whole body of the tree frog, a relative of the spring peeper, is covered with little tubercles, which give it a roughened appearance. The eyes are black with the iris of reddish color. The tongue is like that of other frogs, hinged to the front of the lower jaw; it is sticky and can be thrust far out to capture insects, of which the tree frogs eat vast numbers.

The spring peepers breathe by the rapid pulsation of the membrane of the throat, which makes the whole body tremble. The nostrils are two tiny holes on either side of the tip of the snout. The ears are a little below and just behind the eyes, and are in the form of circular discs.

The eggs of the spring peepers are laid in ponds during April; each egg has a little globe of jelly about it and is fastened to a stone or a water plant. The tadpoles are small and delicate; the under side of the body is reddish and shines with metallic



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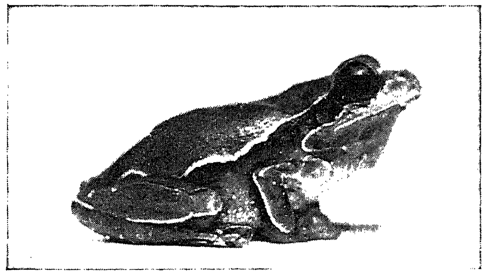
Common tree toad, Hyla versicolor versicolor. *From Maine and southern Canada to the Gulf states is the range of these tree toads; their habitat is trees, logs, or stone fences. The color varies from ashy gray to brown or green; on the back is an irregular dark star. The eggs, in groups of thirty to forty, are attached to vegetation at the surface of the water*



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Anderson tree frog, Hyla andersonii. *This is a small, beautiful, green frog with a light-bordered, plum-colored band along each side of its body. It lives chiefly in white cedar swamps from New Jersey to South Carolina*

luster. These tadpoles differ from those of other frogs in that they often leave the water while the tail is still quite long. In summer, they may be found among the leaves and moss around the banks of ponds. They are indefatigable in hunting for gnats, mosquitoes, and ants; their destruction of mosquitoes, as pollywogs and as grown up frogs, renders them of great use to us. The voice of this peeper may be occasionally heard among the shrubs and vines or in trees during late summer and until November. The little creatures sleep beneath moss and leaves during the winter, waking to give us the earliest news of spring.

Suggested Reading — *The Frog Book,* by Mary C. Dickerson; *Handbook of Frogs and Toads,* by Anna A. and Albert H. Wright; *Mother Nature Series,* by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest; The Pond Book,* by Walter P. Porter and Einar A. Hansen; also, readings on page 170.

LESSON 46

Spring Peeper or Pickering's Hyla

Leading Thought — The prettiest part of the spring chorus of the frog ponds is sung by the spring peepers. These little frogs have the tips of their toes specially fitted for climbing up the sides of trees.

Method — Make a moss garden in an aquarium jar or a two-quart can. Place stones in the bottom and moss at one side, leaving a place on the other side for a tiny pond of water. In this garden place a spring peeper, cover the jar with mosquito netting, and place in the shade. The frogs may be found by searching the banks of a pond at night with a lantern. However, this lesson is usually given when by accident the spring peeper is discovered. Any species of tree frog will do; but the Pickering's hyla, known everywhere as the spring peeper, is the most interesting species to study.

Observations — 1. How large is the peeper? What is its color? Describe the markings.

2. Place the peeper on some light-colored surface like a piece of white blotting paper. Note if it changes color after a half hour. Later place it upon some dark surface. Note if it changes color again. How does this power of changing color benefit the animal? Place a peeper on a piece of bark. After a time does it become inconspicuous?

3. Describe the eyes. Note how little the creature turns its head to see anything behind it. Describe its actions if its attention is attracted to anything. What color is the pupil? The iris?

4. Note the movement of breathing. Where does this show the most? Examine the delicate membrane beneath the throat. What has this to do with the breathing?

5. What is the peeper's note? At what time of day does it peep? At what time of year? Describe how the frog looks when peeping.

6. How does the peeper climb? When it is climbing up a vertical surface study its toes. How many on the front foot? How are they arranged? How many toes on the hind foot? Sketch the front and hind feet. How do the toe-discs look when pressed against the glass? How does it manage to make the discs cling and then let go? Are there any more discs on the under side of the toes? Is there a web between the toes of the hind feet? Of the front feet?

7. Look at a peeper very closely and describe its nostrils and its ears.

8. Are the peepers good jumpers? What is the size and length of the hind legs as compared with the body?

9. When and where are the eggs of the peeper laid? How do they look?

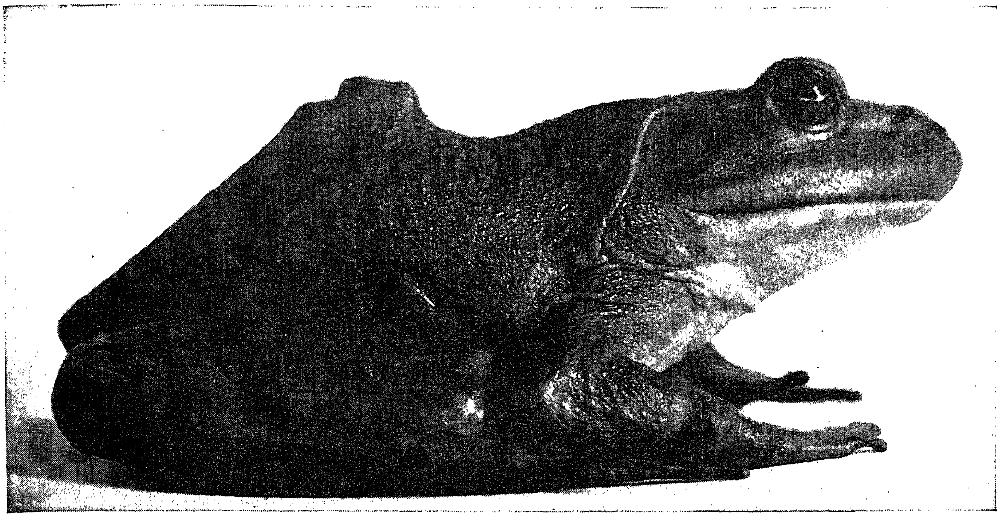
10. How do the peeper tadpoles differ from other tadpoles? Describe them if you have ever seen them. In what situations do they live?

11. Of what use are the peepers to us?

THE FROG

The stroller along brooksides is likely to be surprised some day at seeing a bit of moss and earth suddenly make a long, high leap, without apparent provocation. An investigation resolves the clump of moss into a brilliantly green-spotted frog with two light-yellow raised stripes down his back; and then the stroller wonders how he could have overlooked such an obvious creature. But the leopard frog is only obvious when it is out of its environment. The common green frog is quite as well protected since its color is exactly that of green pools. Most frogs spend their lives in or about water, and if caught on land they make great leaps to reach their native element; the leopard frog and a few other species, however, sometimes wander far afield.

In form, the frog is more slim than the toad, and is not covered with great warts; it is cold and slippery to the touch. The frog's only chance of escaping its enemies is through the slipperiness of its body and by making long, rapid leaps. As a jumper, the frog is much more powerful than the toad because its hind legs are so much larger and more muscular, in comparison with its size. The first toe in the front foot of the male leopard frog is much swollen, making a fat thumb; the mechanics of the hind legs make it possible for the frog to feather the webbed feet as it swims. On the bottom of the toes are



A. H. Wright

The bullfrog, Rana catesbeiana. *This is our largest frog, sometimes attaining a length of 8 inches. It is widely distributed east of the Rocky Mountains from Canada to Mexico. The bullfrog has a greenish drab back and a yellowish underside. The eggs are laid in a film, perhaps 2 feet square on the surface of still water. Its sonorous bass notes, jug-o'-rum, are heard in the evenings of early summer*

hardened places at the joints, and sometimes others besides, which give the foot a strong hold when pushing for the jump. The toe tips, when they are pressed against the glass, resemble slightly the peepers' discs. The hind foot is very long, while on the front foot the toes radiate almost in a circle. The foot and leg are colored like the back of the body above, and on the under side resemble the under parts.

The frog is likely to be much more brightly colored than the toad, and usually has much of green and yellow in its dress. But the frog lives among green things, while it is to the toad's advantage to be the color of the soil. Frogs also have the chameleon power of changing color to harmonize with their environment. I have seen a very green leopard frog change to a slate-gray when placed upon slate-colored rock. The change took place in the green portions. The common green frog will likewise change to slate-color, in a similar situation. A leopard frog changed quickly from dark green to pale olive, when it was placed in the water after having been on the soil.

The eyes of frogs are very prominent, and are beautiful when observed closely. The green frog has a dark bronze iris with a gleaming gold edge around the pupil, and around the outer margin. The eye of the leopard frog is darker; the iris seems to be black, with specks of ruddy gold scattered through it, and there is an outer band of red-gold around the margin. When the frog winks, the nictitating membrane rises from below and covers the whole eye; and when the frog makes a special effort of any sort, it has a comical way of drawing its eyes back into its head. When trying to hide at the bottom of the aquarium, the leopard species lets the eyelids fall over the eyes, so that they do not shine up and attract pursuers.

The ear is in a similar position to that of the toad, and in the bullfrog is larger than the eye. In the green frog, it is a dull grayish disc, almost as large as the eye. In the leopard frog, it is not so large as the eye, and may have a giltish spot at the center.

The nostrils are small and are closed when below the water, as may be easily seen by a lens. The mouth opens widely, the corners extending back under the eye.

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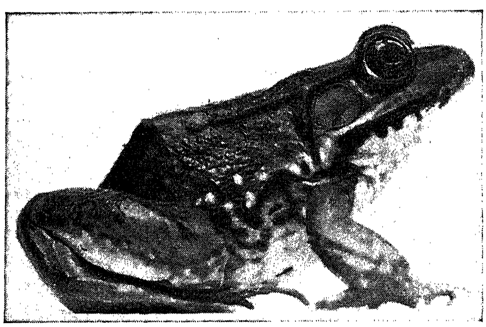
Male green frog, Rana clamitans. *These inhabitants of deep and shallow ponds are found in eastern North America from Hudson Bay to the Gulf. In the North they are among the largest frogs, ranging from 2 to 4 inches in length. The female is shown in the following picture*

The jaws are horny and are armed with teeth, which are for the purpose of biting off food rather than for chewing it. When above water, the throat keeps up a rhythmic motion which is the process of breathing; but when below water this motion ceases. The food of frogs is largely composed of insects which frequent damp places or live in the water.

The sound-sacs of the leopard frogs, instead of being beneath the throat, as is the case with toads and peepers, are at the side of the throat; and when inflated may extend from just back of the eyes, out above the front legs and part way down the sides. The song is characteristic, and pleasant to listen to, if not too close by. Perhaps exception should be made to the lay of the bullfrog, which like the song of some noted opera singers, is more wonderful than musical; the boom of the bullfrog makes the earth fairly quake. If we seize the frog by the hind leg, it will usually croak and thus demonstrate for us the position of its sound-sacs.



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Female green frog, Rana clamitans. *The color of these frogs in general is greenish brown with a bright green mark from the eardrum forward along the jaw. Note that the eardrum of the male is larger than that of the female*

In addition to the snakes, the frogs have inveterate enemies in the herons, which frequent shallow water and eat them in great numbers. The frogs hibernate in mud and about ponds, burrowing deep enough to escape freezing. In the spring, they come up and sing their spring songs and the mother leopard frogs lay their eggs in masses of jelly on the bottom of the pond, usually where the water is deeper than in the situations where the toads' eggs are laid. The eggs of the two can always be distinguished, since the toads' are laid in strings of jelly, while the leopard frogs' are laid in masses. The bullfrog and green frog lay large films of eggs on the surface of the water.

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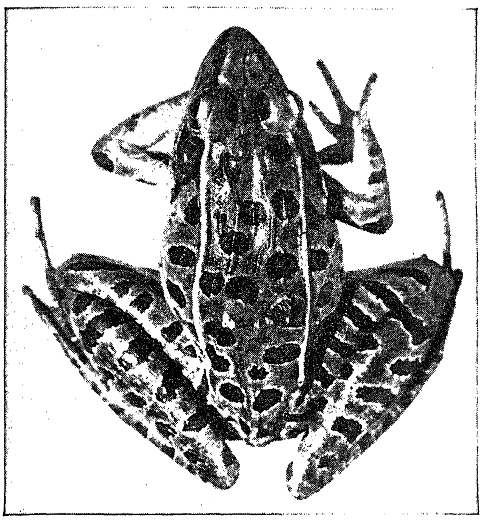
Wood frog, Rana sylvatica. *In spring these frogs are found about ponds and temporary pools in wooded areas; at other times they are in the woods. They even hibernate under stumps, stones, or logs in or near woods. Their color varies from tan to brown, a prominent black mask covering the sides of the head. They range from Quebec and Nova Scotia south to the Carolinas and westward to the plains*

It is amusing to watch with a lens the frog tadpoles seeking for their microscopic food along the glass of the aquarium. There are horny upper and lower jaws, the latter being below and back of the former. The upper jaw moves back and forth slightly and rhythmically, but the dropping of the lower jaw opens the mouth. There are three rows of tiny black teeth below the mouth and one row above; at the sides and below these teeth are little, finger-like fringes. Fringes, rows of teeth, and jaws all work together, up and down, out and in, in the process of breathing. The nostrils, although minute, are present in the tadpole in its early stages. The pupil of the eye is almost circular and the iris is usually yellow or copper-bronze, with black mottling. The eyes do not wink or withdraw. The breathing-pore, which is



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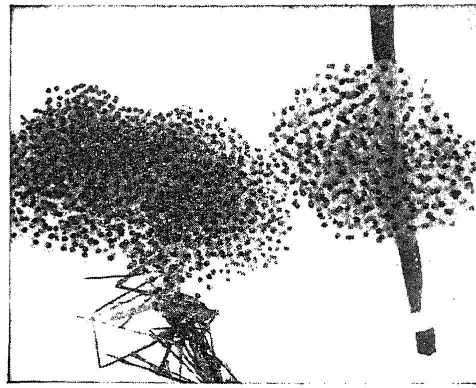
Southern leopard frog, Rana sphenocephala. *The home of this frog is in swamps, overflowed areas, or ponds in the southeastern states and northward along the coast to New Jersey. The pointed snout, glistening white underside, and ridges extending backward from each eye are characteristic*

on the left side, is a hole in a slight protuberance.

At first, the tadpoles of the frogs and toads are very much alike; but later most of the frog tadpoles are lighter in color, usually being olive-green, mottled with specks of black and white. The frog tadpoles usually remain much longer than the toads in the tadpole stage, and when finally they change to adults, they are far larger in size than the toads are when they attain their jumping legs.

Suggested Reading—*Along the Brook,* by Raymond T. Fuller; *The Frog Book,* by Mary C. Dickerson; *Handbook of*



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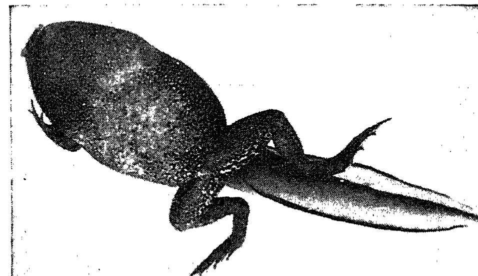
Eggs of leopard frog, Rana pipiens pipiens, *and wood frog,* Rana sylvatica. *The eggs of the leopard frog are laid in a flattened sphere in waters of swampy marshes, overflows, and ponds. In summer, the adults are found in swampy areas, grassy woodlands, or even hay or grain fields. They range from the Pacific coast states into Mexico. The eggs of the wood frog are laid in round masses*

Frogs and Toads, by Anna A. and Albert H. Wright; *Holiday Pond,* by Edith M. Patch; *Nature and Science Readers,* by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; The Pond Book,* by Walter P. Porter and Einar A. Hansen; *The Story of Frogs,* by Mary B. Herring (Unit Study Book, No. 351); also, readings on page 170.

LESSON 47
The Frog

Leading Thought — The frog lives near or in ponds or streams. It is a power-



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Wright's bullfrog, Rana heckscheri. *This is a transforming tadpole. Note that the left front leg has not yet pushed through the skin. The range of this frog is from South Carolina to Mississippi*

TAILLESS AMPHIBIANS

1 *and* 2. American Bell Toad, Ascaphus truei, *male and female. The size of this toad is* $1\frac{1}{8}$ *to* 2 *inches. Note that the male is tailed.*

Range: *Northern California, Oregon, and Washington, and eastward into Montana.* Habitat: *Usually under rocks in small, cold mountain streams; in rainy seasons they may be found a short distance away from the water. They seem to be rather solitary in habit.*

3 *and* 4. Oak Toad, Bufo quercicus. *The adults of this pigmy toad range in size from* $\frac{3}{4}$ *to* $1\frac{1}{4}$ *inches. Its color varies from light brown to almost black. Note the expanded vocal sac of the male* (*No.* 4); *when deflated it is an apron fold under the throat. The call is a high whistle, which is more birdlike than froglike. A chorus of calls can be heard for more than an eighth of a mile.*

Range: *North Carolina to Florida, west to Louisiana.* Habitat: *Pine barrens.*

5. Narrow Mouth Toad, Microhyla carolinensis. *The size of these dark, smooth-skinned toads ranges from* $\frac{4}{5}$ *to* $1\frac{2}{5}$ *inches. The voice of the males resembles the bleating of sheep. The eggs are laid in a surface film, each egg being clearly outlined.*

Range: *From Virginia to Florida, westward to Texas.* Habitat: *In moist places under virtually any kind of cover, even haycocks and decaying logs.*

6. Canyon *or* Spotted Toad, Bufo punctatus. *This toad is* $1\frac{3}{5}$ *to* 3 *inches in size; its color varies from greenish tan to red. The call is high pitched and birdlike. The eggs are laid singly in pools of intermittent streams. This toad breeds from April to July.*

Range: *South central Texas to Lower California and California.* Habitat: *Desert canyons.*

7. Great Plains Toad, Bufo cognatus. *These large-bodied, brown, gray, or greenish toads measure from* $1\frac{7}{8}$ *to* 4 *inches. Their call is harsh and low pitched. The vocal sac is shaped like a sausage stood on end.*

Range: *Mostly west of the* 100*th meridian, from North Dakota southwestward to Mexico and eastern California.* Habitat: *Grazing lands in flood plains.*

8. Spadefoot Toad, Bufo compactilis. *The size of this desert toad is* 2 *to* $3\frac{1}{2}$ *inches; its color is pinkish drab. It breeds in pools or even in cattle tanks. Note the expanded sausage-like vocal sac of this male.*

Range: *Utah and Nevada eastward to Oklahoma and southward into Mexico.* Habitat: *Deserts.*

9. Hammond's Spadefoot, Scaphiopus hammondii. *This toad ranges from* $1\frac{1}{2}$ *to* $2\frac{1}{2}$ *inches in size. It breeds in temporary pools; the tadpoles eat many mosquitoes, and the toads eat many tadpoles. It is seldom seen above ground except during rains of long duration. The unusual call is plaintive and catlike.*

Range: *From North Dakota southward to Mexico, and westward to the Pacific coast.* Habitat: *Burrows, which it digs in moist ground with its strong, spadelike feet, and into which it pushes itself by rocking its body.*

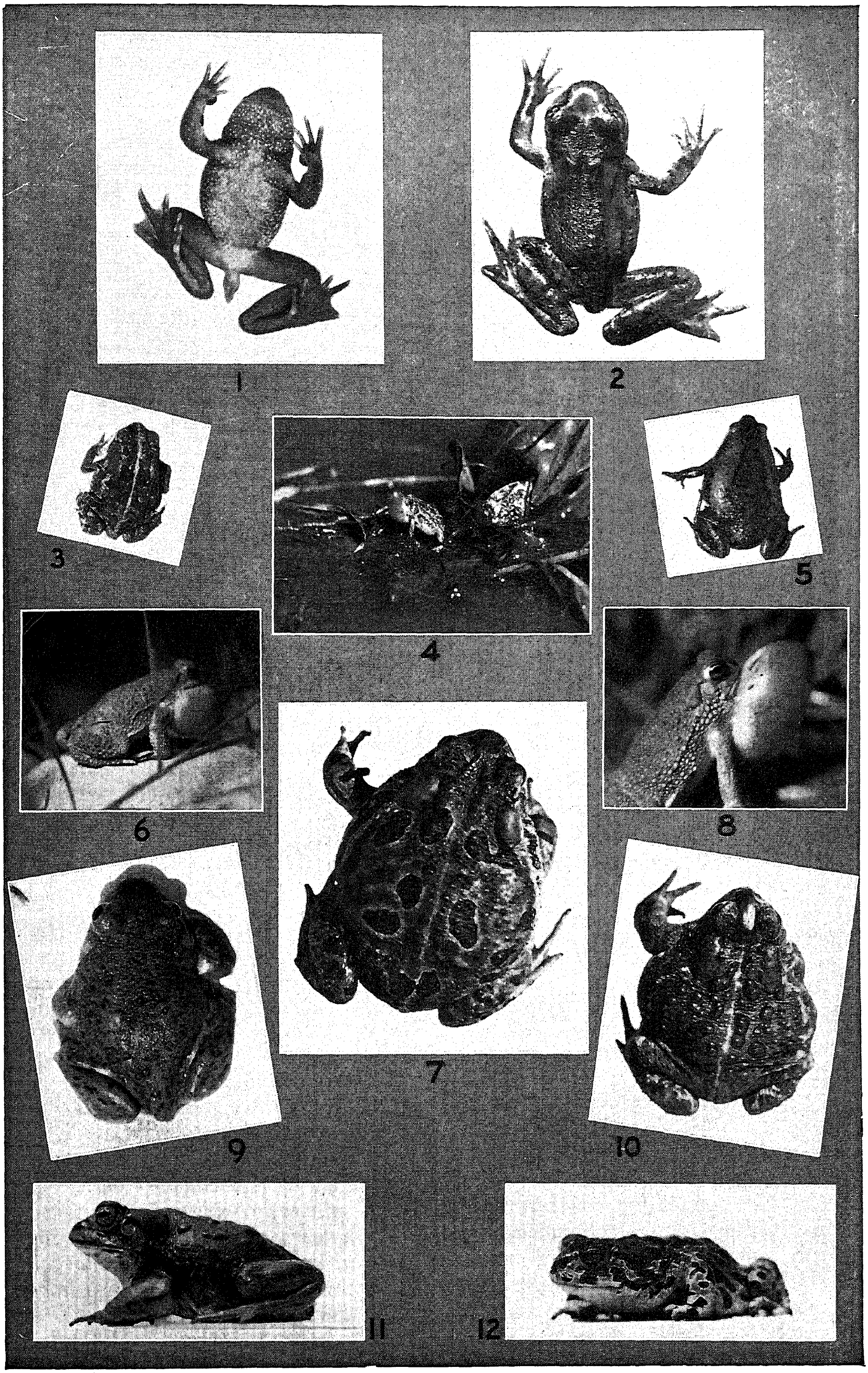
10. Canadian *or* Winnipeg Toad, Bufo hemiophrys. *In size this toad ranges from* $2\frac{1}{4}$ *to* $3\frac{1}{5}$ *inches. It has a very prominent heavy, horny boss between its eyes and on its snout. It may breed in the shallows at the edges of any body of fresh water.*

Range: *North Dakota to Manitoba.* Habitat: *Lakes and stream valleys.*

11 *and* 12. Yosemite Toad, Bufo canorus, *male and female. This is the only toad in the United States that shows marked difference between male and female. The male* (*No.* 11) *is olive-colored, while the female* (*No.* 12) *is light gray with many black areas. Its size is from* 2 *to* 3 *inches.*

Range: *Yosemite National Park and central Sierra Nevada at altitudes of* 1000 *to* 1100 *feet.* Habitat: *Wet meadows and margins of streams and lakes.*

Photographs by A. A. and A. H. Wright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ful jumper and has a slippery body. Its eggs are laid in masses of jelly at the bottom of ponds.

METHOD — The frog may be studied in its native situation by the pupils or it may be brought to the school and placed in an aquarium; however, to make a frog aquarium there needs to be a stick or stone projecting above the water, for the frog likes to spend part of the time entirely out of water or only partially submerged.

OBSERVATIONS — 1. Where is the frog found? Does it live all its life in the water? When found on land how and where does it seek to escape?

2. Compare the form of the frog with that of the toad. Describe the frog's skin, its color and texture. Compare the skins of the two.

3. Describe the colors and markings of the frog on the upper and on the under side. How do these protect it from observation from above? From below? How do we usually discover that we are in the vicinity of a frog?

4. Describe the frog's ears, eyes, nostrils, and mouth.

5. Compare its "hands and feet" with those of the toad. Why the difference in the hind legs and feet?

6. How does the frog feel to your hand? Is it easy to hold him? How does this slipperiness of the frog benefit it?

7. On what does the frog feed? What feeds on it? How does it escape its enemies?

8. What sounds does the frog make? Where are the sound-sacs of the leopard frog located? How do they look when they are inflated?

9. Is the frog a good swimmer? Is it a better jumper than the toad? Why?

10. Where are the leopard frog's eggs laid? How do they look?

11. Can you tell the frog tadpoles from those of the toad? Which remains longer in the tadpole stage? Study the frog tadpoles, following the questions given in Lesson 44.

12. What happens to the frog in winter?

FESTINA LENTE

Once on a time there was a pool
Fringed all about with flag-leaves cool
And spotted with cow-lilies garish,
Of frogs and pouts the ancient parish.
Alders the creaking redwings sink on,
Tussocks that house blithe Bob o' Lincoln,
Hedged round the unassailed seclusion,
Where muskrats piled their cells Carthusian;
And many a moss-embroidered log,
The watering-place of summer frog,
Slept and decayed with patient skill,
As watering-places sometimes will.
Now in this Abbey of Theleme,
Which realized the fairest dream
That ever dozing bull-frog had,
Sunned, on a half-sunk lily pad,
There rose a party with a mission
To mend the polliwog's condition,
Who notified the selectmen
To call a meeting there and then.
"Some kind of steps," they said, "are needed;
They don't come on so fast as we did:
Let's dock their tails; if that don't make 'em
Frogs by brevet, the Old One take 'em!
That boy, that came the other day
To dig some flag-root down this way,
His jack-knife left, and 'tis a sign
That Heaven approves of our design:
'T were wicked not to urge the step on,
When Providence has sent the weapon."
Old croakers, deacons of the mire,
That led the deep batrachian choir,
"Uk! Uk! Caronk!" with bass that might
Have left Lablache's out of sight,
Shook nobby heads, and said "No go!
You'd better let 'em try to grow:
Old Doctor Time is slow, but still
He does know how to make a pill."
But vain was all their hoarsest bass,
Their old experience out of place,
And spite of croaking and entreating
The vote was carried in marsh-meeting.
"Lord knows," protest the polliwogs,
"We're anxious to be grown-up frogs;
But don't push in to do the work
Of Nature till she prove a shirk;
'Tis not by jumps that she advances,

But wins her way by circumstances;
Pray, wait awhile, until you know
We're so contrived as not to grow;
Let Nature take her own direction,
And she'll absorb our imperfection;
You mightn't like 'em to appear with,
But we must have the things to steer with."
" No," piped the party of reform,
" All great results are ta'en by storm;
Fate holds her best gifts till we show
We've strength to make her let them go;
The Providence that works in history,
And seems to some folks such a mystery,
Does not creep slowly on, incog.,
But moves by jumps, a mighty frog;
No more reject the Age's chrism,
Your queues are an anachronism;
No more the future's promise mock,
But lay your tails upon the block,
Thankful that we the means have voted
To have you thus to frogs promoted."
The thing was done, the tails were cropped,
And home each philotadpole hopped,
In faith rewarded to exult,
And wait the beautiful result.
Too soon it came; our pool, so long
The theme of patriot bull-frog's song,
Next day was reeking, fit to smother,
With heads and tails that missed each other, —
Here snoutless tails, there tailless snouts;
The only gainers were the pouts.

MORAL

From lower to the higher next,
Not to the top is Nature's text;
And embryo Good, to reach full stature,
Absorbs the Evil in its nature.

— Lowell

THE TAILED AMPHIBIANS

The best-known representatives of this group are the salamanders of various types. Barring accidents, a salamander retains its tail throughout life. Salamanders resemble lizards in shape, and many people have incorrectly called them lizards. It is not difficult to distinguish them, if one bears in mind that the covering of the salamander is rather soft and somewhat moist, while that of the lizard is rather dry and in the form of scales.

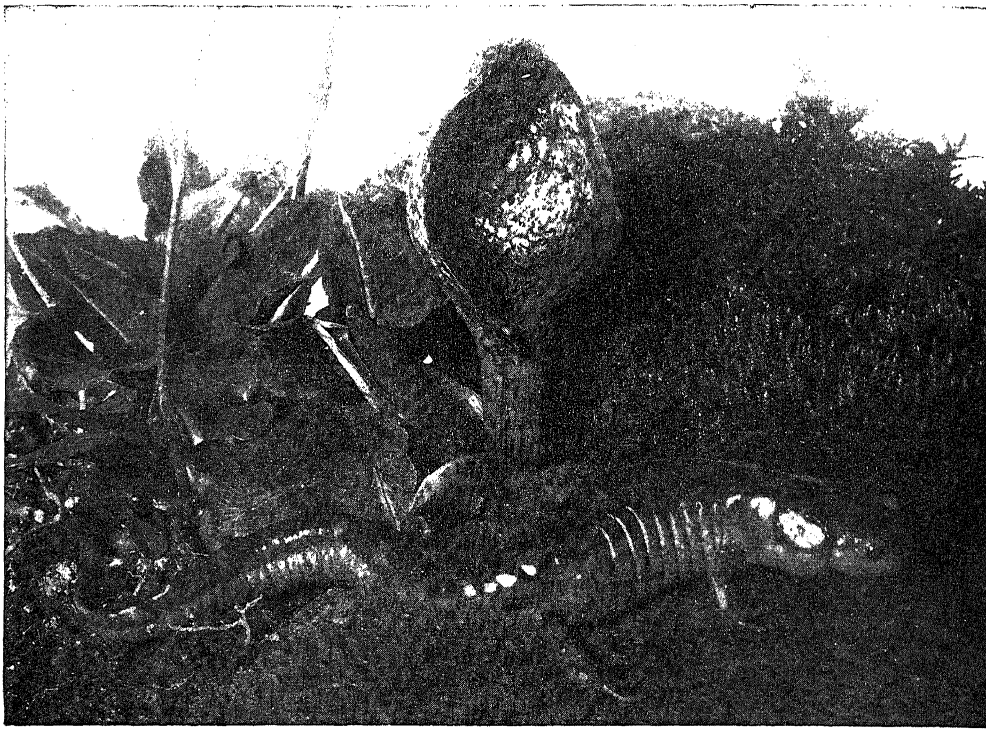
The red-backed salamander lacks the amphibian habits usual to the group; it lives on land during its entire life. The eggs are laid in a small cluster, in a decaying log or stump; the adult is often to be found quite near the egg cluster. On the other extreme, the mud puppies and hellbenders spend their entire lives in the water. They are rarely seen, live chiefly under rocks in stream beds, and feed chiefly at night.

The many local forms of amphibians offer excellent opportunities for interesting outdoor studies. Of the tailed amphibians, the newt is considered in detail, and pictures of other representative salamanders are shown.

Suggested Reading — *Backyard Exploration*, by Paul G. Howes; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 4, *Our Earth and Its Life*; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 170.

THE NEWT OR EFT

One of the most commonly seen salamanders is the newt or eft. After a rain in spring or summer, we see these little orange-red creatures sprawling along roads or woodland paths, and since they are rarely seen except after rain, the wise people of old declared they rained down, which was an easy way of explaining their

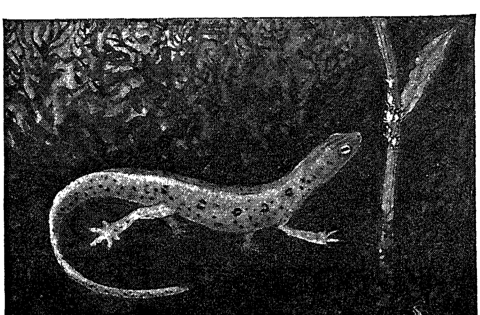


A spotted salamander in natural surroundings

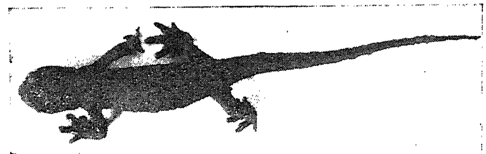
presence. But the newts do not rain down, they rain up instead, since if they have journeys to make they must needs go forth when the ground is damp; otherwise they would dry up and die. Thus, the newts make a practice of not going out except when the ground is rather moist. A closer view of the eft shows plenty of peculiarities in its appearance to interest us. Its colors are decidedly gay, the body color being orange, ornamented with vermilion dots along each side of the back, each red dot being usually margined with tiny black specks; but the eft is careless about these decorations and may have more spots on one side than on the other. Besides these vermilion dots, it is also adorned with black specks here and there, and especially along its sides looks as if it had been peppered. The newt's greatest beauty lies in its eyes; these are black, with elongated pupils, almost parallel with the length of the head, and bordered above and below with bands of golden, shining iris which give the eyes a fascinating brilliancy. The nostrils are mere pinholes in the end of the snout.

The legs and feet look queerly inadequate for such a long body, since they are short and far apart. There are four toes on the front feet and five on the hind feet, the latter being decidedly pudgy. The legs are thinner where they join the body and wider toward the feet. The eft can move very rapidly with its scant equipment of legs. It has a misleading way of remaining motionless for a long time and then darting forward like a flash, its long body falling into graceful curves as it moves. But it can go very slowly when exploring; it then places its little hands cautiously and lifts its head as high as its short arms will allow, in order to take observations. Although it can see quite well, yet on an unusual surface, like glass, it seems to feel the way by touching its lower lip to the surface as if to test it. The tail is flattened at the sides and is used to twine around objects in time of need; and I am sure it is also used to push the eft while crawling, for it curves this way and that vigorously, as the feet progress, and obviously pushes against the ground. Then, too, the tail is an aid when, by some chance, the eft is turned over on its back, for with its help it can right itself speedily. The eft's method of walking is interesting; it moves forward one front foot and then the hind foot on the other side; after a stop for rest, it begins just where it left off when it again starts on. Its beautiful eyes seem to serve the newt well indeed, for I find that, when it sees my face approaching the moss jar, it climbs promptly over to the other side. There are no eyelids for the golden eyes, but the eft can pull them back into its head and close the slit after them, thus making them very safe.

The eft with whose acquaintance I was most favored was not yet mature and was afraid of earthworms; but he was very fond of plant lice and it was fun to see the little creature stalking them. A big rose plant louse would be squirming with satisfaction as it sucked the juice of the leaf, when the eft would catch sight of it and become greatly excited, evidently holding his breath, since the pulsating throat would become rigid. There was a particularly alert attitude of the whole front part of the body and especially of the eyes and the head; then the neck would stretch out long and thin, and the orange snout approach stealthily to within half an inch of the smug aphid. Then there would be a flash as of lightning, something too swift to see coming out of the eft's mouth and swooping up the unsuspecting louse. Then



Red-spotted newt stalking plant lice



S. C. Bishop

Giant or California newt, Triturus torosus. *About ponds and streams from lower California to Alaska this newt may be seen; its body is stout and is about six inches long*

there would be a gulp or two and all would be over. If the aphid happened to be a big one, the eft made visible effort to swallow it. Sometimes his eftship would become greatly excited when he first saw the plant louse, and he would sneeze and snort in a very comical way, like a dog eager for game.

This is the history of this species as summarized from Mrs. S. H. Gage's charming *Story of Little Red Spot.* The egg is laid in some fresh-water pond or the still borders of some stream where there is a growth of water weed. The egg, which is about the size of a sweet pea seed, is fastened to a water plant. It is covered with a tough but translucent envelope, and has at the center a little yellowish globule. In a little less than a month the eft hatches, but it looks very different from the form with which we are most familiar. It has gray stripes upon its sides and three tiny bunches of red gills on each side, just back of its broad head. The keeled tail is long and very thin. The newt is an expert swimmer and breathes water as does a fish. After a time it becomes greenish above and buff below, and by the middle of August it develops legs and has changed its form so that it is able to live upon land; it no longer has gills; soon the coat changes to the bright orange hue which makes the little creature so conspicuous.

The newt usually keeps hidden among moss, or under leaves, or in decaying wood, or in other damp and shady places; but after a rain, when the whole world is damp, it feels confidence enough to go out in the open and hunt for food. For about two and a half years it lives upon land; then it returns to the water. When this

1 *and* 2. SPOTTED SALAMANDER, Ambystoma maculatum. *The adults are 6 inches long or more; the body is glistening black with prominent yellow spots. These, like other salamanders, are entirely harmless; they neither bite nor scratch. Their egg-masses are deposited during early spring, while the water is still very cold, in swampy areas or stagnant pools, and are often attached to sticks or to submerged parts of plants. While the eggs are developing, a greenish color, caused by the presence of numerous algae, appears in the gelatin of the egg-mass. This seems to be peculiar to the egg-mass of this salamander, and biologists are trying to learn the reason for it.*

Range: *Locally in central North America from Wisconsin and Nova Scotia southward.* Habitat: *Damp dark places during most of the year. In spring they migrate to ponds to breed.*

3. RED SALAMANDER, Pseudotriton ruber. *Adults are about 6 inches long; young adults are coral red with irregular black spots; older adults are somewhat purplish brown; the eggs, laid in autumn, are attached to the underside of a stone in a stream.*

Range: *Locally from New York to Georgia, westward to the Mississippi River.* Habitat: *Under flat stones in shallow water.*

4. MARBLED SALAMANDER, Ambystoma opacum. *Adults are about 5 inches long, bluish beneath and slaty gray on the back, with about 14 grayish-white bars. The creature is not likely to be mistaken for any other large salamander found within its range, because the others are marked with yellow.*

Range: *Eastern and central North America.* Habitat: *Under flat stones or in burrows in the soil.*

5. MUD PUPPY, Necturus maculosus. *This animal, which looks like a huge salamander, has no scales, and its body is shiny. It does not come out on land.*

Range: *Eastern and central United States.* Habitat: *Rivers and lakes.*

6. TIGER SALAMANDER, Ambystoma tigrinum. *This is a large, dark brown, yellow-splotched salamander. The young, which are called Axolotl, may even breed while still retaining their external gills and living in the water.*

Range: *The United States east of the Cascades.*

7. SLIMY SALAMANDER, Plethodon glutinosus. *Adults are about 5 to 6 inches long. The body, which is very sticky, has a ground color of black; the speckles vary from white to gray or even silver. The belly has a dull lead color which may or may not be flecked with white.*

Range: *New York to Wisconsin, south to Florida and Texas.*

8. SLENDER SALAMANDER, Batrachoseps attenuatus. *The body of this salamander is slender, the legs are small and weak, and the tail is long. The color in general is brown, but slightly lighter on the back than on the belly and sides.*

Range: *The Pacific slope from southwestern Oregon to California.*

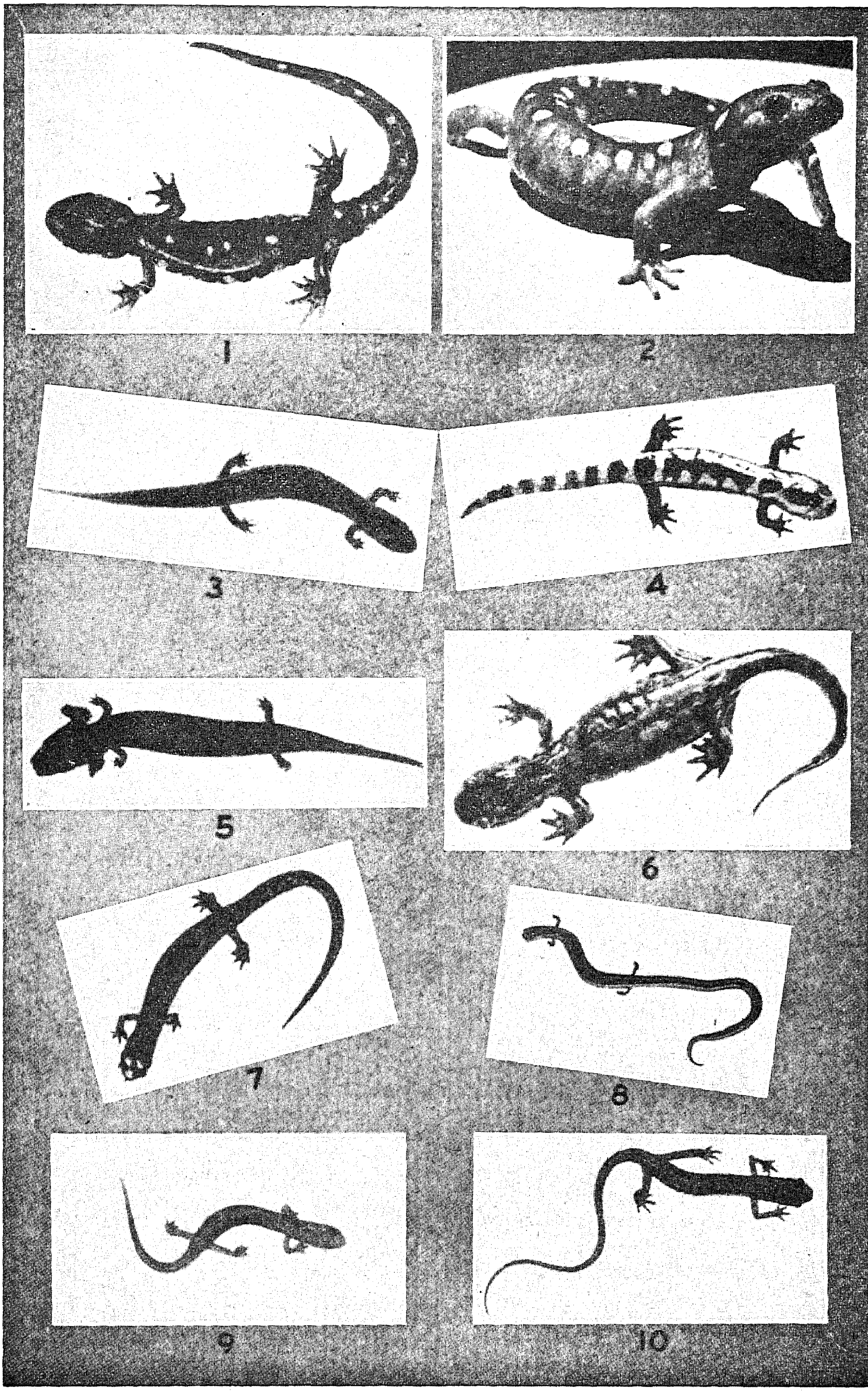
9. CAVE SALAMANDER, Typhlotriton spelæus. *This inconspicuous salamander has a uniformly pale — almost white — body. The eyes are rudimentary and are somewhat concealed by the skin.*

Range: *The Ozark plateau region of Arkansas, Kansas, and Missouri.* Habitat: *Caves.*

10. CAVE SALAMANDER, Eurycea lucifuga. *The back of this salamander is vermilion or orange, with irregular dark brown or black spots.*

Range: *The central portion of the Mississippi drainage basin.* Habitat: *Caves.*

Photographs, except Figure 2, by S. C. Bishop; Figure 2 by Charles E. Mohr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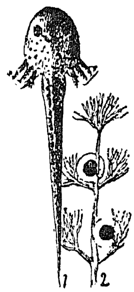
impulse comes upon it, it may be far from any stream; but it seems to know instinctively where to go. After it enters the water, it is again transformed in color, becoming olive-green above and buff below, although it still retains the red spots



Anna Stryke

Early stage of vermilion-spotted newt. Eggs of newt attached to water plant

along the back; and it also retains its pepper-like dots. Its tail develops a keel which extends along its back and is somewhat ruffled.

The male has the hind legs very large and flat; the lighter-colored female has more delicate and smaller legs. It is here in the water that the efts find their mates and finish careers which must surely have been hazardous. During its long and varied life, the eft often sheds its skin like the snake; it has a strange habit of swallowing its cast-off coat.

Suggested Reading—*Along the Brook*, by Raymond T. Fuller; also, readings on pages 170 and 185.

LESSON 48

The Newt or Eft

Leading Thought — The newts are born in the water and at first have gills. Later they live on land and have lungs for breathing air; then they go back to the water and again develop the power of breathing the oxygen contained in water; they also develop a keeled tail.

Method — The little, orange eft or red-spotted salamander may be kept in an aquarium which has in it an object, such as a stone or a clump of moss, which projects above the water. For food it should be given small earthworms or leaves covered with plant lice. In this way it may be studied at leisure.

Observations — 1. Look at the eft closely. Is it all the same color? How many spots upon its back and what colors are they? Are there the same number of spots on both sides? Are there any spots or dots besides these larger ones? How does the eft resemble a toad?

2. Is the head the widest part of the body? Describe the eyes, the shape and color of the pupil and of the iris. How does the eft wink? Do you think it can see well?

3. Can you see the nostrils? How does the throat move and why?

4. Are both pairs of legs the same size? How many toes on the front feet? How many toes on the hind feet? Does the eft toe in with its front feet like a toad?

5. Does it move more than one foot at a time when walking? Does it use the feet on the same side in two consecutive steps? After it puts forward the right front foot what foot follows next? Can it move backward?

6. Is the tail as long as the head and body together? Is the tail round or flat at the sides? How is it used to help the eft when traveling? Does the tail drag or is it lifted, or does it push by squirming?

7. How does the eft act when startled? Does it examine its surroundings? Do you think it can see and is afraid of you?

8. Why do we find more of these creatures during wet weather? Why do people think they rain down?

9. What does the eft eat? How does it catch its prey? Does it shed its skin? How many kinds of efts have you seen?

10. From what kind of egg does the eft hatch? When is this egg laid? How does it look? On what is it fastened?

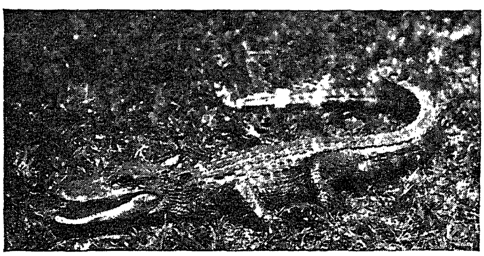
REPTILES

Yet when a child and barefoot, I more than once, at morn,
Have passed, I thought, a whiplash unbraided in the sun,
When, stooping to secure it, it wrinkled, and was gone.
— EMILY DICKINSON

The animals in the reptile group have a covering of bony plates or scales. These animals vary greatly in size and shape and include such forms as snakes, lizards, turtles, crocodiles, and alligators. They make their homes in a great variety of places; the alligators, the crocodiles, and some of the snakes and turtles live in or near water, while many of the snakes and lizards are quite at home in desert regions.

If the teacher could bring herself to take as much interest as did Mother Eve in that "subtile animal," as the Bible calls the serpent, she might, through such interest, enter the paradise of the boyish heart instead of losing a paradise of her own. How many teachers, who have an aversion for snakes, are obliged to teach small boys whose pet diversion is capturing these living ribbons and bringing them into the schoolroom stowed away not too securely in pockets! In one of the suburban Brooklyn schools, boys of this stripe sought to frighten their teacher with their weird prisoners. But she was equal to the occasion, and surprised them by declaring that there were many interesting things to be studied about snakes, and forthwith sent to the library for books which discussed these reptiles; and this was the beginning of a nature-study club of rare efficiency and enterprise.

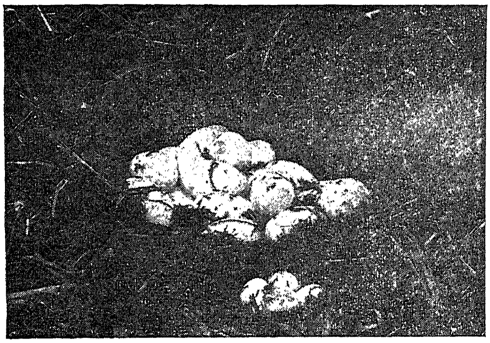
There are abroad in the land many erroneous beliefs concerning snakes. Most people believe that they are all venomous, which is far from true. The rattlesnake still holds its own in rocky, mountainous places, and the moccasin haunts the bayous of the southern coast; however, in most localities, snakes are not only harmless but are beneficial to the farmer. The superstition that if a snake is killed, its tail will live until sundown is general and has but slender foundation in the fact that with snakes, which are lower in their nerve-organization than mammals, the process of death is a slow one. Some people firmly believe that snakes spring or jump from the ground to seize their prey, which is quite false since no snake jumps clear of the ground as it strikes, nor does it spring from a perfect coil. Nor are snakes slimy; on the contrary, they are covered with perfectly dry scales. But the most general superstition of all is that a snake's thrusting out its tongue is an act of animosity; the fact is, the tongue is a sense organ and is used as an insect uses its feelers or antennæ, and the act is also supposed to aid the creature in hearing; thus when a snake thrusts out its tongue, it is simply trying to find out about its surroundings and what is going on.



F. Harper

Alligator, Alligator mississippiensis. *Alligators may reach a length of twelve feet; they live in or about rivers and swamps of tropical and sub-tropical regions. Their food consists chiefly of fish, mammals, and waterfowl. They are unique among reptiles in being able to produce a loud bellowing noise. In the past, alligators have been ruthlessly slaughtered and even now need more protection*

Snakes are the only creatures able to swallow objects larger than themselves.



F. Harper and A. A. Wright

Alligator eggs. More than 30 eggs may be laid by one female alligator; they are placed above water level in a nest of swamp vegetation. When hatching, the young alligators are about 8 inches long. Turtle eggs, often laid in the same pile of vegetation, are shown in the foreground

This is rendered possible by the elasticity of the body walls, and by the fact that snakes have an extra bone hinging the upper to the lower jaw, allowing them to spread widely; the lower jaw also separates at the middle of its front edge and spreads apart sidewise. In order to force a creature into a " bag " so manifestly too small, a special mechanism is needed; the teeth supply this by pointing backward, and thus assisting in the swallowing. The snake moves by literally walking on the ends of its ribs, which are connected with the crosswise plates on its lower side; each of these crosswise plates has the hind edge projecting down so that it can hold to an object. Thus, the graceful, noiseless progress of the snake is brought about by many of these crosswise plates worked by the movement of the ribs.

Some species of snakes simply chase their prey, striking at it and catching it in the open mouth, while others, like the pilot black snake, wind themselves about their victims and crush them to death. Snakes can live a long time without food; many instances on record show that they have been able to exist a year or more without anything to eat. In our northern climate they hibernate in winter, going to sleep as soon as the weather becomes cold and not waking up until spring. As snakes grow, they shed their skins; this occurs only two or three times a year. The crested flycatcher adorns its nest with these phantom snakes.

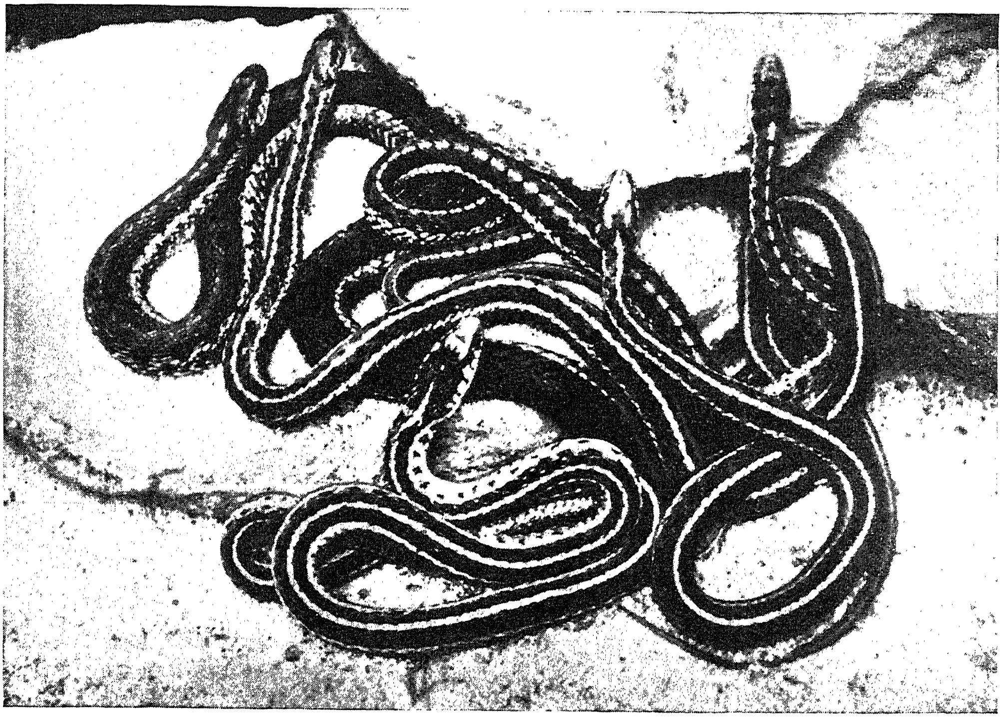
SUGGESTED READING — *Along Nature's Trails*, by Lillian C. Athey; *Animals in the Sun*, by William W. Robinson; *Backyard Exploration*, by Paul G. Howes; *Desert Neighbors*, by Edith M. Patch and Carroll L. Fenton; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 4, *Our Earth and Its Life*; *Our Great Outdoors, Reptiles, Amphibians and Fishes*, by C. W. G. Eifrig; *Out-of-Doors — A Guide to Nature*, by Paul B. Mann and George T. Hastings; *The Pond Book*, and *Fields and Fencerows*, both by Walter P. Porter and Einar A. Hansen; *Reptiles and Amphibians, Their Habits and Adaptations*, by Thomas Barbour; *Reptiles of North America, Snakes of the World, Reptiles of the World, The Book of Living Reptiles*, all by Raymond L. Ditmars; *Snakes Alive and How They Live*, by Clifford H. Pope; *The Stir of Nature*, by William H. Carr; see also *Bibliography*.

THE GARTER OR GARDEN SNAKE

A chipmunk, or a sudden-whirring quail,
Is startled by my step as on I fare.
A gartersnake across the dusty trail,
Glances and — is not there.

— RILEY

Garter snakes can be easily tamed, and are ready to meet friendly advances half way. A handsome yellow-striped, black garter lived for four years beneath our porch and was very friendly and unafraid of the family. The children of the campus

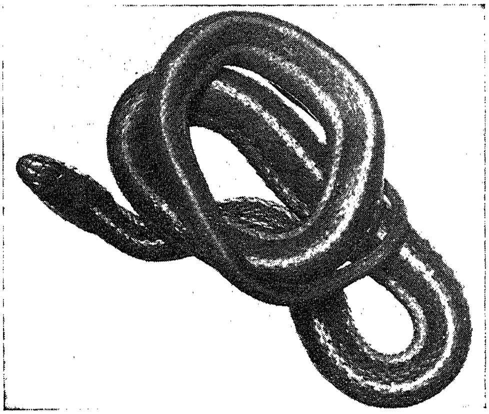


Garter snakes

made it frequent visits, and never seemed to be weary of watching it; but the birds objected to it very much, although it never attempted to reach their nests in the vine above. The garter snakes are the most common of all, in our northeastern states. They vary much in color; the ground color may be olive, brown, or black, and down the center of the back is usually a yellow, green, or whitish stripe, usually bordered by a darker band of ground-color. On each side is a similar stripe, but not so brightly colored; sometimes the middle stripe and sometimes the side stripes are broken into spots or absent; the lower side is greenish white or yellow. When fully grown this snake is two to two and one-half feet in length.

The garters are likely to congregate in numbers in places favorable for hibernation, like rocky ledges or stony sidehills. Here each snake finds a safe crevice, or makes a burrow which sometimes extends a yard or more underground. During the warm days of Indian summer, these winter hermits crawl out in the middle of the day and sun themselves, retiring again to their hermitages when the air grows chilly toward night; and when the cold weather arrives, they go to sleep and do not awaken until the first warm days of spring; then, if the sun shines hot, they crawl out and bask in its welcome rays.

After the warm weather comes, the snakes scatter to other localities more favorable for finding food, and thus these hibernating places are deserted during the summer. The banks of streams and the edges of woods are places which furnish snakes their food, which consists of earthworms, insects, toads, salamanders, frogs, etc. The young are born from late July to mid September and are about six inches long at birth; one mother may have in her brood from eleven to fifty snakelings; she often stays with them only a few hours. There are many stories about the way the young ones run down the mother's throat in case of attack; but as yet no scientist has seen this act or placed it



A. A. and A. H. Wright

Common garter snake
Thamnophis sirtalis sirtalis

on record. The little snakes shift for their own food, catching small toads, earthworms, and insects. If it finds food in plenty, the garter snake will mature in one year. Hawks, crows, skunks, weasels, and other predacious animals seem to find the garter snake attractive food.

Suggested Reading — *Holiday Hill*, by Edith M. Patch; also, readings on page 194.

LESSON 49

The Garter or Garden Snake

Leading Thought — The garter snake is a common and harmless little creature and has many interesting habits which are worth studying.

Method — A garter snake may be captured and placed in a box with a glass cover and thus studied in detail in the schoolroom, but the lesson should begin with observations made by the children on the snakes in their native haunts.

Observations — 1. What are the colors and markings of your garter snake? Do the stripes extend along the head as well as the body? How long is it?

2. Describe its eyes, its ears, its nostrils, and its mouth.

3. If you disturb it how does it act? Why does it thrust its tongue out? What shape is its tongue?

4. In what position is the snake when it rests? Can you see how it moves? Look upon the lower side. Can you see the little plates extending crosswise? Do you think it moves by moving these plates? Let it crawl across your hand, and see if you can tell how it moves.

5. What does the garter snake eat? Did you ever see one swallow a toad? A frog? Did it take it head first or tail first?

6. Where does the garter spend the winter? How early does it appear in the spring?

7. At what time of year do you see the young snakes? Do the young ones run down the throat of the mother for safety when attacked? Does the mother snake defend her young?

8. What enemies has the garter snake?

No life in earth or air or sky;
The sunbeams, broken silently,
On the bared rocks around me lie, —

Cold rocks with half warmed lichens scarred,
And scales of moss; and scarce a yard
Away, one long strip, yellow-barred.

Lost in a cleft! 'Tis but a stride
To reach it, thrust its roots aside,
And lift it on thy stick astride!

Yet stay! That moment is thy grace!
For round thee, thrilling air and space,
A chattering terror fills the place!

A sound as of dry bones that stir,
In the dead valley! By yon fir
The locust stops its noon-day whir!

The wild bird hears; smote with the sound,
As if by bullet brought to ground
On broken wing, dips, wheeling round!

The hare, transfixed, with trembling lip,
Halts breathless, on pulsating hip,
And palsied tread, and heels that slip.

Enough, old friend! — 'tis thou. Forget
My heedless foot, nor longer fret
The peace with thy grim castanet!

From "Crotalus (The Rattlesnake),"
Bret Harte

THE MILK SNAKE OR SPOTTED ADDER

The grass divides as with a comb, a spotted shaft is seen,
And then it closes at your feet, and opens farther on.
— Emily Dickinson

This is the snake which is said to milk cows, a most absurd belief; it would not milk a cow if it could, and it could not if it would. It has never yet been induced to drink milk when in captivity; and if it were very thirsty, it could not drink more than two teaspoonfuls of milk at most; thus in any case, its depredations upon the milk supply need not be feared. Its object in frequenting milk houses and stables is far other than the milking of cows, for it is an inveterate hunter of rats and mice and is thus of great benefit to the farmer. It is a constrictor, and squeezes its prey to death in its coils.

The ground color of the milk snake is pale gray, but it is covered with so many brown or dark gray saddle-shaped blotches, that they seem rather to form the ground color; the lower side is white, marked with square black spots and blotches. The snake attains a length of two and one-half to three feet when fully grown. Although it is commonly called the spotted adder, it does not belong to the adders at all, but to the family of the king snakes.

During July and August, the mother snake lays from seven to twenty eggs; they are deposited in loose soil, in moist rubbish, in compost heaps, etc. The egg is a symmetrical oval in shape and is about one and one-eighth inches long by a half inch in diameter. The shell is soft and white, like kid leather, and the egg resembles a puffball. The young hatch nearly two months after the eggs are laid; meanwhile the eggs have increased in size so that the snakelings are nearly eight inches long when they hatch. The saddle-shaped blotches on the young have much red in them. The milk snake is not venomous; it will sometimes, in defense, try to chew the hand of the captor, but the wounds it can inflict are very slight and heal quickly.

Suggested Reading — Readings on page 194.

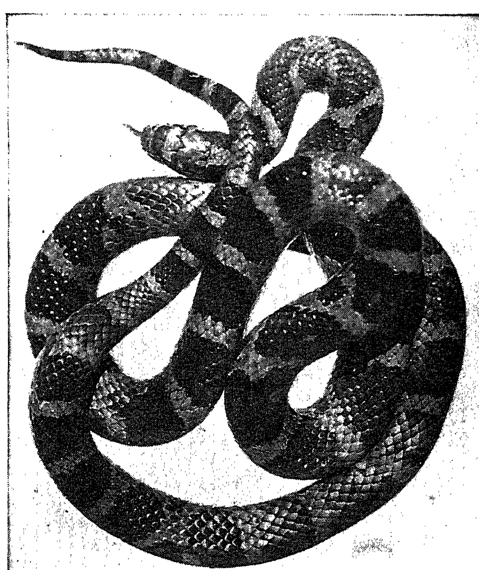
LESSON 50

The Milk Snake or Spotted Adder

Leading Thought — The milk snake is found around stables where it hunts for rats and mice; it never milks the cows.

Method — Although the snake acts fierce, it is perfectly harmless and may be captured in the hands and placed in a glass-covered box for a study in the schoolroom.

Observations — 1. Where is the milk snake found? Why is it called milk snake? Look at its mouth and see if you think it could possibly suck a cow. See if you can get the snake to drink milk.



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Milk snake
Lampropeltis triangulum triangulum

2. What does it live upon? How does it kill its prey? Can the milk snake climb a tree?

3. Where does the mother snake lay her eggs? How do the eggs look? How large are they? How long are the little snakes when they hatch from the egg? Are they the same color as the old ones?

4. Describe carefully the colors and markings of the milk snake and explain how its colors protect it from observation. What are its colors on the underside?

5. Have you ever seen a snake shed its skin? Describe how it was done. How does the sloughed-off skin look? What bird usually puts snake skins around its nest?

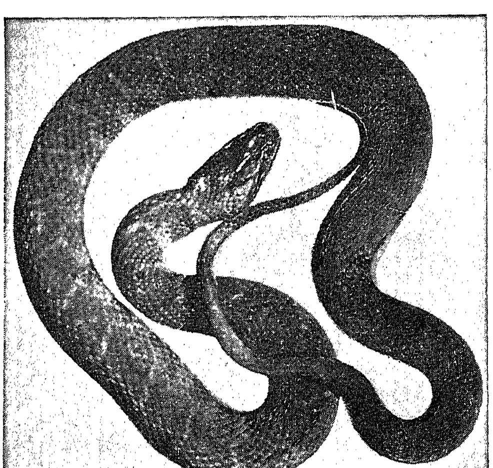
I have the same objection to killing a snake that I have to the killing of any other animal, yet the most humane man I know never omits to kill one.

Aug. 5, 1853.
The mower on the river meadows, when he comes to open his hay these days, encounters some overgrown water adder, full of young (?) and bold in defense of its progeny, and tells a tale when he comes home at night which causes a shudder to run through the village — how it came at him and he ran, and it pursued and overtook him, and he transfixed it with a pitchfork and laid it on a cock of hay, but it revived and came at him again. This is the story he tells in the shops at evening. The big snake is a sort of fabulous animal. It is always as big as a man's arm and of indefinite length. Nobody knows exactly how deadly is its bite but nobody is known to have been bitten and recovered. Irishmen introduced into these meadows for the first time, on seeing a snake, a creature which they have seen only in pictures before, lay down their scythes and run as if it were the Evil One himself and cannot be induced to return to their work. They sigh for Ireland, where they say there is no venomous thing that can hurt you.

— Thoreau's Journal

THE WATER SNAKE

Every boy who goes fishing knows the snake found commonly about milldams and wharves or on rocks and bushes near the water. The teacher will have accomplished a great work, if these boys are made to realize that this snake is more interesting as a creature for study, than as an object to pelt with stones.



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Common water snake
Natrix sipedon sipedon

The water snake is a dingy brown in color, with cross-bands of brown or reddish brown which spread out into blotches at the side. Its color is very protective as it lies on stones or logs in its favorite attitude of sunning itself. It is very local in its habits, and generally has a favorite place for basking and returns to it year after year on sunny days.

This snake lives mostly upon frogs and salamanders and fish; however, it preys usually upon fish of small value, so it is of little economic importance. It catches its victims by chasing and seizing them in its jaws. It has a very keen sense of smell and probably traces its prey in this manner, something as a hound follows a fox. It is an expert swimmer, usually lifting the head a few inches above the water when swimming, although it is able to dive and remain below the water for a short time.

The water snake is a bluffer, and, when cornered, it flattens itself and strikes fiercely. But its teeth contain no poison and it can inflict only slight and harmless wounds. When acting as if it would "rather fight than eat," if given a slight chance to escape, it will flee to the water like a "streak of greased lightning," as any boy will assure you.

The water snake may attain a length of about four feet; but the usual size is two and one-half to three feet. The young do not hatch from eggs, but are born alive in August and September; they differ much in appearance from their parents as they are pale gray in color, with jet-black cross-bands. The young often number twenty-five to forty and are about eight inches long.

SUGGESTED READING — *Along the Brook*, by Raymond T. Fuller; *Field Book of Ponds and Streams*, by Ann H. Morgan; also, readings on page 194.

LESSON 51

THE WATER SNAKE

LEADING THOUGHT — The water snake haunts the banks of streams because its food consists of creatures that live in and about water.

METHOD — If water snakes are found in the locality, encourage the boys to capture one without harming it, and bring it to school for observation. However, as the water snake is very local in its habits, and haunts the same place year after year, it will be better nature-study to get the children to observe it in its native surroundings.

OBSERVATIONS — 1. Where is the water snake found? How large is the largest one you ever saw?

2. Why does the water snake live near water? What is its food? How does it catch its prey?

3. Describe how the water snake swims. How far does its head project above the water when swimming? How long can it stay completely beneath the water?

4. Describe the markings and colors of the water snake. How do these colors protect it from observation? How do the young look?

5. Does each water snake have a favorite place to which it will usually go to sun itself?

6. Where do the water snakes spend the winter?

May 12, 1858.

Found a large water adder by the edge of Farmer's large mudhole, which abounds with tadpoles and frogs, on which it was probably feeding. It was sunning on the bank and would face me and dart its head toward me when I tried to drive it from the water. It is barred above, but indistinctly when out of the water, so that it appears almost uniformly dark brown, but in the water, broad, reddish brown bars are seen, very distinctly alternating with very dark-brown ones. The head was very flat and suddenly broader than the neck behind. Beneath, it was whitish and reddish flesh-color. It was about two inches in diameter at the thickest part. The inside of its mouth and throat was pink. They are the biggest and most formidable-looking snakes that we have. It was awful to see it wind along the bottom of the ditch at last, raising wreaths of mud amid the tadpoles, to which it must be a very sea-serpent. I afterward saw another, running under Sam Barrett's grist-mill, the same afternoon. He said that he saw a water-snake, which he distinguished from a black snake, in an apple tree near by, last year, with a young robin in its mouth, having taken it from the nest. There was a cleft or fork in the tree which enabled it to ascend.

— THOREAU'S JOURNAL

SNAKES

1. Ribbon Snake, Thamnophis sauritus sauritus. *This slender, harmless snake feeds chiefly upon earthworms and young frogs and toads.*

Range: *From Maine, Ontario, and Michigan to Georgia, Alabama, and Mississippi.* Habitat: *Swamps and moist places.*

2. Coral Snake, Micrurus fulvius fulvius. *This beautiful snake is extremely poisonous. Few persons are bitten by it, however, for it is nocturnal in habit and during the day it hides in burrows. Moreover, it does not strike, as most snakes do, but bites into the flesh and chews. It injects so much venom in that way that when it does attack its bite is very dangerous. This dangerous coral snake can be easily distinguished from certain other snakes, which appear to mimic its coloration, by the yellow bands which separate its black from its red bands. Look out for the snake with the yellow bands! Gentle though it may seem, do not play with it.*

3. Rubber Boa, Charina bottæ. *Often spoken of as blind, this boa does have rudimentary eyes, which are, however, almost useless.*

Range: *In humid regions from Utah and Montana to the Pacific coast.*

4. Rough Green Snake, Opheodrys æstivus. *Gentle and harmless, this snake is chiefly insectivorous. It can seldom be induced to bite, and when it does so, its teeth rarely break the skin.*

Range: *From New Jersey south to the Gulf of Mexico and west to Missouri and New Mexico.* Habitat: *Trees and bushy places.*

5. Timber Rattler, Crotalus horridus. *In North America, this rattlesnake is the best known and the most widely distributed. It is more variable in color than is any other rattler. In winter, great numbers hibernate in the same area, and in early spring, when there is a warm day, may crawl out into the sunshine. They usually remain near the den and again seek its protection if the temperature drops appreciably. The food of the timber rattler consists chiefly of warm-blooded animals such as birds, rats, mice, and rabbits. It is generally 3 to 5 feet long.*

Range: *Eastern United States to Mississippi Valley states.* Habitat: *More various than that of any other rattler; it is found in both swampy and mountainous regions.*

6. Desert Gopher Snake *or* Bull Snake, Pituophis catenifer deserticola. *This useful snake, which feeds chiefly on rodents, is in some states protected by law. The length of an adult is usually more than 4 feet.*

Range: *Southern California to Idaho and Washington. Other bull snakes are found from British Columbia to Mexico.* Habitat: *Desert areas.*

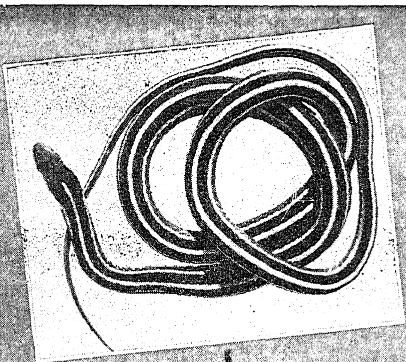
7. Ring-necked Snake *or* Eastern Ring-necked Snake, Diadophis punctatus edwardsii. *The food of this snake shows great variety; it includes other small snakes, lizards, salamanders, and earthworms.*

Range: *Species are found generally over southern Canada, the United States, and Mexico.* Habitat: *Under old boards, loose stones, or pieces of bark.*

8. Sidewinder *or* Horned Rattlesnake, Crotalus cerastes. *Its peculiar means of locomotion gives this snake its name: the body is thrown forward in a series of large loops, and moves at an angle from the direction in which the head is pointed. This way of getting over the ground seems better adapted than the gait of most snakes would be to life in sandy deserts, to which the sidewinder's habitat is virtually limited. It is known to feed on such animals as pocket mice, kangaroo rats, and lizards.*

Range: *Lower California to southwest Utah.*

Photographs by A. A. and A. H. Wright



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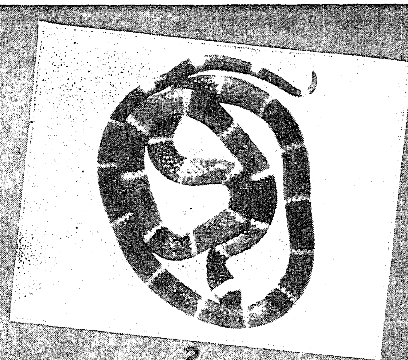

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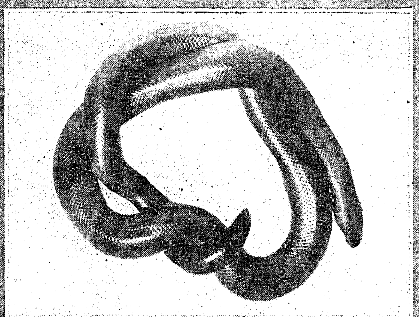

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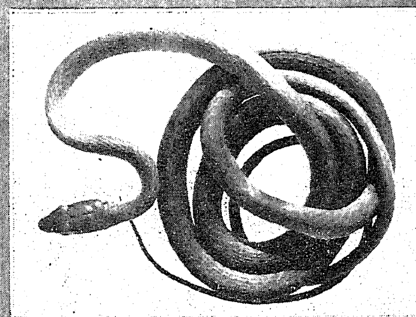

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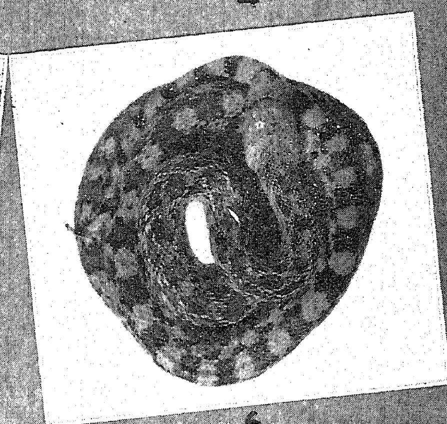

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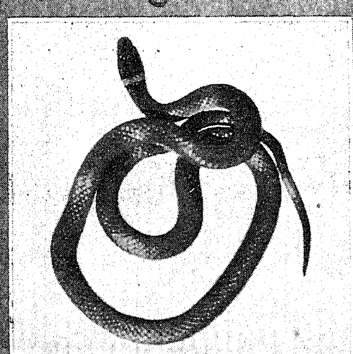

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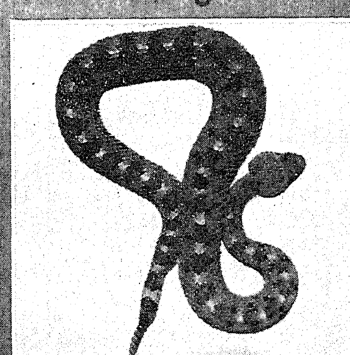

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SNAKES

1. Pike-headed Tree Snake *or* Arizona Long-headed Snake, Oxybelis micropthalamus. *This gentle, slender snake can produce a poisonous bite, which it uses to paralyze its prey. It feeds chiefly on lizards and various small animals.*

Range: *In the United States, southern Arizona.* Habitat: *Trees.*

2. Pilot Black Snake, Elaphe obsoleta obsoleta. *Rats and other small rodents are the food of this useful snake. Adults are usually 5½ feet long, but have reached a length of 7 and 8 feet.*

Range: *From southern New England westward to Michigan, southward to Florida and Texas.*

3. Copperhead, Agkistrodon mokasen mokasen. *The copperhead is common in many parts of the United States, and is probably responsible for more bites than is any other kind of snake. Deaths from its bite have been recorded, but reports from the Antivenin Institute over a period of two years show that although in this time more than three hundred persons were bitten, there were no fatalities, whether or not treatment was given. The food of the copperhead consists mainly of insects, birds, small rodents, and amphibians. It is rather sluggish in habits, and, when molested, usually tries to escape; but if it is taken by surprise or cornered, it defends itself vigorously.*

Range: *Massachusetts to Florida and westward to Arkansas and Texas.* Habitat: *The copperhead usually inhabits drier ground than its relative the moccasin (No. 6).*

4. Boyle's King Snake *or* Boyle's Milk Snake, Lampropeltis getulus boylii. *This snake belongs to a great group of king snakes, all of which do much good to farmers by destroying rodents and many other harmful creatures, including even poisonous snakes.*

Range: *Arizona, western Nevada, and California. Other species are widely distributed.* Habitat: *Regions of small streams, especially where chaparral is present.*

5. Gray Pilot Snake, Elaphe obsoleta confinis. *The habits of this snake are similar to those of the pilot black snake (No. 2).*

Range: *The lower Mississippi Valley, South Atlantic, and Gulf states.*

6. Water Moccasin *or* Cottonmouth, Agkistrodon piscivorus. *This poisonous snake is heavier and larger than the copperhead, since it grows from 3 to 5 or even 6 feet in length. The name of* cottonmouth *has been given it because of the white appearance of the open mouth. It is found in regions of swamps or slow-flowing streams, and in sunny hours is often to be seen at rest on any object that overhangs the water; it stays in such a position that if danger appears it can dive into the water. It eats both warm- and cold-blooded animals, even including other snakes. The young are born alive.*

Range: *From southern Virginia to Florida and the Gulf states.* Habitat: *Swampy areas.*

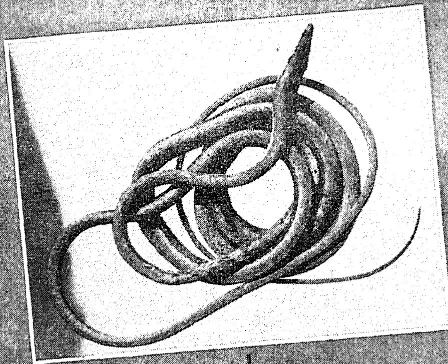
7. California Lyre Snake, Trimorphodon vandenburghi. *The bite of this slender, non-aggressive snake, which it uses to kill or numb the small animals that are its prey, is possibly poisonous to man.*

Range: *California. Other snakes of this group are found in the southwestern United States, Mexico, and Central and South America.*

8. Southern Hognose Snake, Heterdon simus. *When threatened, this harmless snake may "play possum"; or it may expand its body, flatten its head, and hiss. It seems to feel that all dead snakes should lie on their backs; for, if turned on its belly when playing dead, it will flop over on its back. After a short time, if it is not disturbed again, it will turn over and crawl away. Because their threatening actions and ferocious appearance have led people to consider them dangerous to man, many of these inoffensive snakes have been killed.*

Range: *From Florida to Indiana.*

Photographs by A. A. and A. H. Wright



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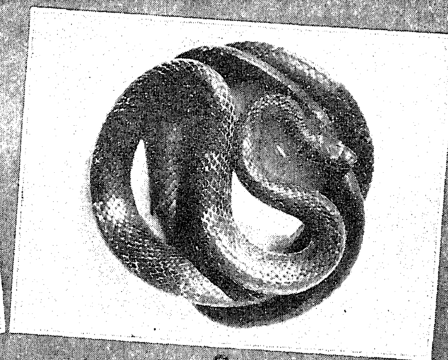

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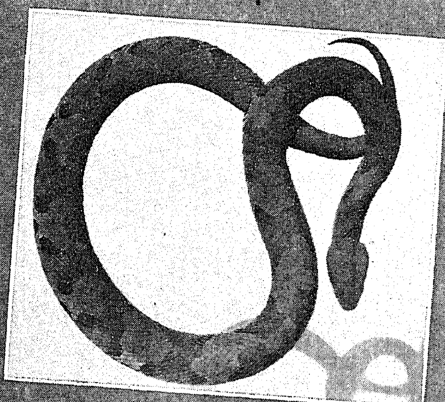

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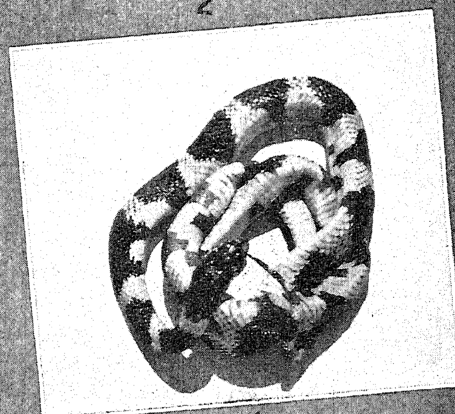

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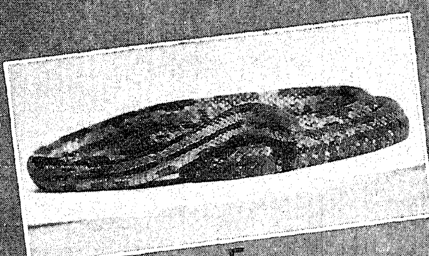

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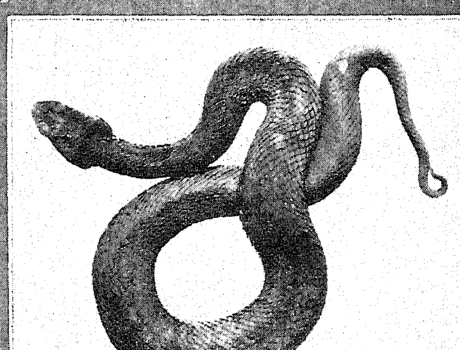

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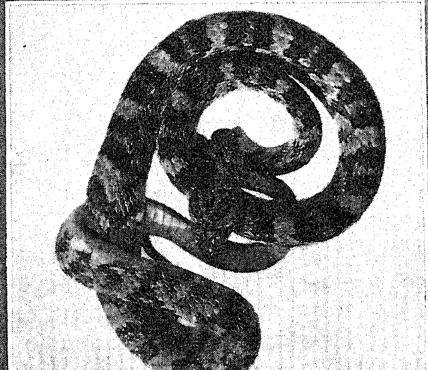

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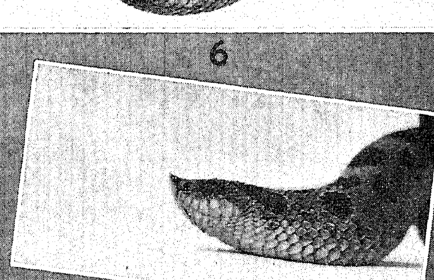

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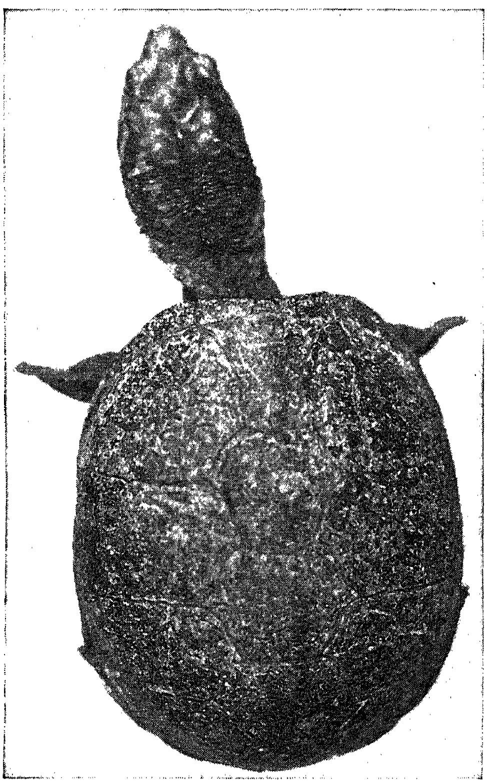
THE TURTLE

A turtle is at heart a misanthrope; its shell is in itself proof of its owner's distrust of this world. But we need not wonder at this misanthropy, if we think for a moment of the creatures that lived on this earth at the time when turtles first appeared. Almost any of us would have been glad of a shell in which to retire if we had been contemporaries of the smilodon and other monsters of earlier geologic times.

When the turtle feels safe and walks abroad for pleasure, his head projects far from the front end of his shell, and the legs, so wide and soft that they look as if they had no bones in them, project out at the side, while the little, pointed tail brings up an undignified rear; but frighten him and at once head, legs, and tail all disappear, and even if we turn him over, we see nothing but the tip of the nose, the claws of the feet and the tail turned deftly sidewise. When frightened, he hisses threateningly; the noise seems to be made while the mouth is shut, and the breath emitted through the nostrils.



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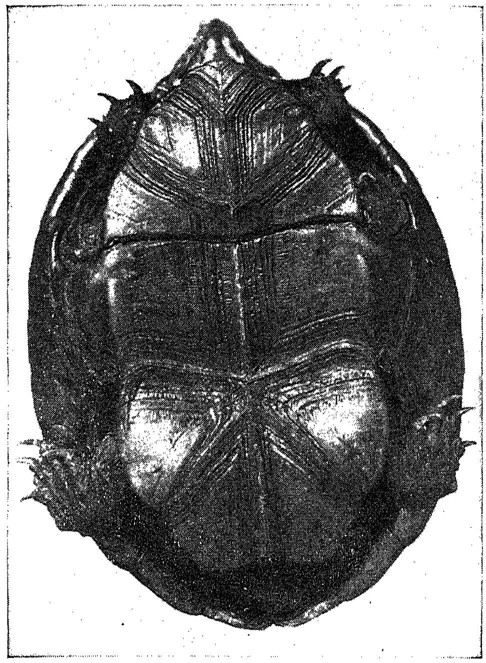
Mud turtle, Kinosternon subrubrum hippocrepis, *viewed from above. Many species of mud turtles are found in the eastern, central, and southern United States. The one pictured is found from Alabama to Texas and north to Kansas. When in captivity, mud turtles will eat lettuce and meat*



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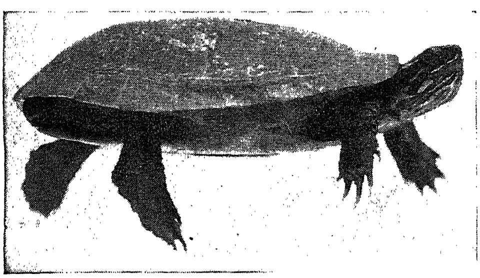
Mud turtle viewed from below

The upper shell of the turtle is called the carapace and the lower shell, the plastron. There is much difference in the different species of turtles in the shape of the upper shell and the size and shape of the lower one. In most species the carapace is sub-globular but in some it is quite flat. The upper shell is grown fast to the backbone of the animal, and the lower shell to the breastbone. The markings and colors of the shell offer excellent subjects for drawing. The painted terrapin has a red-mottled border to the shell, very ornamental; the wood turtle has a shell made up of plates each of which is ornamented with concentric ridges; and the box turtle has a front and rear trap door, which can be pulled up against the carapace when the turtle wishes to retire, thus covering it entirely.

The turtle's head is decidedly snakelike. Its color differs with different species. The wood turtle has a triangular, horny covering on the top of the head, in which the color and beautiful pattern of the shell are repeated; the underparts are brick-red with indistinct yellowish lines under the



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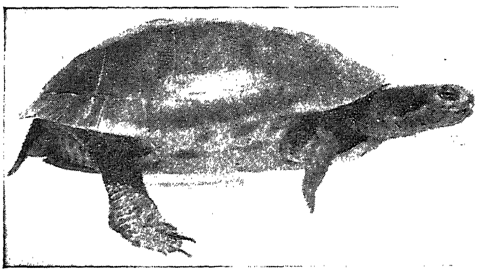
Painted turtle, or terrapin, Chrysemys belli marginata. *The painted turtle pictured is found from the Mississippi River eastward; but species can be found anywhere in the United States except in deserts and very high mountains. This turtle often swims about rocks and logs that protrude above the water*

jaw. The eyes are black with a yellowish iris, which somehow gives them a look of intelligence. The turtle has no eyelids like our own, but has a nictitating membrane which comes up from below and completely covers the eye; if we seize the turtle by the head and attempt to touch its eyes, we can see the use of this eyelid. When the turtle winks, it seems to turn the eyeball down against the lower lid.

The turtle's nostrils are mere pinholes in the snout. The mouth is a more or less hooked beak, and is armed with cutting edges instead of teeth. The constant pulsation in the throat is caused by the turtle's swallowing air for breathing.



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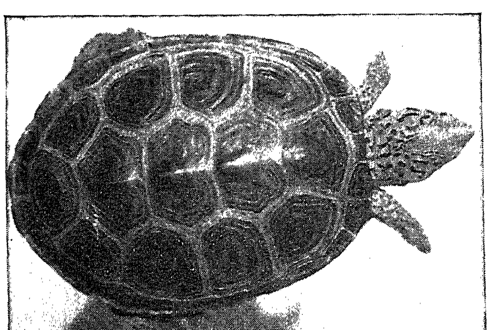
Chicken turtle, Deirochelys reticularia. *This turtle is at home on the coastal plain from North Carolina to Mississippi. Its high shell may reach a length of eight inches; its neck is long and snakelike*

The turtle's legs, although so large and soft, have bones within them, as the skeleton shows. The claws are long and strong; there are five claws on the front and four on the hind feet. Some species have a distinct web between the toes; in others it is less marked, depending upon whether the species lives mostly in water or out of it. The color of the turtle's body varies with the species; the body is covered with coarse, rough skin which frequently bears many scales or plates. Thus, large bright-colored scales are conspicuous on the fore legs of the wood turtle, and the tail of the snapping turtle bears a saw-toothed armor of dorsal plates.

The enemies of turtles are the larger fishes and other turtles. Two turtles should never be kept in the same aquar-



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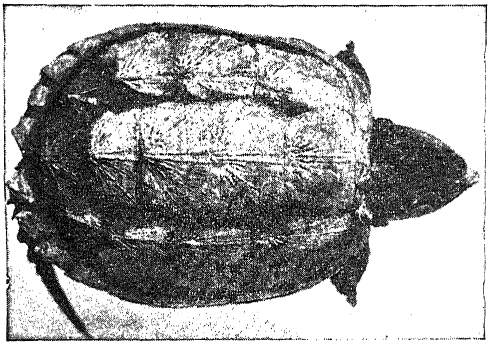
Diamond back terrapin, Malaclemys centrata. *The home of the diamond back is in salt marshes from Florida to Massachusetts. In captivity it will eat lettuce, oysters, beef, chopped clams, or fish. Its flesh is used as meat and for making soup*



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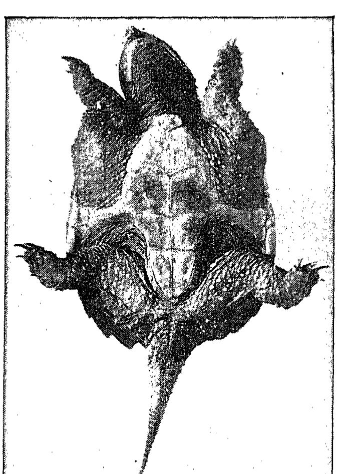
Florida snapper, Chelydra osceola, *viewed from above. Snappers live in slow-running streams, ponds, or marshes; the female often goes some distance from her regular home to bury her round, white eggs — usually about two dozen in number.*

ium, since they eat each other's tails and legs with great relish. They feed upon insects, small fish, or almost anything soft-bodied which they can find in the water; they are especially fond of earthworms. The species which frequent the land feed upon tender vegetation and also eat berries. In an aquarium, a turtle should be fed earthworms, chopped fresh beef, lettuce leaves, and berries. The wood turtle is especially fond of cherries.

The aquarium should always have in it a stone or some other object projecting above the water, so that the turtle may



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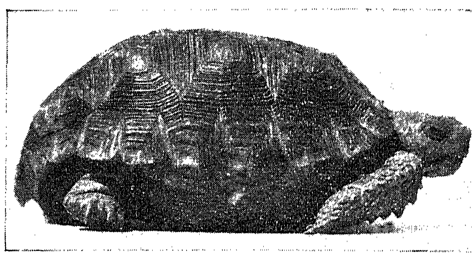
Florida snapper viewed from below

climb out, if it chooses. In winter, water turtles may bury themselves in the ooze at the bottom of ponds and streams. The land turtles dig themselves into the earth. Their eggs have white leathery shells, are oblong or round, and are buried by the mother in the sand or soil near a stream or pond. The long life of turtles is a well-authenticated fact; dates carved upon their shells show them to have attained the age of thirty or forty years.

The following are common kinds:

(a) *The Snapping Turtle* — This sometimes attains a shell fourteen inches long and a weight of forty pounds. It is a vicious



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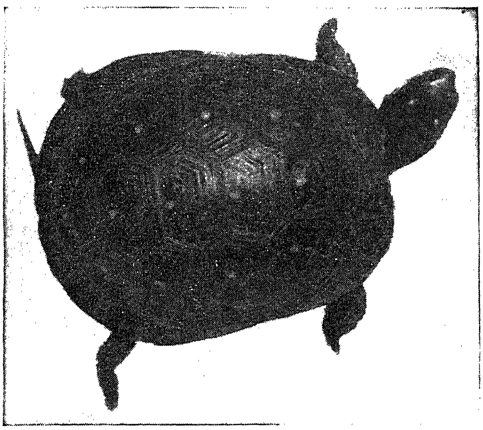
Gopher turtle, Gopherus berlandieri. *These turtles are related to the huge turtles of the Galapagos Islands. The one pictured is found in the Rio Grande region; but the range of the gopher turtles extends widely through the South and the Southwest*

creature and inflicts a severe wound with its sharp, hooked beak; it should not be used for a nature-study lesson unless the specimen is very young. The large alligator snapper of the South may attain a weight of one hundred pounds.

(b) *The Mud Turtle* — The musk turtle and the common mud turtle both inhabit slow streams and ponds; they are truly aquatic and only come to shore to deposit their eggs. They cannot eat unless they are under water, and they seek their food in the muddy bottoms. The musk turtle, when handled, emits a very strong odor; it has on each side of the head two broad yellow stripes. The mud turtle has no odor. Its head is ornamented with greenish yellow spots.

(c) *The Painted Terrapin, or Pond Turtle* — This can be determined by the red mottled border of its shell. It makes a good pet, if kept in an aquarium by itself, but will destroy other creatures. It will eat meat or chopped fish, and is fond of earthworms and soft insects. It finds its food most readily under water.

(d) *The Spotted Turtle* — This has the upper shell black with numerous round yellow spots upon it. It is common in ponds and marshy streams and its favorite perch is upon a log with many of its companions. It feeds under water, eating insect larvæ, dead fish, and vegetation. It likes fresh lettuce.



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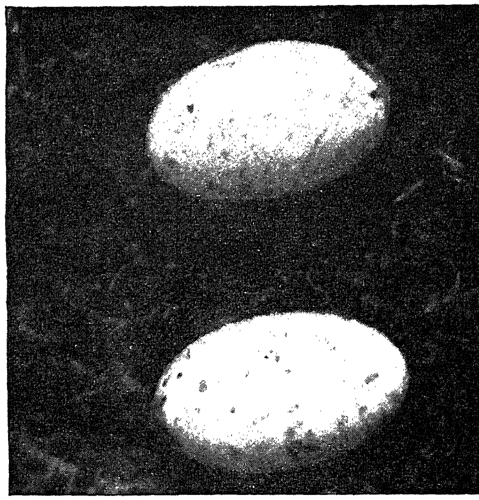
Spotted turtle, Clemmys guttata. *The range of the spotted turtles extends from Michigan to Maine and south to Florida. In captivity they often become very tame; they prefer raw food — earthworms, aquatic insects, ground beef, or fish*

(e) *The Wood Terrapin* — This is our most common turtle; it is found in damp woods and wet places, since it lives largely upon the land. Its upper shell often reaches a length of six and one-half inches and is made up of many plates, ornamented with concentric ridges. This is the turtle upon whose shell people carve initials and dates and then set it free. All the fleshy parts of this turtle, except the top of the head and the limbs, are brick-red. It feeds on tender vegetables, berries, and insects, but also enjoys chopped meat. It makes an interesting pet and will soon learn to eat from the fingers of its master.



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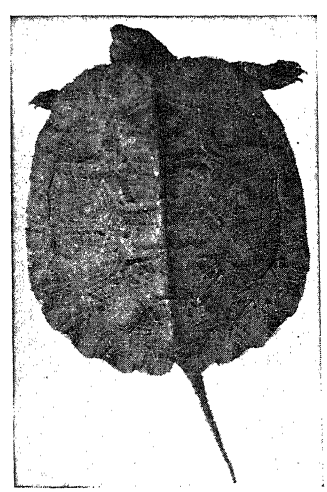
Eggs of spotted turtle
Clemmys guttata

(f) *The Box Turtle* — This is easily distinguished from the others, because the front and rear portions of the lower shell are hinged so that they can be pulled up against the upper shell. When this turtle is attacked, it draws into the shell and closes both front and back doors, and is very safe from its enemies. It lives entirely upon land and feeds upon berries, tender vegetation, and insects. It, too, in captivity will eat chopped meat. It lives to a great age.



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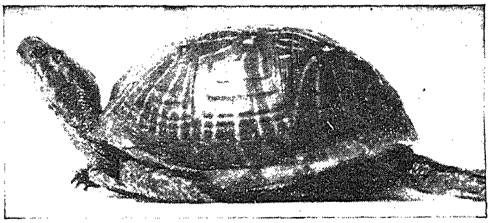
A young wood turtle
Clemmys insculpta



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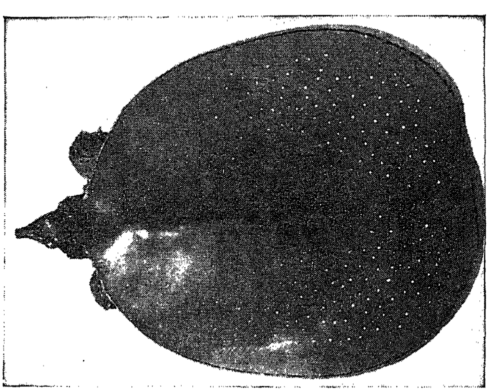
Box turtle, Terrapene major. *One or more species of box turtle can be found in almost any portion of the United States from the Rocky Mountains eastward*

(g) *The Soft-shelled Turtle* — These are found in streams and canals. The upper shell looks as if it were of one piece of soft leather, and resembles a griddle-cake. The neck is very long and the head particularly snakelike with a piglike snout. Although soft-shelled, these turtles are far from soft-tempered, and must be handled with care. In captivity they must be kept in water.

Suggested Reading — *Along the Brook,* by Raymond T. Fuller; *Field Book of Ponds and Streams,* by Ann H. Morgan; *First Lessons in Nature Study,* and *Holiday Pond,* both by Edith M. Patch; Humphrey: *One Hundred Years along the Wayside with a Box Turtle,* by Marjorie Flack; *The Spring of the Year,* by Dallas Lore Sharp (Turtle Eggs for Agassiz); also, readings on page 194.



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Soft-shelled turtle, Amyda emoryi. *The species pictured is found in Texas, Oklahoma, and Arkansas; other species may be found from Canada south to the Gulf and as far west as Colorado*

LESSON 52

The Turtle

Leading Thought — The turtle's shell is for the purpose of protecting its owner from the attack of enemies. Some turtles live upon land and others in water.

Method — A turtle of any kind, in the schoolroom, is all that is needed to make this lesson interesting.

Observations — 1. How much can you see of the turtle when it is walking? If you disturb it what does it do? How much of it can you see then? Can you see more of it from the lower side than from the upper? What is the advantage to the turtle of having such a shell?

J. T. Lloyd

A snapping turtle

2. Compare the upper shell with the lower as follows: How are they shaped differently? What is their difference in color? Would it be a disadvantage to the turtle if the upper shell were as light colored as the lower? Why? Make a drawing of the upper and the lower shell showing the shape of the plates of which they are composed. Where are the two grown together?

3. Is the border of the upper shell different from the central portion in color and markings? Is the edge smooth or scalloped?

4. How far does the turtle's head project from the front of the shell? What is the shape of the head? With what colors and pattern is it marked? Describe the eyes. How are they protected? How does the turtle wink? Can you discover the little eyelid which comes up from below to cover the eye?

5. Describe the nose and nostrils. Do you think the turtle has a keen sense of smell?

6. Describe the mouth. Are there any teeth? With what does it bite off its food? Describe the movement of the throat. What is the cause of this constant pulsation?

7. What is the shape of the leg? How is it marked? How many claws on the front feet? Are any of the toes webbed? On which feet are the webbed toes? Why should they be webbed? Describe the way a turtle swims. Which feet are used for oars?

8. Describe the tail. How much can be seen from above when the turtle is walking? What becomes of it, when the turtle withdraws into its shell?

9. How much of the turtle's body can you see? What is its color? Is it rough or smooth?

10. What are the turtle's enemies? How does it escape from them? What noise does the turtle make when frightened or angry?

11. Do all turtles live for part of the time in water? What is their food and where do they find it? Write an account of all the species of turtles that you know.

12. How do turtle eggs look? Where are they laid? How are they hidden?

LIZARDS

1 *and* 2. BANDED GECKO, Coleonyx brevis. *The gecko, a male, shown in* (1) *has lost the tip of its fragile tail. In* (2) *another gecko, a female, is pictured with a complete tail. An interesting fact about these creatures is that after the tail has been lost another complete tail may later be regenerated. This is characteristic of lizards. The banded gecko is* 2 *to* 3 *inches long, and is yellow and brown in color; its small scales give it a very soft, smooth appearance.*

Range: *Found only in Texas.* Habitat: *Under stones; it comes out at night.*

3. CHAMELEON, Anolis carolinensis. *This well-known lizard changes color with temperature conditions: it may fade from dark brown to pale green in three minutes. Often seen in captivity, it can be fed on meal worms and flies; it needs water to drink.*

Range: *North Carolina and Florida to the Rio Grande.*

4. FENCE LIZARD, Sceloporus thayeri. *Like other lizards, this animal eats insects. It is about* 5 *inches long.*

5. GLASS SNAKE *or* LEGLESS LIZARD, Ophisaurus ventralis. *This long, slender lizard is smooth and glassy. It has a ground color of olive, black, or brown, with greenish to black markings, and a greenish white on the under portions of the body. The long tail makes up about two-thirds of the total length of the animal. An average full-grown specimen is about* 24 *inches long, but some individuals may attain a length of* 3 *feet. Like most other lizards, the glass snake, if seized, can shed its tail. While its astonished pursuer gazes at the tail, the body escapes. A new tail begins to grow at once, but it seems never to grow quite as large as the original. The glass snake can be distinguished from a true snake by an ear opening on each side of the head, by numerous rows of small, overlapping scales on its belly, and by movable eyelids.*

Range: *Virginia to Florida westward to Nebraska, Wisconsin, and Mexico.* Habitat: *Chiefly in the ground.*

6. ALLIGATOR LIZARD *or* PLATED LIZARD, Gerrhonotus infernalis. *Whatever this lizard hears must "go in one ear and out the other"; for one can look through the ear openings directly through the head. These lizards, which are about* 18 *inches long, make interesting pets.*

Range: *Southern Texas and northern Mexico.*

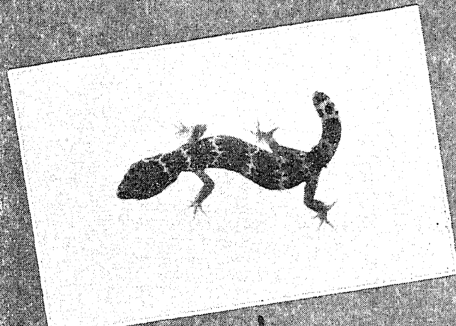
7. SONORAN SKINK, Eumeces obsoletus. *Skinks are seldom seen in captivity, for they are hard to capture. They are active in daylight. The females of some skinks stay with their eggs until they hatch.*

Range: *Utah and Kansas to northern Mexico. Other kinds are widely distributed over North and Central America; there are many in the Old World.*

8. GILA MONSTER, Heloderma suspectum. *As far as is known, no two gila monsters show exactly the same color patterns. Orange, salmon, and brown or black are the chief colors, but they are variously arranged. This and the closely related Mexican beaded lizard are the only poisonous lizards known in the New World. In the gila monster the poison glands are situated in the lower jaw and the venom flows out around the teeth and gums. Therefore, since the teeth are above the level of the glands, the poison sometimes does not enter a wound made by the teeth. This lizard is rather sluggish and quite often will not bite even if it is given a good chance to do so. When it does bite, it holds on with a strong grip. In walking it moves slowly and seems awkward, but it is active enough to climb trees and bushes, evidently in search of bird's eggs, of which it is very fond. If it is given plenty of drinking water, it can be kept in captivity for years on a diet of hen's eggs.*

Range: *Arizona and New Mexico.* Habitat: *Deserts.*

Photographs by A. A. and A. H. Wright



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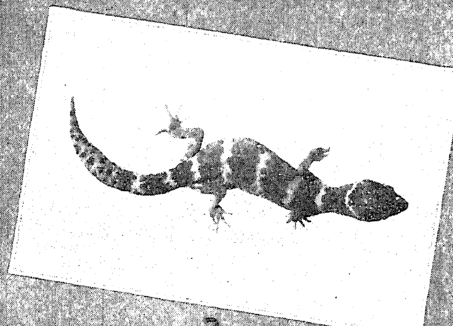

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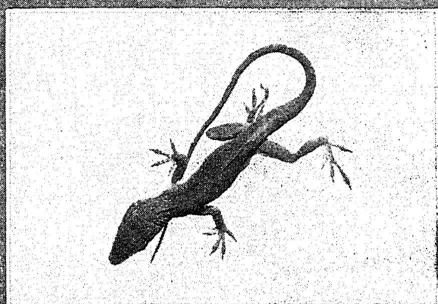

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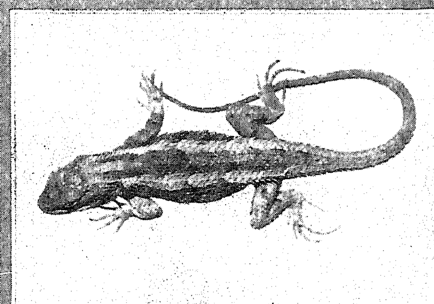

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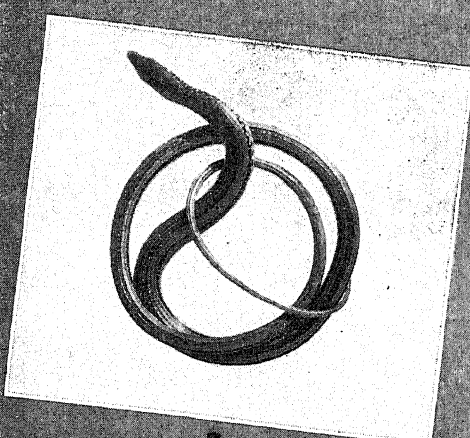

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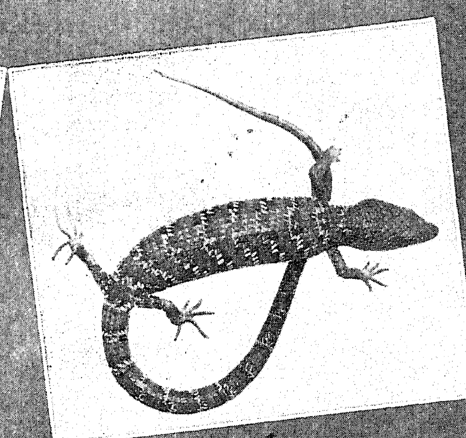

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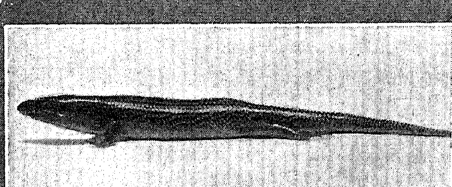

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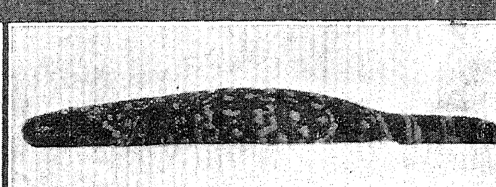

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LIZARDS

1 *and* 2. REGAL HORNED TOAD, Phrynosoma solare. *This lizard is called "regal" because the row of spines across the sides and rear of the head gives the effect of a crown. Its color is yellowish, brownish, reddish, or grayish. The eggs are shown in No.* 2.

Range: *Arizona and Lower California. Other kinds are found throughout the western and southwestern states and northern Mexico.*

3. HORNED TOAD, Phrynosoma blainvillii. *These lizards, commonly called "horned toads," are inhabitants of hot, dry regions. In the warmer months they live above ground during the hours of daylight, and are most active when the heat is greatest. Before dark they bury themselves in the sand. They hibernate in winter. In color they often resemble somewhat the ground where they live. A strange habit of the horned toad is that of "squirting blood" from one or both eyes, perhaps as a means of self-defense. The blood has not been found to be poisonous, and must be ejected more to scare than actually to injure the enemy. The horned toad can be tamed, and is often kept for a pet. All too often, however, its owner does not provide enough of the right kind of food—various kinds of small insects—for it, and in such circumstances its ability to live for a long time without food or water serves only to prolong its discomfort. In the Southwest these lizards are sometimes stuffed and sold to tourists as souvenirs, but some states have passed laws prohibiting such sales.*

Range: *San Francisco into Lower California.*

4. HORNED TOADS FEEDING ON ANTS. *In this picture several kinds of horned toads are shown feeding on ants in a pile of sand. They did not dash into the pile, but stood about it in a circle and caught the ants as they came out.*

5. MALE FENCE LIZARD, Sceloporus spinosus. *On either side of the belly the male lizard has a large blue or purple spot margined with black. Such marks are used to identify many male lizards.*

Range: *Northern Mexico, New Mexico, and Texas to western Florida.* Habitat: *Trunks of standing or fallen trees.*

6. MOUNTAIN BOOMER *or* COLLARED LIZARD, Crotaphytus collaris baileyi. *This unusual looking animal makes a good pet if enough food can be provided for it. It lives chiefly on insects and blossoms of various plants, but it also has cannibalistic habits, and so must not be kept in a cage with other lizards of equal or smaller size. It is found about rocks at high altitudes. If alarmed or pursued, it runs until it can find a crevice in the rocks. It is a swift runner and a high jumper, being able to clear an object as much as two feet high. In the hottest part of the day its colors seem brighter than during the cooler hours.*

Range: *Southwestern United States and Mexico.* Habitat: *Dry, rocky regions.*

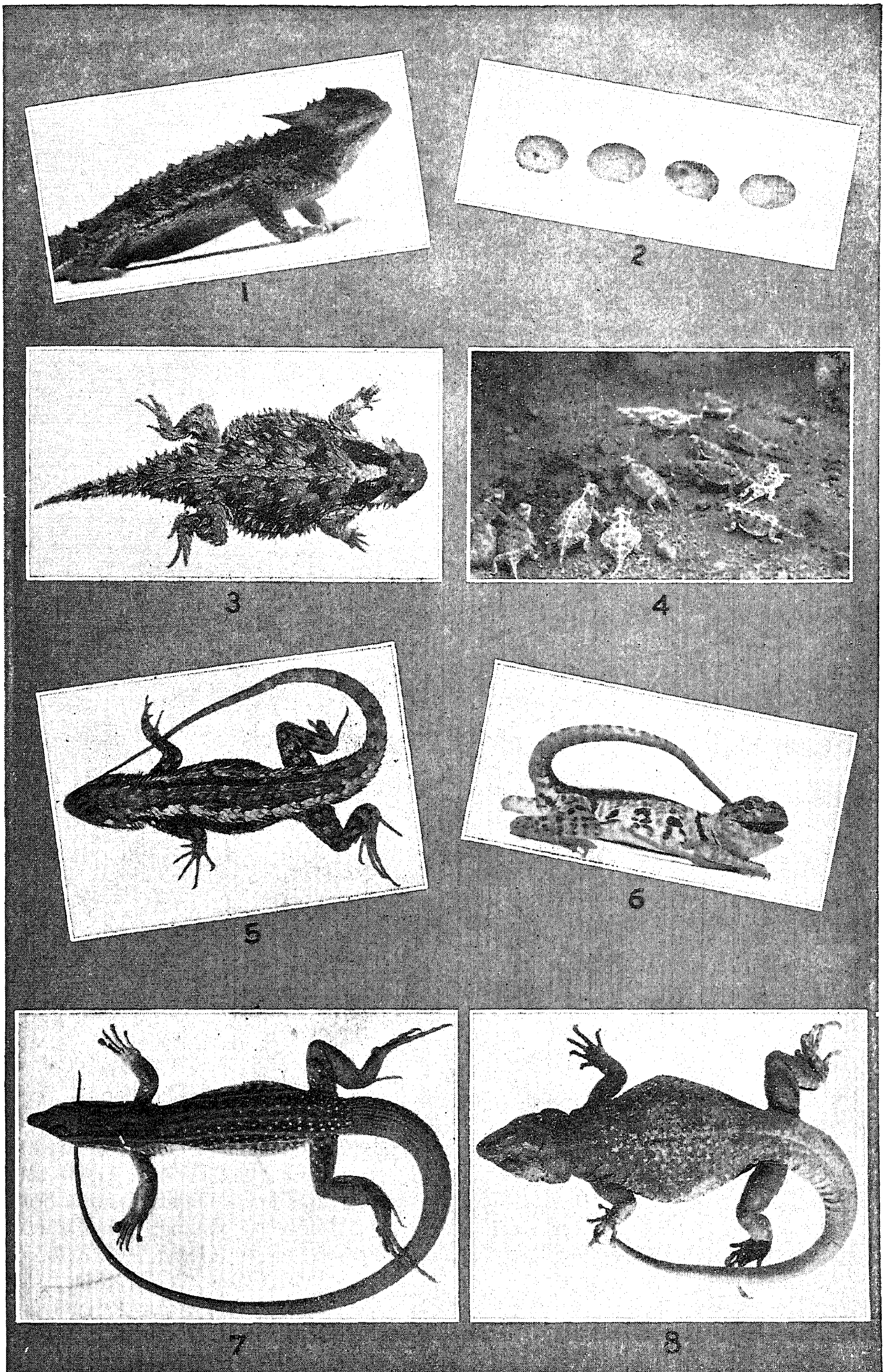
7. WHIP-TAIL *or* RACE RUNNER, Cnemidophorus gularis. *These striped lizards are active all day under the hottest sun in open areas. In the specimen pictured here, note the balls of dirt on its toes from running in soft dirt after a rain.*

Range: *Southwestern United States and northern Mexico. A six-line race runner is common in the East.*

8. CHUCK-WALLA, Sauromalus obesus. *This large lizard,* 10 *to* 16 *inches long, is a vegetarian. It protects itself by escaping into crevices. This specimen ran into a crevice and puffed himself up to such a size that it was hard to get him out.*

Range: *Southwestern United States.* Habitat: *Rocky places in desert areas.*

Photographs by A. A. and A. H. Wright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MAMMALS

Mammals, in contrast to fishes, amphibians, and reptiles, are warm-blooded animals, as are birds. The skin of most mammals is more or less hairy, in contrast to the scale-covered fish and the feathered birds. The young of most mammals are born alive, whereas the young of birds, fish, amphibians, and some species of reptiles hatch from eggs. After birth young mammals breathe by lungs rather than by gills as do the fish; for a time they are nourished with milk produced by the mother.

Marthe Ann, one year old. Human beings are mammals

Great variations exist in the mammal group. Some of the typical animals in the mammal group which illustrate these variations are opossum, armadillo, whale, deer, buffalo, rabbit, mouse, woodchuck, mole, bat, bear, horse, cat, dog, and man.

Man has always depended a great deal on the lower mammal forms; he uses them for food, clothing, transportation, and numerous other purposes. Many forms are domesticated and have served as man's obedient servants for many centuries.

Some of the so-called game animals have suffered wanton destruction at the hands of "civilized man," but in more recent years many laws and regulations have been passed to give these animals more chances to live. Even more stringent laws are needed and rigid enforcement must be exacted if wild animals in general are to be expected to increase in number.

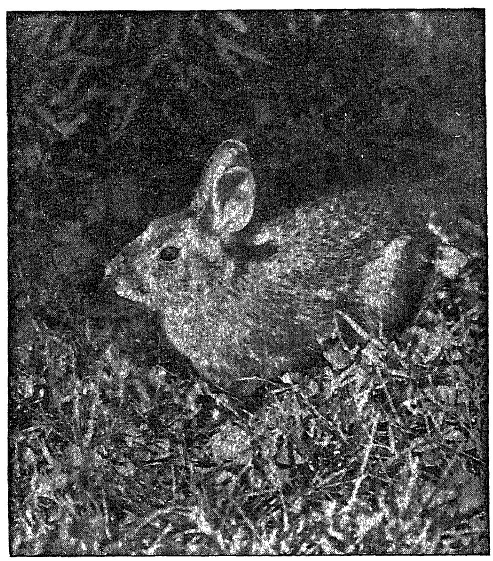
Suggested Reading — *Along Nature's Trails*, by Lillian C. Athey; *Animals of America*, edited by H. E. Anthony; *The Book about Animals*, published by Frederick Warne and Company; *Field Book of North American Mammals*, by H. E. Anthony; *Homes and Habits of Wild Animals*, by Karl P. Schmidt; *Lives of Game Animals*, by Ernest Thompson Seton; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 4, *Our Earth and Its Life*; *Our Great Outdoors, Mammals*, by C. W. G. Eifrig; *Our Wild Animals*, by Edwin L. Moseley; *Out of Doors: A Guide to Nature*, by Paul B. Mann and George T. Hastings; *The Picture Book of Animals, The Second Picture Book of Animals*, both by Isabel E. Lord; *Present Day Mammals*, by Claude W. Leister; *The Stir of Nature*, by William H. Carr; *Tracks and Trails*, by Leonard Rossell; *Wild Animals of North America*, by E. W. Nelson; additional references are to be found in the bibliography in the back of this Handbook, under various headings: Mammals, Animals in General, Nature-study in General, Textbooks and Readers, Nature Poetry, Magazines and Periodicals, Books for Parents and Teachers.

THE COTTON-TAIL RABBIT

The Bunnies are a feeble folk whose weakness is their strength.
To shun a gun a Bun will run to almost any length. — Oliver Herford

It is well for Molly Cotton-tail and her family that they have learned to shun more than guns, for almost every predatory animal and bird makes a dinner of them on every possible occasion. But despite these enemies, moreover, with the addition of guns, men, and dogs, the cotton-tail lives and flourishes in our midst. A " Molly " raised two families last year in a briar-patch back of our garden on the Cornell campus, where dogs of many breeds abound; and after each fresh fall of snow this winter we have been able to trace our bunny neighbors in their night wanderings around the house, beneath the spruces and in the orchard. The track consists of two long splashes, paired, and between and a little behind them, two smaller ones; the rabbit uses its front feet as a boy uses a vaulting pole and lands the hind feet on each side and ahead of them; because the bottoms of the feet are hairy the print is not clear-cut. When the rabbit is not in a hurry it has a peculiar lope, but when frightened it makes long jumps. The cotton-tails are night wanderers and usually remain hidden during the day. In summer, they feed on clover or grass or other juicy herbs and show a fondness for sweet apples and fresh cabbage; in our garden last summer Molly was very considerate. She carefully pulled all the grass out of the garden-cress bed, leaving the salad for our enjoyment. In winter, the long, gnawing teeth of the cotton-tail are sometimes used to the damage of fruit trees and nursery stock since the rabbits are obliged to feed upon bark in order to keep alive.

The long, strong hind legs and the long ears tell the whole bunny story. Ears to hear the approach of the enemy, and legs to propel the listener by long jumps to a safe retreat. The attitude of the ears is a good indication of the bunny's state of mind; if they are set back to back and directed backward, they indicate placidity, but a placidity that is always on guard; if lifted straight up they signify attention and anxiety; if one is bent forward and the other backward the meaning is: " Now just where did that sound come from? "

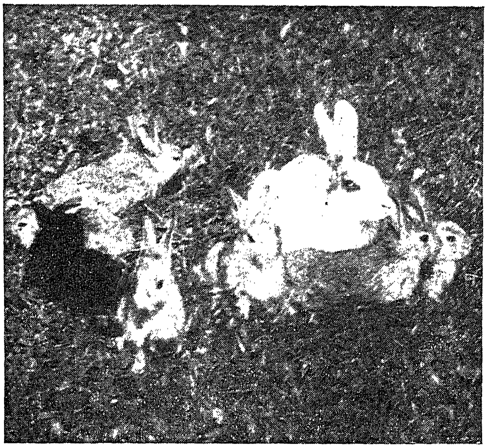


A cotton-tail rabbit

When the rabbit is running or resting in the form, the ears are laid back along the neck. When the cotton-tail stands up on its haunches with both ears erect, it looks very tall indeed.

Not only are the ears always alert, but also the nose; the nostrils are partially covered and in order to be always sure of getting every scent they wabble constantly, the split upper lip aiding in this performance; when the rabbit is trying to get a scent it moves its head up and down in a sagacious, apprehensive manner.

The rabbit has an upper and lower



Verne Morton

The rabbits' ears are ever alert for any sign of danger

pair of incisors like other rodents, but on the upper jaw there is a short incisor behind each of the large teeth; these are of no use now but are inherited from some ancestor which found them useful. There are at the back of each side of the upper jaw six grinding teeth, and five on each side of the lower jaw. The split upper lip allows the free use of the upper incisors. The incisors are not only used for taking the bark from trees, but also for cutting grass and other food. The rabbit has a funny way of taking a stem of grass or clover at the end and with much wabbling of lips finally taking it in, meanwhile chewing it with a sidewise motion of the jaws. The rabbit's whiskers are valuable as feelers, and are always kept on the *qui vive* for impressions; when two cotton-tails meet each other amicably, they rub whiskers together. The eyes are large and dark and placed on the bulge at the side of the head, so as to command the view both ways. Probably a cotton-tail winks, but I never caught one in the act.

The strong hind legs of the rabbit enable it to make prodigious jumps, of eight feet or more; this is a valuable asset to an animal that escapes its enemies by running. The front feet are short and cannot be turned inward like those of the squirrel, to hold food. There are five toes on the front feet, and four on the hind feet; the hair on the bottom of the feet is a protection, much needed by an animal which sits for long periods upon the snow. When sleeping, the rabbit folds the front paws under and rests on the entire hind foot, with the knee bent, ready for a spring at the slightest alarm; when awake, it rests on the hind feet and front toes; and when it wishes to see if the coast is clear, it rises on its hind feet, with front paws drooping.

The cotton-tail has a color well calculated to protect it from observation; it is brownish-gray on the back and a little lighter along the sides, grayish under the chin and whitish below; the ears are edged with black, and the tail when raised shows a large, white fluff at the rear. The general color of the rabbit fits in with natural surroundings; since the cotton-tail often escapes its enemies by " freezing," this color makes the scheme work well. I once saw a marsh hare, on a stone in a brook, " freezing " most successfully. I could hardly believe that a living thing could seem so much like a stone; only its bright eyes revealed it to us.

The rabbit cleans itself in amusing ways. It shakes its feet one at a time with great vigor and rapidity to get off the dirt and then licks them clean. It washes its face with both front paws at once. It scratches its ear with the hind foot, and pushes it forward so that it can be licked; it takes hold of its fur with its front feet to pull it around within reach of the tongue.

The cotton-tail does not dig a burrow,

A Dutch rabbit and Belgian hares

but sometimes occupies the deserted burrow of a woodchuck or skunk. Its nest is called a "form," which simply means a place beneath a cover of grass or briars, where the grass is beaten down or eaten out for a space large enough for the animal to sit. The mother prepares a shallow excavation in which she makes a soft bed for the young, using grass and her own hair for the purpose; and she constructs a coarse felted coverlet, under which she tucks her babies with care every time she leaves them. Young rabbits are blind at first, but when about three weeks old are sufficiently grown to run quite rapidly. Although there may be five or six in a litter, yet there are so many enemies that only a few escape.

Fox, mink, weasel, hawk, owl, snake, and occasionally red squirrel all relish the young cotton-tail if they can get it. Nothing but its runways through the briars can save it. These roads wind in and out and across, twisting and turning perplexingly; they are made by cutting off the grass stems, and are just wide enough for the rabbit's body. However, a rabbit has weapons and can fight if necessary; it leaps over its enemy, kicking it on the back fiercely with its great hind feet. Mr. Seton tells of this way of conquering the black snake, and Mr. Sharp saw a cat completely vanquished by the same method. Mr. E. W. Cleeves told me of a Belgian doe which showed her enmity to cats in a peculiar way. She would run after any cats that came in sight, butting them like a billy goat. The cats soon learned her tricks, and would climb a tree as soon as they caught sight of her. The rabbit can also bite, and when two males are fighting, they bite each other savagely. The rabbit's sound of defiance is thumping the ground with the strong hind foot. Some have declared that the front feet are used also for stamping; although I have heard this indignant thumping more than once, I could not see the process. The cotton-tail and the common domestic rabbit are true rabbits. The jack rabbit is a true hare.

Not the least of tributes to the rabbit's sagacity are the Negro folk stories told by Uncle Remus, wherein Brer Rabbit, although often in trouble, is really the most clever of all the animals. I have often thought when I have seen the tactics which rabbits have adopted to escape dogs, that we in the North have underrated the cleverness of this timid animal. In one instance at least that came under our observation, a cotton-tail led a dog to the verge of a precipice, then doubled

Rabbits playing in the moonlight

back to safety, while the dog went over, landing on the rocks nearly three hundred feet below.

An interesting relative of the cotton-tail is the varying hare or snow-shoe rabbit that lives in the wooded regions of north-eastern North America. Of all animals he is one of the most defenseless; foxes, mink, and other flesh-eating inhabitants of the woods find him an easy prey. He has not even a burrow to flee to when pursued by his enemies.

He passes the day half asleep and motionless beneath the sheltering branches of a low fir tree or in a dense thicket. With the coming of night he starts off in search of food.

He has one important advantage over his enemies: twice each year his heavy coat of fur is shed. In the summer the coat is a reddish brown that so blends with his surroundings that he is hardly noticeable; in the winter it is perfectly white so that against a background of snow he is nearly invisible.

Suggested Reading — *Farm Animals*, by James G. Lawson; *Holiday Hill*, by Edith M. Patch; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals; The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *Our Backdoor Neighbors*, by Frank C. Pellett; *The Pet Book*, by Anna B. Comstock; *Wild Animals I Have Known*, or *Lobo, Rag and Vixen*, both by Ernest Thompson Seton; also, readings on page 214.

LESSON 53

The Cotton-tail Rabbit

Leading Thought — The cotton-tail thrives amid civilization; its color protects it from sight; its long ears give it warning of the approach of danger; and its long legs enable it to run by swift, long leaps. It feeds upon grasses, clover, vegetables, and other herbs.

Method — This study may be begun in the winter, when the rabbit tracks can be observed and the haunts of the cotton-tail discovered. If caught in a box trap, the cotton-tail will become tame if properly fed and cared for, and may thus be studied at close range. The cage I have used for rabbits thus caught is made of wire screen nailed to a frame, making a wire-covered box two feet high and two or three feet square, with a door at one side and no bottom. It should be placed upon oilcloth or linoleum, and thus may be moved to another carpet when the floor needs cleaning. If it is impossible to study the cotton-tail, the domestic rabbit may be used instead.

Observations — 1. What sort of tracks does the cotton-tail make in the snow? Describe and sketch them. Where do you find these tracks? How do you know which way the rabbit was going? Follow the track and see if you can find where the rabbit went. When were these tracks made, by night or by day? What does the rabbit do during the day? What does it find to eat during the winter? How are its feet protected so that they do not freeze in the snow?

2. What are the two most noticeable peculiarities of the rabbit? Of what use are such large ears? How are the ears held when the rabbit is resting? When startled? When not quite certain about the direction of the noise? Explain the reasons for these attitudes. When the rabbit wishes to make an observation to see if there is danger coming, what does it do? How does it hold its ears then? How are the ears held when the animal is running?

3. Do you think the rabbit has a keen sense of smell? Describe the movements of the nostrils and explain the reason. How does it move its head to be sure of getting the scent?

4. What peculiarity is there in the upper lip? How would this be an aid to the rabbit when gnawing? Describe the teeth; how do these differ from those of the mouse or squirrel? Of what advantage are the gnawing teeth to the rabbit? How does it eat a stem of grass? Note the rabbit's whiskers. What do you think they are used for?

5. Describe the eyes. How are they placed so that the rabbit can see forward and backward? Do you think that it sleeps with its eyes open? Does it wink?

6. Why is it advantageous to the rabbit to have such long, strong hind legs? Compare them in size with the front legs. Compare the front and hind feet. How many toes on each? How are the bottoms of the feet protected? Are the front feet ever used for holding food like the squirrel's? In what position are the legs when the rabbit is resting? When it is standing? When it is lifted up for observation?

7. How does the cotton-tail escape being seen? Describe its coat. Of what use is the white fluff beneath the tail? Have you ever seen a wild rabbit "freeze"? What is meant by "freezing" and what is the use of it?

8. In making its toilet how does the rabbit clean its face, ears, feet, and fur?

9. What do the cotton-tails feed upon during the summer? During the winter? Do they ever do much damage?

10. Describe the cotton-tail's nest. What is it called? Does it ever burrow in the ground? Does it ever use a second-hand burrow? Describe the nest made for the young by the mother. Of what is the bed composed? Of what is the coverlet made? What is the special use of the coverlet? How do the young cotton-tails look? How old are they before they are able to take care of themselves?

11. What are the cotton-tail's enemies? How does it escape them? Have you ever seen the rabbit roads in a briar-patch? Do you think that a dog or fox could follow them? Do rabbits ever fight their enemies? If so, how? How do they show anger? Do they stamp with the front or the hind foot?

12. Tell how the cotton-tail differs in looks and habits from the common tame rabbit. How do the latter dig their burrows? How many breeds of tame rabbits do you know?

13. Write or tell stories on the following topics: "A Cotton-tail's Story of Its Own Life until It Is a Year Old"; "The Jack Rabbit of the West"; "The Habits of the White Rabbit or Varying Hare"; "The Rabbit in Uncle Remus' Tales."

Silas Lottridge

Winter lodge of muskrats

THE MUSKRAT

Having finished this first course of big-neck clams, they were joined by a third muskrat, and, together, they filed over the bank and down into the meadow. Shortly two of them returned with great mouthfuls of the mud-bleached ends of calamus-blades. Then followed the washing.

They dropped their loads upon the plank, took up the stalks, pulled the blades apart, and soused them up and down in the water, rubbing them with their paws until they were as clean and white as the whitest celery one ever ate. What a dainty picture! Two little brown creatures, humped on the edge of a plank, washing calamus in moonlit water! — Dallas Lore Sharp

Tracking is a part of the education of every boy who aspires to a knowledge of wood lore; and a boy with this accomplishment is sure to be looked upon with great admiration by other boys less skilled in the interpretation of that writ-

Silas Lottridge
The Muskrat

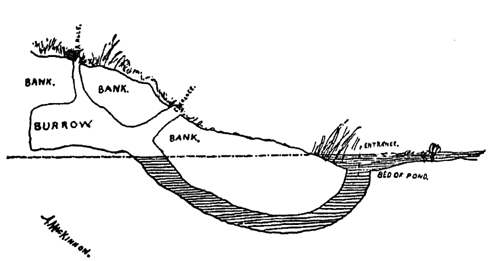
ing made by small feet on the soft snow or on the mud of stream margins. To such a boy, the track of the muskrat is well known and very easily recognized.

The muskrat is essentially a water animal, and therefore its tracks are to be looked for along the edges of ponds, streams, or in marshes. Whether the tracks are made by walking or jumping depends upon the depth of the snow or mud; if it is deep, the animal jumps, but in shallow snow or mud it simply runs along. The tracks show the front feet to be smaller than the hind ones. The muskrat track is, however, characterized by the tail imprint. When the creature jumps through the snow, the mark of the tail follows the paired imprints of the feet; when it walks, there is a continuous line made by this strong, naked tail. This distinguishes the track of the muskrat from that of the mink, as the bushy tail of the latter does not make so distinct a mark. Furthermore the claws of the feet show distinctly in a muskrat track; those of the mink do not. Measuring the track is a simple device for making the pupils note its size and shape more carefully. The tracks may be looked for during the thaws of March or February, when the muskrats come out of the water to seek food.

In appearance the muskrat is peculiar. The body is usually about a foot in length and the tail about eight inches. The body is stout and thickset, the head is rounded and looks like that of a giant meadow mouse; the eyes are black and shining; the ears are short and close to the head; the teeth, like those of other rodents, consist of a pair of front teeth on each jaw, then a long, bare space, and then four grinders on each side. There are long sensitive hairs about the nose and mouth, like the whiskers of mice.

The muskrat's hind legs are much larger and stronger than the front ones; the hind feet are likewise much longer than the front feet and have a web between the toes; there are also stiff hairs which fill the space between the toes outside the web, thus making this large hind foot an excellent swimming organ. The front toes are not webbed and are used for digging. The claws are long, stout, and sharp. The tail is long, stout, and flattened at the sides; it has little or no fur upon it but is covered with scales; it is used as a scull and also as a rudder when the muskrat is swimming.

The muskrat's outer coat consists of long, rather coarse hairs; its under coat is of fur, very thick and fine, and although short, it forms a waterproof protection for the body of the animal. In color, the fur is dark brown above with a darker streak along the middle of the back; beneath, the body is grayish, changing to whitish on the throat and lips, with a brown spot on the chin. In preparing the pelts for commercial use, the long hairs are some-



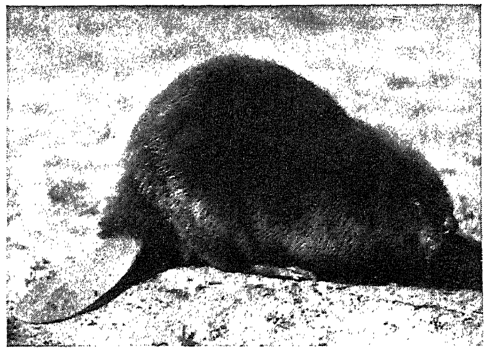
A muskrat's summer home, drawn by A. MacKinnon, a boy of thirteen years times plucked out leaving the soft, fine under coat, which is often dyed black and sold under the name of "Hudson seal."

The muskrat is far better fitted by form for life in the water than upon the land. Since it is heavy-bodied and short-legged it cannot run rapidly, but its strong, webbed hind feet are most efficient oars, and it swims rapidly and easily; for rudder and propeller the strong, flattened tail serves admirably, while the fine fur next the body is so perfectly waterproof that, however much the muskrat swims or dives, it is never wet. It is a skillful diver and can stay under water for several minutes; when swimming, its nose and sometimes the head and the tip of the tail appear on the surface of the water.

The food of muskrats is largely roots, especially those of the sweet flag and the yellow lily. Muskrats also feed on other aquatic plants and are fond of the fresh-water shell-fish. Mr. Sharp tells us, in one of his delightful stories, how the muskrats wash their food by sousing it up and down in water many times before eating it. Often, a muskrat chooses some special place upon the shore which it uses for a dining room, bringing there and eating pieces of lily root or fresh-water clams, and leaving the debris to show where it habitually dines. It does most of its hunting for food at night, although sometimes

Frank H. Steinicke

A beaver lodge in winter. In the foreground is the " air hole." In general this home looks like that of the muskrat, but it is larger and is made of coarser materials



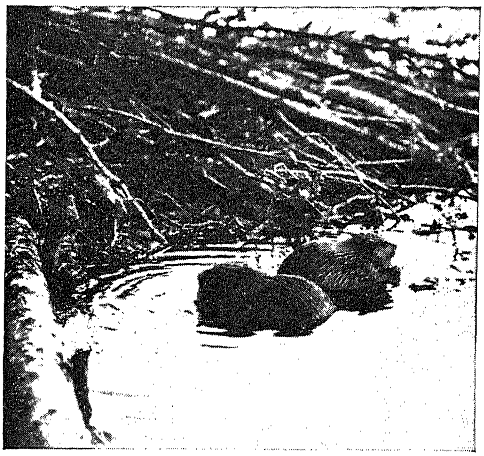
National Parks Bureau, Dominion of Canada

Adult Beaver. The habits of beavers somewhat resemble those of muskrats. Beavers may weigh from 40 to 60 pounds and reach a length of 40 inches. In North America they range from Hudson Bay and Alaska south into Mexico in the West and the southern Alleghenies in the East

it may be seen thus employed during the day.

The winter lodge of the muskrat is a most interesting structure. A foundation of tussocks of rushes, in a stream or shallow pond, is built upon with reeds, making a rather regular dome which may be nearly two or three feet high; or, if many-chambered, it may be a grand affair of four or five feet elevation; but it always looks so much like a natural hummock that the eye of the uninitiated never regards it as a habitation. Beneath this dome and above the water line is a snug, covered chamber carpeted with a soft bed of leaves and moss, which has a passage leading down into the water below, and in some instances an air-hole. In these cabins, closely cuddled together, three or four in a chamber, the muskrats pass the winter. After the pond is frozen they are safe from their enemies except the mink and are always able to go down into the water and feed upon the roots of water plants. These cabins are sometimes built in the low, drooping branches of willows or on other objects.

Whether the muskrat builds itself a winter lodge or not depends upon the nature of the shore which it inhabits; if it is a place particularly fitted for burrows, then a burrow will be used as a winter retreat; but if the banks are shallow, the muskrats unite in building cabins. The main entrance to the muskrat burrow is usually below the surface of the water, the burrow slanting upward and leading to a nest well lined, which is above the reach of high water; there is also often a passage, with a hidden entrance, leading out to dry land.



National Parks Bureau, Dominion of Canada

Young beavers feeding in the shallow water near the lower edge of a beaver dam

The flesh of the muskrat is delicious, and therefore the animal has many enemies; foxes, weasels, dogs, minks, and also hawks and owls prey upon it. It is, indeed, a good human food. It escapes the sight of its enemies as does the mouse, by having inconspicuous fur; when discovered, it escapes its enemies by swimming, although when cornered it is courageous and fights fiercely, using its strong incisors as weapons. In winter, it dwells in safety when the friendly ice protects it from all its enemies except the mink; but it is exposed to great danger when the streams break up in spring, for it is then often driven from its cabin by floods, and preyed upon while thus helplessly exposed.

It is called muskrat because of the odor, somewhat resembling musk, which it excretes from two glands on the lower side of the body between the hind legs; these glands may be seen when the skin is removed, which is the too common plight of this poor creature, since it is hunted mercilessly for its pelt.

The little muskrats are born in April and there are usually from three to seven in a litter. Another litter may be produced in June or July and a third in August or September. It is only thus, by rearing large families often, that the muskrats are able to hold their own against the hunters and trappers and their natural enemies.

Suggested Reading — *The Beaver: Its Work and Its Ways*, by Edward R. Warren; *Beaver Pioneers*, by Wendell and Lucie Chapman; *The Fall of the Year*, and *Winter*, both by Dallas L. Sharp; also, readings on page 214.

LESSON 54

The Muskrat

Leading Thought — The muskrat, while a true rodent, is fitted for life in the water more than for life upon the land. Its hind feet are webbed for use as oars and its tail is used as a rudder. It builds lodges of cattails and rushes in which it spends the winter.

Method — It might be well to begin this work by asking for observations on the tracks of the muskrat which may be found about the edges of almost any creek, pond, or marsh. If there are muskrat lodges in the region they should be visited and described. For studying the muskrat's form a live muskrat in captivity is almost necessary. The pupils can thus study it at leisure although they should not be allowed to handle the creature as it inflicts very severe wounds and is never willing to be handled. If a live muskrat cannot be obtained, perhaps some hunter in the neighborhood will supply a dead one for this observation lesson.

While studying the muskrat the children should read all the stories of beavers which are available, as the two animals are very much alike in their habits.

Observations — 1. In what locality have you discovered the tracks of the muskrat? Describe its general appearance. Measure the muskrat's track as follows:

(a) width and length of the print of one foot; (b) the width between the prints of the two hind feet; (c) the length between the prints made by the hind feet in several successive steps or jumps.

2. Was the muskrat's track made when the animal was jumping or walking? Can you see in it a difference in the size of the front and hind feet? Judging from the track, where do you think the muskrat came from? What do you think it was hunting for?

3. What mark does the tail make in the snow or mud? Judging by its imprint, should you think the muskrat's tail was long or short, bare or brushy, slender or stout?

4. How long is the largest muskrat you ever saw? How much of the whole length is tail? Is the general shape of the body short and heavy or long and slender?

5. Describe the muskrat's eyes, ears, and teeth. For what are the teeth especially fitted? Has the muskrat whiskers like mice and rats?

6. Compare the front and hind legs as to size and shape. Is there a web between the toes of the hind feet? What does this indicate? Do you think that the muskrat is a good swimmer?

7. Describe the muskrat fur. Compare the outer and under coat. What is its color above and below? What is the name of muskrat fur in the shops?

8. Describe the tail. What is its covering? How is it flattened? What do you think this strong, flattened tail is used for?

9. Do you think the muskrat is better fitted to live in the water than on land? How is it fitted to live in the water in the following particulars: Feet? Tail? Fur?

10. How much of the muskrat can you see when it is swimming? How long can it stay under water when diving?

11. What is the food of the muskrat? Where does it find it? How does it prepare the food for eating? Does it seek its food during the night or day? Have you ever observed the muskrat's dining room? If so, describe it.

12. Describe the structure of the muskrat's winter lodge, or cabin, in the following particulars: What is its size? Where built? Of what material? How many rooms in it? Are these rooms above or below the water level? Of what is the bed made? How is it arranged so that the entrance is not closed by the ice? Is such a home built by one or more muskrats? How many live within it? Do the muskrats always build these winter cabins? What is the character of the shores where they are built?

13. Describe the muskrat's burrow in the bank in the following particulars: Is the entrance above or below water? Where and how is the nest made? Is it ventilated? Does it have a back door leading out upon the land?

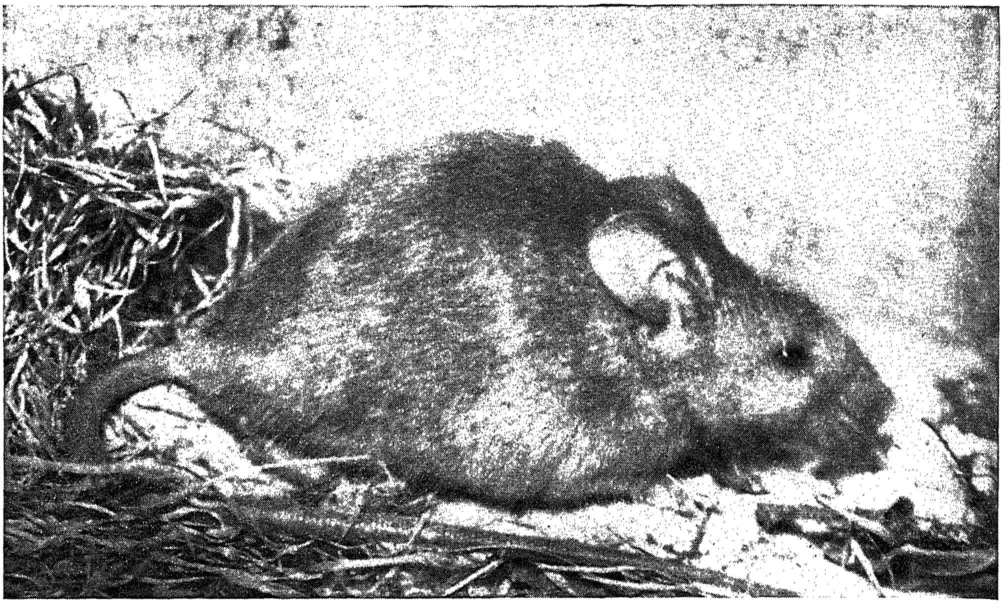
14. What are the muskrat's enemies? How does it escape them? How does it fight? Is it a courageous animal? How does the muskrat give warning to its fellows when it perceives danger? At what time of year is it comparatively safe? At what time is it exposed to greatest danger?

15. Why is this animal called muskrat? Compare the habits of muskrats with those of beavers and write an English theme upon the similarity of the two.

Leonard K. Beyer

Trees felled by beavers. Unlike muskrats, beavers fell trees. They have cut these birches either to use the bark for food or the trunks for reinforcement of a dam. In the background, note the area covered by water held by a beaver dam

16. At what time of year do you find the young muskrats? How many in a litter?



Nature Photography around the Year, Percy A. Morris,
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THE HOUSE MOUSE

Somewhere in the darkness a clock strikes two;
And there is no sound in the sad old house,
But the long veranda dripping with dew,
And in the wainscot — a mouse. — Bret Harte

Were mouse-gray a less inconspicuous color, there would be fewer mice; when a mouse is running along the floor, it is hardly discernible, it looks so like a flitting shadow; if it were black or white or any other color, it would be more often seen and destroyed. It has been very closely associated with man; as a result of this fact the species has been able to spread over the world.

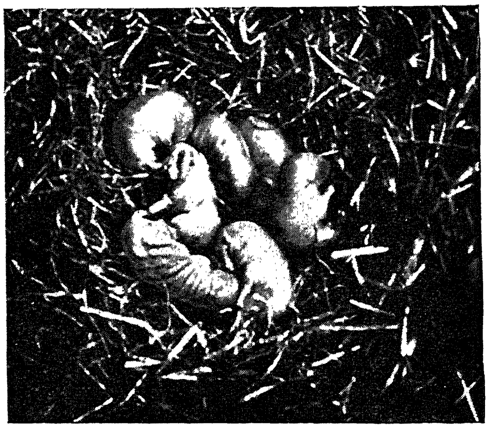
At first glance one wonders what possible use a mouse can make of a tail which is as long as its body, but a little careful observation will reveal the secret. The tail is covered with transverse ridges and is bare save for sparse hairs, except toward the tip. Dr. Ida Reveley first called my attention to the fact that the house mouse uses its tail in climbing. I verified this interesting observation, and found that my mouse used the tail for aid when climbing a string. He would go up the string hand over hand like a sailor, and then in trying to stretch to the edge of his jar, he invariably wound his tail about the string two or three times, and hanging to the string with the hind feet and tail, would reach far out with his head and front feet. Also, when clinging to the edge of the cover of the jar, he invariably used his tail as a brace against the side of the glass, so that it pressed hard for more than half its length. Undoubtedly the tail is of great service in climbing up the sides of walls.

The tail is also of some use when the mouse jumps directly upward. The hind legs are very much longer and stronger than the front legs. The hind feet are also much longer and larger than the front feet; and although the mouse, when it makes its remarkable jumps, depends upon its strong hind legs, I am sure that often the tail is used as a brace to guide and assist the leap. The feet are free from hairs but are downy; the hind foot has three front toes, a long toe behind on the outside and a short one on the inside. The claws are fairly long and very sharp so that they are able to cling to almost anything but glass. When exploring, a mouse stands on its hind feet, folding its little front paws under its chin while it reaches up ready to catch anything in sight; it can stretch up to an amazing height. It feeds upon almost anything that people like to eat and, when eating, frequently holds its food in its front paws like a squirrel.

The thin, velvety ears are flaring cornucopias for taking in sound; the large, rounded outer ear can be moved forward or back to test the direction of the noise. The eyes are like shining, black beads; and if a mouse can wink, it does it so rapidly as not to be discernible. The nose is long, inquisitive, and always sniffing for new impressions. The whiskers are delicate and probably sensitive. The mouth is furnished with two long, curved gnawing teeth at the front of each jaw, then a bare space, and then four grinding teeth on each side, above and below, like the teeth of woodchucks and other rodents. The gnawing teeth are very strong and enable the mouse to gnaw through board partitions and other obstacles.

The energy with which the mouse cleans itself is inspiring to behold. It nibbles its fur and licks it with fervor, reaching around so as to get at it from behind, and taking hold with its little hands to hold firm while it cleans. When washing its face and head, it uses both front feet, licking them clean and rubbing them both simultaneously from behind the ears down over the face. It takes its hind foot in both front feet and nibbles and licks it. It scratches the back of its head with its hind foot.

Young mice are small, downy, pink, and blind when born. The mother makes for them a nice, soft nest of pieces of cloth, paper, grass, or whatever is at hand; the nest is round like a ball and at its center is nestled the family. Mice living in houses have runways between the plaster and the outside wall, or between ceiling and floor. In winter they live on what food they can find, and upon flies or other insects hibernating in our houses. The house mice sometimes live under stacks of corn or grain in the fields, but usually confine themselves to houses or barns.

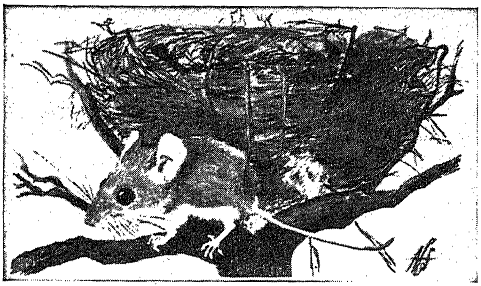


Verne Morton

Young field mice, blind, pink, and hairless

They are thirsty little fellows and they like to make their nests within easy reach of water.

Our house mice came from ancestors which lived in Asia originally; they have always been great travelers and they have followed men wherever they have gone, over the world. They came to America on ships with the first explorers and the Pilgrim fathers. They now travel back and forth, crossing the ocean in ships of all sorts. They also travel across the continent on trains. Wherever our food is carried they go; and the mouse which you see in your room one day may be a thousand miles away within a week. They are clever creatures, and learn quickly to connect cause and effect. For two years I was in an office in Washington, and while there I observed that as soon as the bell rang for noon, the mice would appear instantly, hunting wastebaskets for scraps of lunch. They had learned to connect the sound of the bell with food.



Anna Stryke

A white-footed or deer mouse may use an old bird's nest for its home

Of all our wild mice, the white-footed or deer mouse is the most interesting and attractive. It is found almost exclusively in woods and is quite different in appearance from other mice. Its ears are very large; its fur is fine and beautiful and a most delicate gray in color. It is white beneath the head and under the sides of the body. The feet are pinkish, the front paws have short thumbs, while the hind feet are very much longer and have a long thumb which looks like an elfin hand in a gray-white silk glove. On the bottom of the feet are callous spots which are pink and serve as foot pads. This mouse makes its nest in hollow trees and stores nuts for winter use. We once found two quarts of shelled beechnuts in such a nest. It also likes the hips of the wild rose and many kinds of berries; it sometimes makes its home in a bird's nest, which it roofs over to suit itself. The young mice are usually carried in the mother's mouth, one at a time. As an inhabitant of summer cottages, white-foot is cunning and mischievous; it pulls cotton out of quilts, takes covers from jars, and as an explorer is equal to the squirrel. I once tried to rear some young deer mice by feeding them warm milk with a pipette; although their eyes were not open, they invariably washed their faces after each meal, showing that neatness was bred in the bone. This mouse has a musical voice and often chirps as sweetly as a bird. Like the house mouse it is more active at night.

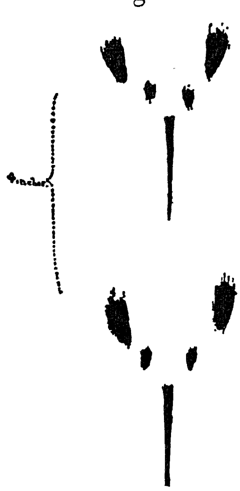
The meadow mouse is the one that makes its runways under the snow, making strange corrugated patterns over the ground which attract our attention in spring. It has a heavy body, short legs, short ears, and a short tail. It is brownish or blackish in color. It sometimes digs burrows straight into the ground, but more often makes its nest in waste meadows. It is the nest of this field mouse which the bumblebee so often takes possession of, after it is deserted. The meadow mouse is a good fighter, sitting up like a woodchuck and facing its enemy bravely. It needs to be courageous, for it is preyed upon by almost every creature that feeds upon small animals; the hawks and owls especially are its enemies. It is well for the farmer that these mice have so many enemies, for they multiply rapidly and would otherwise soon overrun and destroy the grain fields. They cause tremendous damage by girdling valuable fruit trees. This mouse is an excellent swimmer.

A part of winter work is to make the pupils familiar with the tracks of the meadow mice and to teach them how to distinguish them from other tracks.

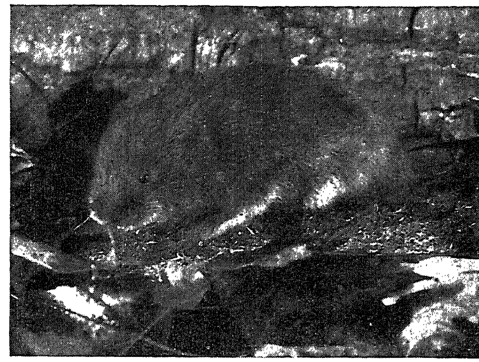
Country Life in America

A white-footed mouse at her own doorway in the woods

Trapping Field Mice — Probably wild animals have endured more cruelty through the agency of traps than through any other form of human persecution. The savage steel traps often catch the animal by the leg, holding it until it gnaws off the imprisoned foot, and thus escapes maimed and handicapped for its future struggle for food; or if the trap gets a strong hold, the poor creature may suffer tortures during a long period, before the owner of the trap appears to put an end to its sufferings by death. If box traps are used, they are often neglected and the imprisoned animal is left to languish and starve. The teacher cannot enforce too strongly upon the child the ethics of trapping. Impress upon him that the box traps are far less cruel; but that if set, they must be examined regularly and not neglected. The study of mice affords a good opportunity for giving the children a lesson in humane trapping. Let them set a tin-can trap for meadow mice or deer mice. They must examine the traps every morning. The little prisoners may be brought to school and studied; meanwhile, they should be treated kindly and fed bountifully. After a mouse has been studied it should be set free, even though it be one of the quite pestiferous field mice. The moral effect of killing an animal after a child has become thoroughly interested in it and its life is always bad.



Tracks of a white-footed mouse. Note how the long tail has left a print in the snow. As this mouse does not hibernate, its tracks are often seen on snow



Nature Photography around the Year, Percy A. Morris, © D. Appleton-Century Co., Inc.

A meadow mouse

Suggested Reading — *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *Winter*, by Dallas L. Sharp; also, readings on page 214.

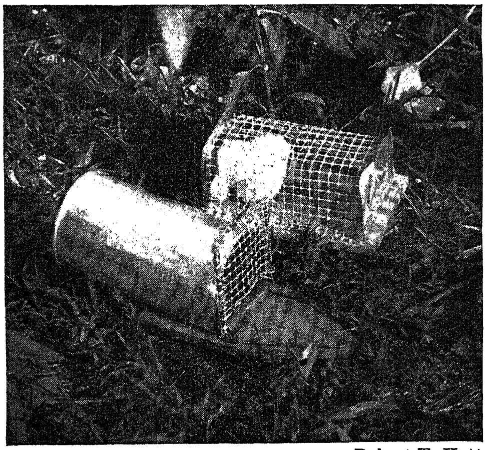
LESSON 55

The House Mouse

Leading Thought — The mouse is fitted by color, form, agility, and habits to thrive upon the food which it steals from man, and to live in the midst of civilized people.

Method — A mouse cage can be easily made of wire window-screen tacked upon a wooden frame. I have even used aquarium jars with wire screen covers; by placing one jar upon another, opening to opening, and then laying them horizontal, the mouse can be transferred to a fresh cage without trouble, and thus the mousy odor can be obviated while the little creature is being studied. A little water in a wide-necked bottle can be lowered into this glass house by a string, and the food can be given in like manner. Stripped paper should be put into the jar for the comfort of the prisoner; a stiff string hanging down from the middle of the cage will afford him a chance to show his feats as an acrobat.

Observations — 1. Why is the color of the mouse of special benefit to it? Do you think it protects it from the sight of



Robert T. Hatt

A tin-can trap for catching small rodents alive. To a choke trap is wired a tin can with a piece slightly larger than the bait treadle of the trap cut out. To the choke wire of the trap is fastened a square of coarse wire mesh

its enemies? Can you see a mouse easily as it runs across the room? What is the nature of the fur of a mouse?

2. How long is a mouse's tail as compared with its body? What is the covering of the tail? Of what use to the mouse is this long, ridged tail? Watch the mouse carefully and discover, if you can, the use of the tail in climbing.

3. Is the mouse a good jumper? Are the hind legs long and strong when compared with the front legs? How high do you think a mouse can jump? Do you think it uses its tail as an aid in jumping? How much of the legs are covered with hair? Compare the front and hind feet. What sort of claws have they? How does the mouse use its feet when climbing the string? How can it climb up the side of a wall?

4. Describe the eyes. Do you think the mouse can see very well? Does it wink? What is the shape of the ears? Do you think it can hear well? Can it move its ears forward or backward?

5. What is the shape of the snout? Of what advantage is this? Note the whiskers. What is their use? Describe the mouth. Do you know how the teeth are arranged? For what other purpose than to bite food does the mouse use its teeth? What other animals have their teeth arranged like those of the mouse? What food does the house mouse live upon? How does it get it?

6. How does the mouse act when it is reaching up to examine something? How does it hold its front feet? Describe how the mouse washes its face; its back; its feet.

7. Where does the house mouse build its nest? Of what material? How do the baby mice look? Can they see when they are first born?

8. House mice are great travelers. Can you tell how they manage to get from place to place? Write a story telling all you know of their habits.

9. How many kinds of mice do you know? Does the house mouse ever live in the field? What do you know of the habits of the white-footed mouse? Of the meadow mice? Of the jumping mice?

American Humane Society

A woodchuck caught in a humane trap. If such traps are visited frequently, animals caught in them do not suffer such agonies as in ordinary steel traps. Information about various types of humane traps can be secured from the American Humane Society, Albany, N. Y.

THE WOODCHUCK

He who knows the ways of the woodchuck can readily guess where it is likely to be found; it loves meadows and pastures where grass or clover lushly grows. It is also fond of garden truck and has a special delectation for melons. The burrow is likely to be situated near a fence or stone heap, which gives easy access to the chosen food. The woodchuck makes its burrow by digging the earth loose with its front feet, and pushing it backward and out of the entrance with the hind feet. This method leaves the soil in a heap near the entrance, from which paths radiate into the grass in all directions. If one undertakes to dig out a woodchuck, one needs to be not only a husky individual, but something of an engineer; the direction of the burrow extends downward for a little way, and then rises at an easy angle, so that the inmate may be in no danger of flood. The nest is merely an enlargement of the burrow, lined with soft grass which the woodchucks bring in in their mouths. During the early part of the season, the father and mother and the litter of young may inhabit the same burrow, although there are likely to be at least two separate nests. There is usually more than one back door to the woodchuck's dwelling, through which it may escape if pressed too closely by enemies; these back doors differ from the entrance in that they are usually hidden and have no earth heaped near them.

The woodchuck usually feeds in the morning and again in the evening, and is likely to spend the middle of the day resting. It often goes some distance from its burrow to feed, and at short intervals lifts

The woodchuck is at home in grassy meadows itself upon its hind feet to see if the coast is clear; if assailed, it will seek to escape by running to its burrow; and when running, it has a peculiar gait well described as " pouring itself along." If it reaches its burrow, it at once begins to dig deeply and throw the earth out behind it, thus making a wall to keep out the enemy. When cornered, the woodchuck is a courageous and fierce fighter; its sharp incisors prove a powerful weapon and it will often whip a dog much larger than itself. Every boy knows how to find whether the wood-

W. J. Hamilton, Jr.

These young woodchucks are as tame as kittens

chuck is in its den or not, by rolling a stone into the burrow, and listening; if the animal is at home, the sound of its digging apprises the listener of the fact. In earlier times, the ground hogs were much preyed upon by wolves, wildcats, and foxes; now only the fox remains and he is fast disappearing, so that at present the farmer and his dog are about the only enemies this burrower has to contend with. In recent years it has been considered a game animal and furnishes much sport for the rifleman. It is an animal of resources and will climb a tree if attacked by a dog; it will also climb trees for fruit, such as wild cherries or peaches. During the late summer, it is the ground hog's business to feed very constantly and become very fat. About the first of October, it retires to its den and sleeps until the end of February or early March, in the eastern United States. During this dormant state, the beating of its heart is so faint as to be scarcely perceptible, and very little nourishment is required to keep it alive; this nourishment is supplied by the fat stored in its body, which it uses up by spring, when it comes out of its burrow looking gaunt and lean. The old saying that the ground hog comes out on Candlemas Day, and if it sees its shadow, goes back to sleep for six weeks more, may savor of meteorological truth, but it is certainly not true of the ground hog.

The full-grown woodchuck ordinarily measures about two feet in length. Its color is grizzly or brownish, sometimes blackish in places; the under parts are reddish and the feet black. The fur is rather coarse, thick, and brown, with longer hairs which are grayish. The skin is very thick and tough and seems to fit loosely, a condition which gives the peculiar " pouring along " appearance when it is running. The hind legs and feet are longer than those in front. Both pairs of feet are fitted for digging, the front ones being used for loosening the earth and the hind pair for kicking it out of the burrow.

The woodchuck's ears are roundish and not prominent; the sense of hearing is acute. The teeth consist of two large white incisors at the front of each jaw, then a bare space, and then four grinders on each side, above and below; the incisors are used for biting food and also for fighting. The eyes are full and bright. The tail is short and brushy, and it, with the hind legs, forms a tripod which supports the animal as it sits with its forefeet lifted.

When feeding, the woodchuck often makes a contented grunting noise; when attacked and fighting, it growls; it also can whistle. I had a woodchuck acquaintance once which always gave a high, shrill, almost birdlike whistle when I came in view. There are plenty of statements in books that woodchucks are fond of music, and Mr. Ingersoll states that at Wellesley College a woodchuck on the chapel lawn was wont to join the morning song exercises with a " clear soprano." The young woodchucks are born from late March to mid May, and the litter usually numbers four or five. In June the " chucklings " may be seen following the mother in the field with much babyish grunting. If captured at this period, they make very interesting pets. By July the young woodchucks leave the home burrow and start burrows of their own.

SUGGESTED READING — *Bozo, the Woodchuck*, by Dorothy L. Brown and Marguerite Butterfield; *Holiday Meadow*, by Edith M. Patch; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 2, *By the Roadside*; *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *The Pet Book*, by Anna B. Comstock; also, readings on page 214.

LESSON 56

THE WOODCHUCK OR GROUND HOG

LEADING THOUGHT — The woodchuck has thriven with civilization, notwithstanding the farmer's dog, gun, traps, and poison. It makes its nest in a burrow in the earth and lives upon vegetation; it hibernates in winter.

METHOD — Within convenient distance for observation by the pupils of every country schoolhouse and of most village schoolhouses, may be found a woodchuck and its dwelling. The pupils should be given the outline for observations which should be made individually through watching the woodchuck for weeks or months.

OBSERVATIONS — 1. Where is the woodchuck found? On what does it live? At what time of day does it feed? How does it act when startled?

2. Is the woodchuck a good fighter? With what weapons does it fight? What are its enemies? How does it escape its enemies when in or out of its burrow? How does it look when running?

3. What noises does the woodchuck make? Play a mouth organ near the woodchuck's burrow and note if it likes music.

4. How does the woodchuck make its burrow? Where is it likely to be situated? Where is the earth placed which is taken from the burrow? How does the woodchuck bring it out? How is the burrow made so that the woodchuck is not drowned in case of heavy rains? In what direction do the underground galleries go? Where is the nest placed in relation to the galleries? Of what is the nest made? How is the bedding carried in? Of what special use is the nest?

5. Do you find paths leading to the entrances of the burrow? If so, describe them. How can you tell whether a woodchuck is at home or not if you do not see it enter? Where is the woodchuck likely to station itself when it sits up to look for intruders?

6. How many woodchucks inhabit the same burrow? Are there likely to be one or more back doors to the burrow? What for? How do the back doors differ from the front doors?

7. How long is the longest woodchuck that you have ever seen? What is the woodchuck's color? Is its fur long or short? Coarse or fine? Thick or sparse? Is the skin thick or thin? Does it seem loose or close fitting?

8. Compare the front and hind feet and describe the difference in size and shape. Are either or both slightly webbed? Explain how both front and hind feet and legs are adapted by their shape to help the woodchuck. Is the tail long or short? How does it assist the animal in sitting up?

9. What is the shape of the woodchuck's ear? Can it hear well? Of what use are the long incisors? Describe the eyes.

10. How does the woodchuck prepare for winter? Where and how does it pass the winter? Did you ever know a woodchuck to come out on Candlemas Day to look for its shadow?

11. When does the woodchuck appear in the spring? Compare its general appearance in the fall and in the spring and explain the reason for the difference.

12. When are the young woodchucks born? What do you know of the way the mother woodchuck cares for her young?

As I turned round the corner of Hubbard's Grove, saw a woodchuck, the first of the season, in the middle of the field six or seven rods from the fence which bounds the wood, and twenty rods distant.

I ran along the fence and cut him off, or rather overtook him, though he started at the same time. When I was only a rod and a half off, he stopped, and I did the same; then he ran again, and I ran up within three feet of him, when he stopped again, the fence being between us. I squatted down and surveyed him at my leisure. His eyes were dull black and rather inobvious, with a faint chestnut iris, with but little expression and that more of resignation than of anger. The general aspect was a coarse grayish brown, a sort of grisel. A lighter brown next the skin, then black or very dark brown and tipped with whitish rather loosely. The head between a squirrel and a bear, flat on the top and dark brown, and darker still or black on the tip of the nose. The whiskers black, two inches long. The ears very small and roundish, set far back and nearly buried in the fur. Black feet, with long and slender claws for digging. It appeared to tremble, or perchance shivered with cold. When I moved, it gritted its teeth quite loud, sometimes striking the under jaw against the other chatteringly, sometimes grinding one jaw on the other, yet as if more from instinct than anger. Whichever way I turned, that way it headed. I took a twig a foot long and touched its snout, at which it started forward and bit the stick, lessening the distance between us to two feet, and still it held all the ground it gained. I played with it tenderly awhile with the stick, trying to open its gritting jaws. Ever its long incisors, two above and two below, were presented. But I thought it would go to sleep if I stayed long enough. It did not sit upright as sometimes, but standing on its fore feet with its head down, i. e., half sitting, half standing. We sat looking at one another about half an hour, till we began to feel mesmeric influences. When I was tired, I moved away, wishing to see him run, but I could not start him. He would not stir as long as I was looking at him or could see him. I walked around him; he turned as fast and fronted me still. I sat down by his side within a foot. I talked to him quasi forest lingo, baby-talk, at any rate in a conciliatory tone, and thought that I had some influence on him. He gritted his teeth less. I chewed checkerberry leaves and presented them to his nose at last without a grit; though I saw that by so much gritting of the teeth he had worn them rapidly and they were covered with a fine white powder, which, if you measured it thus, would have made his anger terrible. He did not mind any noise I might make. With a little stick I lifted one of his paws to examine it, and held it up at pleasure. I turned him over to see what color he was beneath (darker or most purely brown), though he turned himself back again sooner than I could have wished. His tail was also brown, though not very dark, rat-tail like, with loose hairs standing out on all sides like a caterpillar brush. He had a rather mild look. I spoke kindly to him. I reached checkerberry leaves to his mouth. I stretched my hands over him, though he turned up his head and still gritted a little. I laid my hand on him, but immediately took it off again, instinct not being wholly overcome. If I had had a few fresh bean leaves, thus in advance of the season, I am sure I should have tamed him completely. It was a frizzly tail. His is a humble, terrestrial color like the partridge's, well concealed where dead wiry grass rises above darker brown or chestnut dead leaves — a modest color. If I had had some food, I should have ended with stroking him at my leisure. Could easily have wrapped him in my handkerchief. He was not fat nor particularly lean. I finally had to leave him without seeing him move from the place. A large, clumsy, burrowing squirrel. Arctomys, bear-mouse. I respect him as one of the natives. He lies there, by his color and habits so naturalized amid the dry leaves, the withered grass, and the bushes. A sound nap, too, he has enjoyed in his native fields, the past winter. I think I might learn some wisdom of him. His ancestors have lived here longer than mine. He is more thoroughly acclimated and naturalized than I. Bean leaves the red man raised for him, but he can do without them.

— Thoreau's Journal

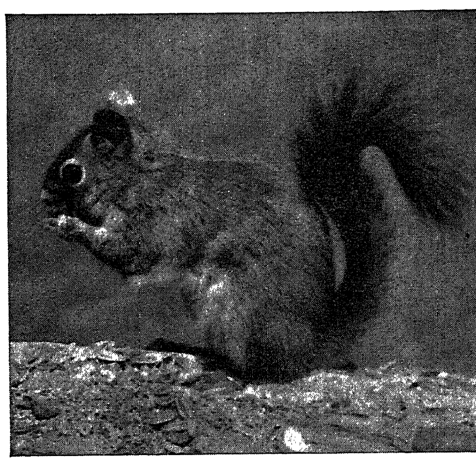
THE RED SQUIRREL OR CHICKAREE

Just a tawny glimmer, a dash of red and gray,
Was it a flitting shadow, or a sunbeam gone astray!
It glances up a tree trunk, and a pair of bright eyes glow
Where a little spy in ambush is measuring his foe.
I hear a mocking chuckle, then wrathful, he grows bold
And stays his pressing business to scold and scold and scold.

We ought to yield admiring tribute to those animals which have been able to flourish in our midst despite man and his gun, this weapon being the most cowardly and unfair invention of the human mind. The only time that man has been a fair fighter in combating his four-footed brethren was when he fought them with a weapon which he wielded in his hand. There is nothing in animal comprehension which can take into account a projectile, and much less a shot from a gun; but though it does not understand, it experiences a deathly fear at the noise. It is pathetic to note the hush in a forest that follows the sound of a gun; every song, every voice, every movement is stilled and every little heart filled with nameless terror. How any man or boy can feel manly when, with this scientific instrument of death in his hands, he takes the life of a little squirrel, bird, or rabbit, is beyond my comprehension. In pioneer days when it was a fight for existence, man against the wilderness, the matter was quite different; but now it seems to me that anyone who hunts what few wild creatures we have left, and which are in nowise injurious, is, whatever he may think of himself, no believer in fair play.

Within my own memory, the beautiful black squirrel was as common in our woods as was his red cousin; the shotgun has exterminated this splendid species locally. Well may we rejoice that the red squirrel has, through its lesser size and greater cunning, escaped a like fate; and that, pugnacious and companionable and shy, it lives in our midst and climbs our very roofs to sit there and scold us for coming within its range of vision. It has succeeded not only in living despite man, but because of man, for it rifles our grain bins and corn cribs and waxes opulent by levying tribute upon our stores.

Thoreau describes most graphically the movements of this squirrel. He says: "All day long the red squirrels came and went. One would approach at first warily, warily,



Dorothy M. Compton

Red squirrel at feeding log

through the shrub-oaks, running over the snow crust by fits and starts and like a leaf blown by the wind, now a few paces this way, with wonderful speed and waste of energy, making inconceivable haste with his "trotters," as if it were for a wager, and now as many paces that way, but never getting on more than half a rod at a time; and then suddenly pausing with a ludicrous expression and a gratuitous somersault, as if all the eyes of the universe were fixed on him . . . and then suddenly, before you could say "Jack Robinson" he would be in the top of a

A red squirrel on his vine bridge

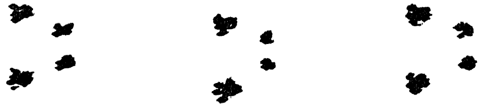
young pitch pine, winding up his clock, and chiding all imaginary spectators, soliloquizing and talking to all the universe at the same time."

It is surely one of the most comical of sights to see a squirrel stop running and take observations; he lifts himself on his haunches, and with body bent forward, presses his little paws against his breast as if to say, "Be still, O my beating heart!" which is all pure affectation because he knows he can scurry away in perfect safety. He is likely to take refuge on the far side of a tree, peeping out from this side and that, and whisking back like a flash as he catches our eye; we might never know he was there except that, as Riley puts it, "he lets his own tail tell on him." When climbing up or down a tree, he goes head first and spreads his legs apart to clasp as much of the trunk as possible; meanwhile his sharp little claws cling securely to the bark. He can climb out on the smallest twigs quite as well, when he needs to do so, in passing from tree to tree or when gathering acorns.

A squirrel always establishes certain roads to and from his abiding place and almost invariably follows them. Such a path may be entirely in the tree tops, with air bridges from a certain branch of one tree to a certain branch of another, or it may be partially on the ground between trees. I have made notes of these paths in the vicinity of my own home, and have noted that if a squirrel leaves them for exploring, he goes warily; while, when following them, he is quite reckless in his haste. When making a jump from tree to tree, he flattens himself as widely as possible and his tail is held somewhat curved, but on a level with the body, as if its wide brush helped to buoy him up and perhaps to steer him also.

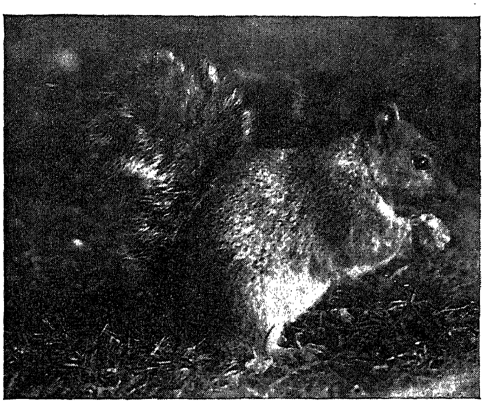
During the winter the chickaree is brightly colored and is a conspicuous object; his back is bright russet, almost red, and along his sides, where the red meets the grayish white of the underside, there is a dark line which is very ornamental. With the coming of summer, however, his coat becomes quite dingy. In November he moults, and his bright color returns. When dashing up a tree trunk, his color is never very striking but looks like the glimmer of sunlight; this has probably saved many of his kind from the gunner, whose eyes, being at the front of his head, cannot compare in efficiency with those of the squirrel, which, large and full and alert, are placed at the sides of the head so as to see equally well in all directions.

The squirrel's legs are short because he is essentially a climber rather than a runner; the hips are very strong, which insures his power as a jumper, and his leaps are truly remarkable. A squirrel uses his front paws for hands in a most human way; with them he washes his face and holds his food up to his mouth while eating, and it is interesting to note the skill of his claws when used as fingers. The track he makes in the snow is quite characteristic. The tracks are paired and those of the large five-toed hind feet are always in front.



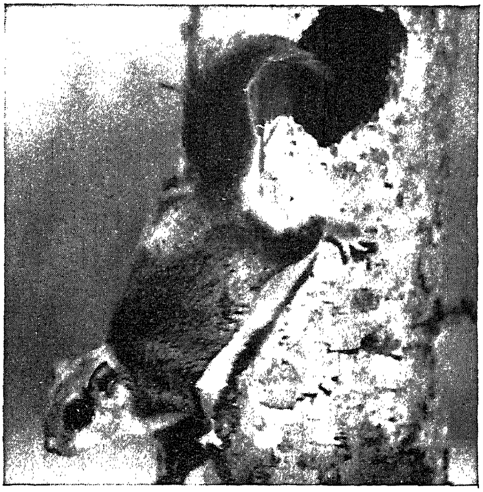
Squirrel tracks

The squirrel has two pairs of gnawing teeth which are very long and strong, as in all rodents, and he needs to keep busy gnawing hard things with them, or they will grow so long that he cannot use them at all and will starve to death. He is very clever about opening nuts so as to get all the meats. He often opens a hickory nut with two holes which tap the places of the nut meats squarely; with walnuts or butternuts, which have much harder shells, he makes four small holes, one opposite each quarter of the kernel. He has no cheek pouches like a chipmunk but he can carry corn and other grain. He often fills his mouth so full that his cheeks bulge out like those of a boy eating popcorn; but anything as large as a nut he carries in his teeth. His food is far more varied than many suppose and he will eat almost anything eatable; he is a little pirate and enjoys stealing from others with keenest zest. In spring, he eats leaf buds and hunts our orchards for apple seeds. In winter, he feeds on nuts, buds, and cones; it is marvelous how he will take a cone apart, tearing off the scales and leaving them in a heap while searching for seeds; he is especially fond of the seeds of Norway spruce and hemlock. Of course, he is fond of nuts of all kinds and will cut the chestnut burs from the tree before they are ripe, so that he may get ahead of the other harvesters. He stores his food for winter in all sorts of odd places and often forgets where he puts it. We often



A. A. Allen

A gray squirrel with food in its paws



Dwight E. Sollberger

Flying squirrel just leaving home

find his winter stores untouched the next summer. He also likes birds' eggs and nestlings, and if it were not for the chastisement he gets from the parent robins, he would work much damage in this way.

The red squirrels use a great variety of places for nests. In different localities various types of nests are constructed; some individuals prefer hollow trees, some build nests in clumps of vines, such as wild grape vines, and still others make their homes in the ground under or about stumps. During the winter, the red squirrel does not remain at home except in the coldest weather, when he lies cozily with his tail wrapped around him like a fur neck-piece to keep him warm. He is too full of interest in the world to lie quietly long, but comes out, hunts up some of his stores, and finds life worth while despite the cold. One squirrel adopted a birdhouse in one of our trees, and he or his kin have lived there for years; in winter, he takes his share of the suet put on the trees for birds, and because of his greediness we have been compelled to use picture wire for tying on the suet.

The young are born in a well-protected nest. There are four to six in a litter and they usually appear in April. If it is necessary to move the young the mother grasps the babies by the loose skin of their underparts and carries them to safety.

The squirrel has several ways of expressing his emotions; one is by various curves in his long, beautiful bushy tail. If the creatures of the wood had a stage, the squirrel would be their chief actor. Surprise, incredulousness, indignation, fear, anger, and joy are all perfectly expressed by tail gestures and also by voice. As a vocalist he excels; he chatters with curiosity, "chips" with surprise, scolds by giving a guttural trill, finishing with a falsetto squeal. He is the only singer I know who can carry two parts at a time. Notice him sometimes in the top of a hickory or chestnut tree when nuts are ripe, and you will hear him singing a duet all by himself, a high shrill chatter with a chuckling accompaniment. Long may he abide with us as an uninvited guest at our cribs! For, though he be a freebooter and conscienceless, yet our world would lack its highest example of incarnate grace and activity if he were not in it.

Suggested Reading — *Bannertail, the Story of a Gray Squirrel*, by Ernest Thompson Seton; *Holiday Hill*, by Edith M. Patch; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals*, Book 2, *By the Roadside*; *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *Our Backdoor Neighbors*, by Frank C. Pellett; *The Pet Book*, by Anna B. Comstock; also, reading on page 214.

LESSON 57

The Red Squirrel or Chickaree

Leading Thought — The red squirrel by its agility and cleverness has lived on, despite its worst enemy — man. By form and color and activity it is fitted to elude the hunter.

Method — If a pet squirrel in a cage can be procured for observation at the school, the observations on the form and habits of the animal can be best studied thus; but a squirrel in a cage is an anomaly and it is far better to stimulate the pupils to observe the squirrels out of doors. Give the following questions, a few at a time, and ask the pupils to report the answers to the entire class. Much should be done with the supplementary reading, as there are many interesting squirrel stories illustrating its habits.

Observations — 1. Where have you seen a squirrel? Does the squirrel trot along or leap when running on the ground? Does it run straight ahead or stop at intervals for observation? How does it look? How does it act when looking to see if the "coast is clear"?

2. When climbing a tree, does it go straight up, or move around the trunk? How does it hide itself behind a tree trunk and observe the passer-by? Describe how it manages to climb a tree. Does it go down the tree head first? Is it able to climb out on the smallest branches? Of what advantage is this to the squirrel?

3. Look closely and see if a squirrel follows the same route always when passing from one point to another. How does it pass from tree to tree? How does it act when preparing to jump? How does it hold its legs and tail when in the air during a jump from branch to branch?

4. Describe the colors of the red squirrel above and below. Is there a dark stripe along its side; if so, what color? How does the color of the squirrel protect it from its enemies? Is its color brighter in summer or in winter?

5. How are the squirrel's eyes placed? Do you think it can see behind as well as in front all the time? Are its eyes bright and alert, or soft and tender?

6. Are its legs long or short? Are its hind legs stronger and longer than the front legs? Why? Why does it not need long legs? Do its paws have claws? How does it use its paws when eating and in making its toilet?

7. Describe the squirrel's tail. Is it as long as the body? Is it used to express emotion? Of what use is it when the squirrel is jumping? Of what use is it in the winter in the nest?

8. What is the food of the squirrel during the autumn? Winter? Spring? Summer? Where does it store food for the winter? Does it steal food laid up by jays, chipmunks, mice, or other squirrels? How does it carry nuts? Has it cheek-pouches like the chipmunk for carrying food? Does it stay in its nest all winter living on stored food like a chipmunk?

9. Where does the red squirrel make its home? Of what is it made and where built? In what sort of nest are the young born and reared? At what time of the year are the young born? How does the mother squirrel carry her little ones if she wishes to move them?

10. How much of squirrel language can you understand? How does it express surprise, excitement, anger, or joy during the nut harvest? Note how many different sounds it makes and try to discover what they mean.

11. Describe or sketch the tracks made by the squirrel in the snow.

12. How does the squirrel get at the meats of the hickory nut and the walnut? How are its teeth arranged to gnaw holes in such hard substances as shells?

FURRY

Furry was a baby red squirrel. One day in May his mother was moving him from one tree to another. He was clinging with his little arms around her neck and his body clasped tightly against her breast when something frightened her, and in her sudden movement she dropped her heavy baby in the grass. Thus, I inherited him and entered upon the rather onerous duties of caring for a baby of whose needs I knew little; but I knew that every well-cared-for baby should have a book detailing all that happens to it, and therefore I made a book for Furry, writing in it each day the things he did. If the children who have pets keep similar books, they will find them most interesting reading afterward, and they will surely enjoy the writing very much.

Extracts from Furry's Notebook

May 18, 1902 — The baby squirrel is just large enough to cuddle in one hand. He cuddles all right when once he is captured; but he is a terrible fighter, and when I attempt to take him in my hand, he scratches and bites and growls so that I have been obliged to name him Fury. I told him, however, if he improved in temper I would change his name to Furry.

May 19 — Fury greets me, when I open his box, with the most awe-inspiring little growls, which he calculates will make me turn pale with fear. He has not cut his teeth yet, so he cannot bite very severely, but that isn't his fault, for he tries hard enough. The Naturalist said cold milk would kill him, so I warmed the milk and put it in a teaspoon and placed it in front of his nose; he batted the spoon with both forepaws and tried to bite it, and thus got a taste of the milk, which he drank eagerly, lapping it up like a kitten. When I hold him in one hand and cover him with the other, he turns contented little somersaults over and over.

May 20 — Fury bit me only once today, when I took him out to feed him. He is cutting his teeth on my devoted fingers. I tried giving him grape-nuts soaked in milk, but he spat it out in disgust. Evidently he does not believe he needs a food for brain and nerve. He always washes his face as soon as he is through eating.

May 21 — Fury lies curled up under his blanket all day. Evidently good little squirrels stay quietly in the nest, when the mother is not at home to give them permission to run around. When Fury sleeps, he rolls himself up in a little ball with his tail wrapped closely around him. The squirrel's tail is his " furs," which he wraps around him to keep his back warm when he sleeps in winter.

May 23 — Every time I meet Uncle

John he asks, " Is his name Fury or Furry now? " Uncle John is much interested in the good behavior of even little squirrels. As Fury has not bitten me hard for two days, I think I will call him Furry after this. He ate some bread soaked in milk to-day, holding it in his hands in real squirrel fashion. I let him run around the room and he liked it.

May 25 — Furry got away from me this morning and I did not find him for an hour. Then I discovered him in a pasteboard box of drawing paper with the cover on. How did he squeeze through?

May 26 — He holds the bowl of the spoon with both front paws while he drinks the milk. When I try to draw the spoon away to fill it again after he has emptied it, he objects and hangs on to it with all his little might, and scolds as hard as ever he can. He is such a funny, unreasonable baby.

May 28 — Tonight I gave Furry a walnut meat. As soon as he smelled it he became greatly excited; he grasped the meat in his hands and ran off and hid under my elbow, growling like a kitten with its first mouse.

May 30 — Since he tasted nuts he has lost interest in milk. The nut meats are too hard for his new teeth, so I mash them and soak them in water and now he eats them like a little piggy-wig with no manners at all. He loves to have me stroke his back while he is eating. He uses his thumbs and fingers in such a human way that I always call his front paws *hands*. When his piece of nut is very small he holds it in one hand and clasps the other hand behind the one which holds the dainty morsel, so as to keep it safe.

May 31 — When he is sleepy he scolds if I disturb him and turning over on his back bats my hand with all of his soft little paws and pretends that he is going to bite.

June 4 — Furry ranges around the room now to please himself. He is a little mischief; he tips over his cup of milk and has commenced gnawing off the wall-paper behind the bookshelf to make him a nest. The paper is green and will probably make him sorry.

June 5 — This morning Furry was hidden in a roll of paper. I put my hand over one end of the roll and then reached in with the other hand to get him; but he got me instead, because he ran up my sleeve and was much more contented to be there than I was to have him. I was glad enough when he left his hiding place and climbed to the top shelf of the bookcase, far beyond my reach.

June 6 — I have not seen Furry for twenty-four hours, but he is here surely enough. Last night he tipped over the ink bottles and scattered nut shells over the floor. He prefers pecans to any other nuts.

June 7 — I caught Furry today and he bit my finger so that it bled. But afterwards, he cuddled in my hand for a long time, and then climbed my shoulder and went hunting around in my hair and wanted to stay there and make a nest. When I took him away, he pulled out his two hands full of my devoted tresses. I'll not employ him as a hairdresser.

June 9 — Furry sleeps nights in the top drawer of my desk; he crawls in from behind. When I pull out the drawer he pops out and scares me nearly out of my wits; but he keeps his wits about him and gets away before I can catch him.

June 20 — I keep the window open so Furry can run out and in and learn to take care of himself out-of-doors.

Furry soon learned to take care of himself, though he often returned for nuts, which I kept for him in a bowl. He does not come very near me out-of-doors, but he often speaks to me in a friendly manner from a certain pitch pine tree near the house.

There are many blank leaves in Furry's notebook. I wish that he could have written on these of the things that he thought about me and my performances. It would certainly have been the most interesting book in the world concerning squirrels.

THE CHIPMUNK

While the chipmunk is a good runner and jumper, it is not so able a climber as is the red squirrel, and it naturally stays nearer the ground. One windy day I was struck by the peculiar attitude of what I first thought was a red squirrel gathering green acorns from a chestnut oak in front of my window. A second glance showed me that it was a chipmunk lying close to the branch, hanging on for " dear life " and with an attitude of extreme caution, quite foreign to the red squirrel in a similar situation. He would creep out, seize an acorn in his teeth, creep back to a larger limb, take off the shell, and with his little paws stuff the kernel into his cheek-pouches; he took hold of one side of his mouth with one hand to stretch it out, as if opening a bag, and stuffed the acorn in with the other. I do not know whether this process was necessary or not at the beginning, for his cheeks were distended when I first saw him; and he kept on stuffing them until he looked as if he had a hopeless case of mumps. Then with obvious care he descended the

Leonard K. Beyer

This chipmunk has his cheek-pouches well stuffed

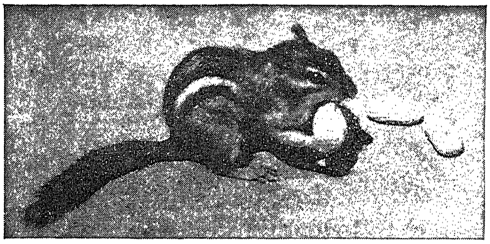
tree and retreated to his den in the sidehill, the door of which I had already discovered, although it was well hidden by a bunch of orchard grass.

Chipmunks are more easily tamed than red squirrels and soon learn that pockets may contain nuts and other things good to eat. The first tame chipmunk of my

" Chipsie," a chipmunk of the Sierras

acquaintance belonged to a species found in the California mountains. He was a beautiful little creature and loved to play about his mistress' room; she, being a naturalist as well as a poet, was able to understand her little companion, and the relations between them were full of mutual confidence. He was fond of English walnuts and would always hide away all that were placed in a dish on the table. One day his mistress, when taking off her hat after returning from church, discovered several of these nuts tucked safely in the velvet bows; they were invisible from the front but perfectly visible from the side. Even yet, she wonders what the people at church that day thought of her original ideas in millinery; and she wonders still more how " Chipsie " managed to get into the hatbox, the cover of which was always carefully closed.

The chipmunk is a good home builder and carries off, presumably in its cheek-pouches, all of the soil which it removes in making its burrow. The burrow is usu-



Dorothy M. Compton

Peanuts are a favorite food of tame chipmunks

ally made in a dry hillside, the passageway just large enough for its own body, widening to a nest which is well bedded down. There is usually a back door also, so that in case of necessity the inmate can escape. It retires to this nest in late November and does not appear again until March. In mild winters it may be up and about on bright, sunny days. In the nest it stores nuts and other grains so that when it wakens, at long intervals, it can take refreshment.

If you really wish to know whether you see what you look at or not, test yourself by trying to describe the length, position, and number of the chipmunk's stripes. These stripes, like those of the tiger in the jungle, make the creature less conspicuous; when on the ground, where its stripes fall in with the general shape and color of the grass and underbrush, it is quite invisible until it stirs. Its tail is not so long nor nearly so bushy as that of the

Chipmunks sometimes cache their food under stumps

squirrel; it does not need a tail to balance and steer with in the tree tops; and since it lives in the ground, a bushy tail would soon be loaded with earth and would be an incubus instead of a thing of beauty.

The chipmunk is not a vocalist like the red squirrel, but he can cluck like a cuckoo and chatter gayly or cogently; and he can make himself into a little bunch with his tail curved up his back, while he eats a nut from both his hands. He is even more amusing than the red squirrel in this attitude, probably because he is more innocent and not so much of a *poseur*. His food consists of all kinds of nuts, grain, and fruit, but he does little or no damage,

Dorothy M. Compton

Common chipmunk, often called ground squirrel

as a rule. He does upon occasion rob the flower garden of valued bulbs. He is pretty and distinctly companionable, and I can rejoice that I have had him and his whole family as my near neighbors for many years. I always feel especially proud when he shows his confidence by scampering around our porch floor and peeping in at our windows, as if taking a reciprocal interest in us.

Suggested Reading — *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *The Pet Book*, by Anna B. Comstock; *Tami, the Story of a Chipmunk*, by Bertha C. Cady; also, readings on page 214.

LESSON 58

The Chipmunk

Leading Thought — The chipmunk lives more on the ground than does the squirrel; its colors are protective and it has cheek-pouches in which it carries food, and also soil when digging its burrow. It stores food for winter in its den.

METHOD — The field notebook should be the basis for this work. Give the pupils an outline of observations to be made, and ask for reports now and then. Meanwhile stimulate interest in the little creatures by reading aloud from some of the references given.

OBSERVATIONS — 1. Do you see the chipmunk climbing around in trees like the red squirrel? How high in a tree have you ever seen a chipmunk?

2. What are the chipmunk's colors above and below? How many stripes has it? Where are they and what are their colors? Do you think that these stripes conceal the animal when among grasses and bushes?

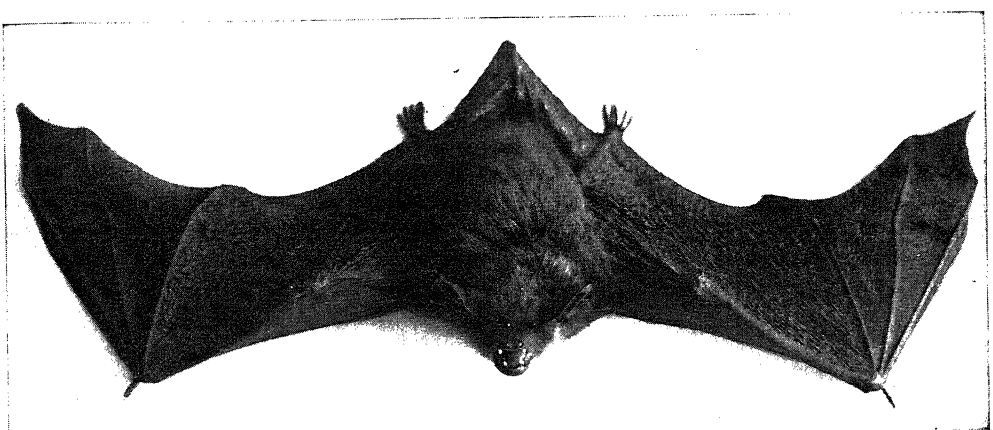
3. Compare the tails of the chipmunk and the red squirrel. Which is the longer and bushier? Tell if you can the special advantage to the chipmunk in having this less bushy tail.

4. What does the chipmunk eat? How does it carry its food? How does it differ in this respect from the red squirrel? Does it store its food for winter use? How does it prepare its nuts? How does it hold its food while eating?

5. Where does the chipmunk make its home? How does it carry away soil from its burrow? How many entrances are there? How is the den arranged inside? Does it live in the same den the year round? When does it retire to its den in the fall? When does it come out in the spring?

6. Does the chipmunk do any damage to crops? What seeds does it distribute? At what time do the little chipmunks appear in the spring?

7. Observe carefully the different tones of the chipmunk and compare its chattering with that of the squirrel.



Verne Morton

A bat

THE LITTLE BROWN BAT

His small umbrella, quaintly halved,
Describing in the air an arc alike inscrutable, —
Elate philosopher! — EMILY DICKINSON

Whoever first said "as blind as a bat," surely never looked a bat in the face, or he would not have said it. The deep-set, keen, observant eyes are quite in keeping with the alert attitude of the erect, pointed ears; while the pug nose and the wide-open little pink bag of a mouth, set with tiny, sharp teeth, give this anomalous little animal a deliciously impish look. Yet how have those old artists belied the bat, who fashioned their demons after his pattern, ears, eyes, nose, mouth, wings, and all! The superstitions which link the bat with evil malign this bright, engaging little creature. There are no other wings so wonderful as the bat's; the thin mem-

Hung up for his daytime nap

brane is equipped with sensitive nerves which inform the flier of the objects in his path, so that he darts among the branches of trees at terrific speed and never touches a twig; a blinded bat was once set free in a room, across which threads were stretched, and he flew about without ever touching one. After we have tamed one of these little, silky flitter-mice we soon get reconciled to his wings for he proves the cunningest of pets; he soon learns who feeds him, and is a constant source of entertainment.

The flight of the bat consists of darting hither and thither with incredible swiftness, and making sharp turns with no apparent effort. Swifts and swallows cannot compete with the bat in wing celerity and agility; it is interesting to note that these birds also catch insects on the wing for food. He makes a collecting net of the wing membrane stretched between the hind legs and tail, doubling it up like an apron on the unfortunate insects, and then reaching down and gobbling them up; and thus he is always doing good service to us on summer evenings by swallowing a multitude of insects.

The short fur of the bat is as soft as silk, and covers the body but not the wings; the plan of the wing is something like that of the duck's foot; it consists of a web stretched between very much elongated fingers. If a boy's fingers were as long in proportion as a bat's, they would measure four feet. Stretched between the long fingers is a thin, rubbery membrane, which extends back to the ankles and thence back to the tip of the bony tail; thus, the bat has a winged margin all around his body. Since fingers make the framework, it is the thumb that projects from the front angle of the wing, in the form of a very serviceable hook, resembling that used by a one-armed man to replace the lost member. These hooks the bat uses in many ways. He drags himself along the floor with their aid, or he scratches the back of his head with them, if occasion requires. He is essentially a creature of the air and is not at all fitted for walking; his knees bend backward in an opposite direction from ours. This renders him unable to walk, and when attempting to do so, he has the appearance of "scrabbling" along on his feet and elbows. When thus moving he keeps his wings fluttering rapidly, as if feeling his way in the dark, and his movements are trembly. He uses his teeth to aid in climbing.

The little brown bat's wings often measure nine inches from tip to tip, and yet he folds them so that they scarcely show; he does not fold them like a fan, but rather like a pocket-knife. The hind legs merely act as a support for the side wing, and the little hip bones look pitifully sharp. The membrane reaches only to the ankle; the tiny foot projecting from it is armed with five wirelike toes, tipped with sharp hooked claws. It is by these claws that he hangs when resting during the day, for he is upside-downy in his sleeping habits, slumbering during the daytime while hanging head downward, without any inconvenience from a rush of blood to the brain; when he is thus suspended, the tail is folded down. Sometimes he hangs by one hind foot and a front hook; and he is a wee thing when all folded together and hung up, with his nose tucked between his hooked thumbs, in a very babyish fashion.

The bat is very particular about his personal cleanliness. People who regard the bat as a dirty creature might well look to it that they be even half as fastidious as he. He washes his face with the front part of his wing, and then licks his washcloth clean; he scratches the back of his head with his hind foot and then licks the foot; when hanging head down, he will reach one hind foot down and scratch behind his ear with an *aplomb* truly comical in such a mite; but it is most fun of all to see him clean his wings; he seizes the edges in his mouth and stretches and licks the membrane until we are sure it is made of silk elastic, for he pulls and hauls it in a way truly amazing.

The bat has a voice which sounds like the squeak of a toy wheelbarrow, and yet it is expressive of emotions. He squeaks in one tone when holding conversation with other bats, and squeaks quite differently when seized by the enemy.

The mother bat feeds her little ones from her breasts as a mouse does its young, only she cradles them in her soft wings while so doing; often she takes them with her when she goes out for insects in the evenings; they cling to her neck during these exciting rides; but when she wishes to work unencumbered, she hangs her tiny youngsters on some twig and goes back for them later. The little ones are born in July and usually occur as twins. During the winter, some bats hibernate like woodchucks or chipmunks. They select for winter quarters some hollow tree or cave or other protected place. They go to sleep when the cold weather comes, and do not awake until the insects are flying; they then come forth in the evenings, or perhaps early in the morning, and do their best to rid the world of insect nuisances. Others migrate to the south with the advent of cold weather.

There are many senseless fears about the bat; for instance, that he likes to get tangled in a lady's tresses, a situation which would frighten him far more than the lady; or that he brings bedbugs into the house when he enters on his quest for insects, which is an ungrateful slander. Some people believe that all bats are vampires, and only await an opportunity to suck blood from their victims. It is true that in South America there are two species which occasionally attack people who are careless enough to sleep with their toes uncovered, but feet thus injured seem to recover speedily. These bats do little damage to people, although they sometimes pester animals; and there are no vampires in the United States. Our bats, on the contrary, are innocent and beneficial to man. There are a few species in our country which have little, leaflike growths on the end of the nose; these growths serve the purpose of sensory organs.

Suggested Reading — *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 3, *In Field and Forest*; *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *The Pet Book*, by Anna B. Comstock; also, readings on page 214.

LESSON 59

The Bat

Leading Thought — Although the bat's wings are very different from those of the bird, yet it is a rapid and agile flier. It flies in the dusk and catches great numbers of mosquitoes and other troublesome insects, upon which it feeds.

Method — This lesson should not be given unless there is a live bat to illustrate it; the little creature can be cared for comfortably in a cage in the schoolroom, as it will soon learn to take flies or bits of raw meat when presented on the point of a pencil or toothpick. Any bat will do for this study, although the little brown bat is the one on which my observations were made.

OBSERVATIONS — 1. At what time of day do we see bats flying? Describe how the bat's flight differs from that of birds. Why do bats dart about so rapidly?

Charles E. Mohr

Little brown bats hibernating in a Pennsylvania cave

2. Look at a captive bat and describe its wings. Can you see what makes the framework of the wings? Do you see the three finger bones extending out into the wings? How do the hind legs support the wing? The tail? Is the wing membrane covered with fur? Is it thick and leathery or thin and silky and elastic? How does the bat fold up its wings?

3. In what position does the bat rest? Does it ever hang by its thumb hooks?

4. Can you see whether the knees of the hind legs bend upward or downward? How does the bat act when trying to walk or crawl? How does it use its thumb hooks in doing this?

5. What does the bat do daytimes? Where does it stay during the day? Do many bats congregate together in their roosts?

6. Describe the bat's head, including the ears, eyes, nose, and mouth. What is its general expression? Do you think it can see and hear well? How is its mouth fitted for catching insects? Does it shut its mouth while chewing or keep it open? Do you think that bats can see by daylight?

7. What noises does a bat make? How does it act if you try to touch it? Can it bite severely? Can you understand why the Germans call it a flitter-mouse?

8. Do you know how the mother bat cares for her young? How does she carry them? At what time of year may we expect to find them?

9. When making its toilet, how does a bat clean its wings? Its face? Its back? Its feet? Do you know if it is very clean in its habits?

10. How and where do the bats pass the winter? How are they beneficial to us? Are they ever harmful? What are some superstitions about the bat?

Nature-study should not be unrelated to the child's life and circumstances. It stands for directness and naturalness. It is astonishing when one comes to think of it, how indirect and how remote from the lives of pupils much of our education has been. Geography still often begins with the universe, and finally, perhaps, comes down to some concrete and familiar object or scene that the pupil can understand. Arithmetic has to do with brokerage and partnerships and partial payments and other things that mean nothing to the child. Botany begins with cells and protoplasm and cryptogams. History deals with political and military affairs, and only rarely comes down to physical facts and to those events that express the real lives of the people; and yet political and social affairs are only the results of expressions of the way in which people live. Readers *begin with mere literature or with stories of scenes the child will never see. Of course these statements are meant to be only general, as illustrating what is even yet a great fault in educational methods. There are many exceptions, and these are becoming commoner. Surely, the best education is that which begins with the materials at hand. A child knows a stone before it knows the earth.*

— "THE NATURE-STUDY IDEA,"
L. H. BAILEY

THE SKUNK

Those who have had experience with this animal surely are glad that it is small; and the wonder always is that so little a creature can make such a large impression upon the atmosphere. A fully grown skunk is about two feet long; its body is covered with long, shining, rather coarse hair, and the tail, which is carried like a flag in the air, is very large and bushy. In color, the fur is sometimes entirely black, but most often has a white patch on the back of the neck, with two stripes extending down the back and along the sides to the tail; the face, also, has a white stripe.

The skunk has a long head and a rather pointed snout; its front legs are very much shorter than its hind legs, which gives it a very peculiar gait. Its forefeet are armed with long, strong claws, with which it digs its burrow, which is usually made in light soil. It also often makes its home in some crevice in rocks, or even takes possession of an abandoned woodchuck's hole; or trusting to its immunity from danger, makes its home under the barn. In the fall it becomes very fat, and during the early part of winter it hibernates within its den; it comes out during the thaws of winter and early spring.

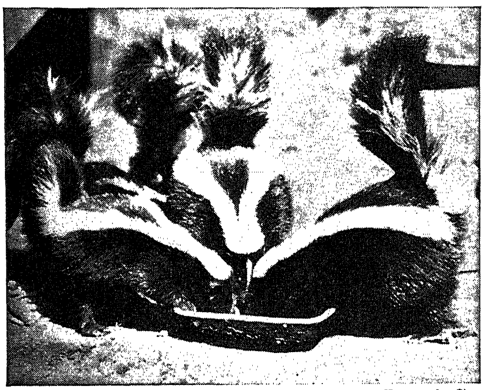
The young skunks appear in May; they are born in an enlarged portion of the burrow, where a nice bed of grass and leaves is made for them; the skunk is scrupulously neat about its own nest. The young skunks are very active and interesting to watch when playing together like kittens.

The skunk belongs to the same family as the mink and weasel, which also give off a disagreeable odor when angry. The fetid material which is the skunk's defense is contained in two glands near the base of the tail. These little glands are about the size of marbles, and the quantity of liquid forced from them in a discharge is considerable and it will permeate the atmosphere with its odor for a distance of half a mile down wind. Because this discharge is so disagreeable to all other creatures, the skunk's intelligence has not become so highly developed as has that of some animals. It has not been obliged to rely upon its cunning to escape its enemies, and has therefore never developed either fear or cleverness. It marches abroad without haste, confident that every creature which sees it will give it plenty of room. It is a night prowler, although it is not averse to a daytime promenade. The white upon its fur gives warning at night that here is an animal which had best be left alone. This immunity from attack makes the skunk careless in learning wisdom from experience; it never learns to avoid a trap, or the dangers of a railway or trolley track. It plods deliberately across highways, leaving its protection to the motorist.

Verne Morton

A skunk. Note the long, pointed head and the bushy tail

The skunk's food consists largely of fruits and berries, insects, mice, snakes, frogs, and other small animals. It also destroys the eggs and young of birds which nest upon the ground. It uses its strong forepaws in securing its prey. Dr. Merriam, who made pets of young skunks after removing their scent capsules, found them very interesting. He says of one which was named "Meph": "We used to walk through the woods to a large meadow that abounded in grasshoppers. Here, Meph would fairly revel in his favorite food, and it was rich sport to watch his manœuvres. When a grasshopper jumped, he jumped, and I have seen him with as many as three in his mouth and two under his forepaws at the same time."



Doubleday, Page & Co.

Pet skunks

The only injury which the skunk is likely to do farmers is the raiding of hens' nests or the beehives; this can be obviated by properly housing the poultry and bees. On the other hand, the skunk is of great use in destroying injurious insects and mice. Often when skunks burrow beneath barns, they completely rid the place of mice. Skunk fur is very valuable and is sold, surprisingly, under its own name; it is exported in great quantities to Europe.

The skunk takes short steps, and goes so slowly that it makes a double track, the imprints being very close together. The foot makes a longer track than that of the cat, as the skunk is plantigrade; that is, it walks upon its palms and heels as well as its toes.

Suggested Reading — *The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *The Pet Book*, by Anna B. Comstock; also, readings on page 214.

LESSON 60

The Skunk

Leading Thought — The skunk has depended so long upon protecting itself from its enemies by its disagreeable odor that it has become stupid and unadaptable, and seems never to be able to learn to keep off railroad tracks or highways. It is a very beneficial animal to the farmer because its food consists so largely of injurious insects and rodents.

Method — The questions should be given the pupils and they should answer them from personal observations or inquiries.

Observations — 1. How large is a skunk? Describe its fur. Where does the black and white occur in the fur? Of what use is the white to the skunk? Is the fur valuable? What is its commercial name?

2. What is the shape of the skunk's head? The general shape of the body? The tail? Are the front legs longer or shorter than the hind legs? Describe the front feet. For what are they used?

3. Where and how does the skunk make its nest? Does it sleep like a woodchuck during the winter? What is its food? How does it catch its prey? Does it hunt for its food during the day or the night? Does the skunk ever hurry? Is it afraid? How does it protect itself from its enemies? Do you think that the skunk's freedom from fear has rendered the animal less intelligent?

4. At what time do the skunk kittens appear? Have you ever seen little skunks playing? If so, describe their antics. How is the nest made soft for the young ones?

5. How does the skunk benefit farmers? Does it ever do them any injury? Do you think that it does more good than harm?

6. Describe the skunk's track as follows: How many toes show in the track? Does the palm or heel show? Are the tracks

near together? Do they form a single or a double line?

Few animals are so silent as the skunk. Zoological works contain no information as to its voice, and the essayists rarely mention it except by implication. Mr. Burroughs says: "The most silent creature known to me, he makes no sound, so far as I have observed, save a diffuse, impatient noise, like that produced by beating your hand with a whisk-broom, when the farm-dog has discovered his retreat in the stone fence." Rowland Robinson tells us that: "The voiceless creature sometimes frightens the belated farm-boy, whom he curiously follows with a mysterious hollow beating of his feet upon the ground." Thoreau, as has been mentioned, heard one keep up a "fine grunting, like a little pig or a squirrel"; but he seems to have misunderstood altogether a singular loud patting sound heard repeatedly on the frozen ground under the wall, which he also listened to, for he thought it "had to do with getting its food, patting the earth to get the insects or worms." Probably he would have omitted this guess if he could have edited his diary instead of leaving that to be done after his death. The patting is evidently merely a nervous sign of impatience or apprehension, similar to the well-known stamping with the hind feet indulged in by rabbits, in this case probably a menace like a doubling of the fists, as the hind legs, with which they kick, are their only weapons. The skunk, then, is not voiceless, but its voice is weak and querulous, and it is rarely if ever heard except in the expression of anger.

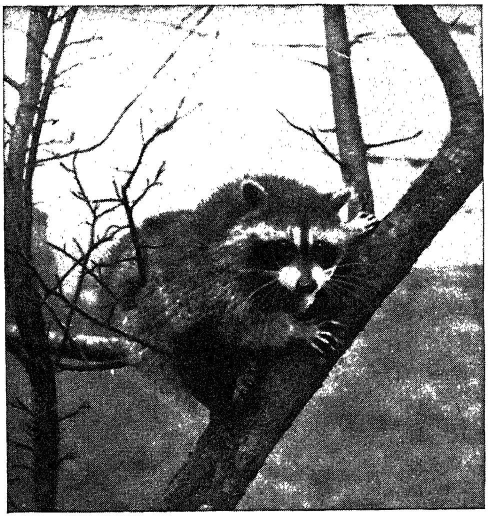
— "WILD NEIGHBORS,"
ERNEST INGERSOLL

General Biological Supply House, Chicago

A raccoon. In the picture the heavy dark portion over the top of his head is caused by a shadow — but he does have a black mask across his eyes

THE RACCOON

None other of our little brothers of the forest has such a mischievous countenance as the coon. The black patch across the face and surrounding the eyes like large goggles, and the black line extending from the long, inquisitive nose directly up the



Treed

forehead give the coon's face an anxious expression; and the keenness of the big, beady, black eyes and the alert, "sassy" looking, broadly triangular ears, convince one that the anxiety depicted in the face is anxiety lest something that should *not* be done be left undone; and I am sure that anyone who has had experience with pet coons will aver that their acts do not belie their looks.

What country child, wandering by the brook and watching its turbulence in early spring, has not viewed with awe a footprint on the muddy banks looking as if it were made by the foot of a very little baby? The first one I ever saw I promptly concluded was made by the foot of a brook fairy. However, the coon is no fairy; it is a rather heavy, logy animal and, like the bear and skunk, is plantigrade, walking on the entire foot instead of on the toes, like a cat or dog. The hind foot is long, with a well-marked heel, and five comparatively short toes, giving it a remarkable resemblance to a human foot. The front foot is smaller and looks like a wide, little hand, with four long fingers and a rather short thumb. The claws are strong and sharp. The soles of the feet and the palms of the hands look as if they were covered with black kid, while the feet above and the backs of the hands are covered with short fur. Coon tracks are likely to be found during the thawing days of winter, along some stream or the borders of swamps, often following the path made by cattle. The full-length track is about two inches long; as the coon puts the hind foot in the track made by the front foot on the same side, only the print of the hind feet is left, showing plainly five toe prints and the heel. The tracks may vary from one-half inch to one foot or more apart depending on how fast the animal is going; when it runs it goes on its toes, but when walking it sets the heel down; the tracks are not in so straight a line as those made by the cat. Sometimes it goes at a slow jump, when the prints of the hind feet are paired, and between and behind them are the prints of the two front feet.

The coon is covered with long, rather coarse hair, so long as almost to drag when the animal is walking; it really has two different kinds of hair, the long, coarse, gray hair, blackened at the tips, covering the fine, short, grayish or brownish undercoat. The very handsome bushy tail is ringed with black and gray.

The raccoon feeds on almost anything eatable, except herbage. It has a special predilection for corn in the milk stage and, in attaining this sweet and toothsome luxury, it strips down the husks and often breaks the plant, doing much damage. It is also fond of poultry and often raids hen houses; it also destroys birds' nests and the young, thus doing harm to the farmer by killing both domestic and wild birds. It is especially fond of fish and is an adept at sitting on the shore and catching them with its hands; it likes turtle eggs, crayfish, and snakes; it haunts the bayous of the Gulf Coast for the oysters which grow there; it is also a skillful frog catcher. Although fond of animal diet, it is also fond of fruit, especially of berries and wild grapes. It usually chooses for a home a hollow tree or a cavern in a ledge near a stream, because of its liking for water creatures.

Coons when in captivity have been known to wash their meat before eating it. I have watched a pet coon perform this act; he would take a piece of meat in his hands, dump it into the pan of drinking water and souse it up and down a few times; then he would get into the pan with his splay feet and roll the meat beneath and between them, meanwhile looking quite unconcernedly at his surroundings, as if washing the meat were an act too mechanical to occupy his mind. After the meat had been soaked until it was white and flabby, he would take it in his hands and hang onto it with a tight grip while he pulled off pieces with his teeth; or sometimes he would hold it with his feet, and use hands as well as teeth in tearing it apart. The coon's teeth are very much like those of the cat, having long, sharp tushes or canines, and sharp, wedge-shaped grinding teeth, which cut as well as grind. After eating, the pet coon always washed his feet by splashing them in the pan.

It is an amusing sight to watch a coon arrange itself for a nap, on a branch or in the fork of a tree; it adapts its fat body to the unevenness of the bed with apparent comfort; it then tucks its nose down between its paws and curls its tail about itself, making a huge, furry ball. In all probability, the rings of gray and black on the tail serve as protective color to the animal sleeping in a tree during the daytime, when sunshine and shadow glance down between the leaves with ever-changing light. The coon spends much of its day asleep in some such situation, and comes forth at night to seek its food.

In the fall, the coon lays on fat enough to last it during its winter sleep. Usually several inhabit the same nest in winter, lying curled up together in a hollow tree, and remain dormant during the most severe weeks of winter, coming out during periods of thaw.

The young are born in April; there are from three to six in a litter; they are blind and helpless at first, and are cared for carefully by their parents; the family remains together until fall. If removed from their parents the young ones cry pitifully, almost like babies. The cry or whistle of the fully grown coon is anything but a happy sound, and is quite impossible to describe. I have been awakened by it many a night in camp, and it always sounded strange, taking on each time new quavers and whimperings. As a cry, it is first cousin to that of the screech owl.

The stories of pet coons are many. I knew one which, chained in a yard, would lie curled up near its post looking like an innocent stone except for one eye kept watchfully open. Soon a hen filled with curiosity would come warily near, looking longingly at remains of food in the pan; the coon would make no move until the disarmed biddy had come close to the pan. Then there would be a scramble and a squawk and with astonishing celerity he would wring her neck and strip off her feathers. Another pet coon was allowed to range over the house at will, and finally had to be sent away because he had learned to open every door in the house, including cupboard doors, and could also open boxes and drawers left unlocked; and I have always believed he could have learned to unlock drawers if he had been given the key. All coons are very curious, and one way of trapping them is to suspend above the trap a bit of bright tin; in studying this glittering mystery, they forget all about traps.

Suggested Reading — *Mother Nature Series*, by Fannie W. Dunn and Eleanor

Marion E. Wesp

This pet raccoon is angry because she has been taken from the shoulder of her mistress and placed on a post to have her picture taken

Troxell, Book 1, *Baby Animals*, Book 3, *In Field and Forest; The Museum Comes to Life*, by Maribelle Cormack and William P. Alexander; *The Pet Book*, by Anna B. Comstock; *Ringtail*, by Alice C. Gall and F. H. Crew; also, readings on page 214.

LESSON 61

The Raccoon

Leading Thought — The raccoon lives in hollow trees or caves along the banks of streams. It sleeps during the day and seeks its food at night. It sleeps during the winter.

Method — If there are raccoons in the vicinity, ask the older boys to look for their tracks near the streams and to describe them very carefully to the class. The ideal method of studying the animal is to have a pet coon where the children may watch at leisure its entertaining and funny performances. If this is impossible, then follow the less desirable method of having the pupils read about the habits of the coon and thus arouse their interest and open their eyes, so that they may make observations of their own when opportunity offers. I would suggest the following topics for oral or written work in English:

"How and Where Coons Live and What They Do"; "The Autobiography of a Coon One Year Old"; "The Queer Antics of Pet Coons"; "Stories of the Coon's Relative, the Bear."

Observations — 1. Where have you found raccoon tracks? How do they differ from those of fox or dog? How far are the foot prints apart? Can you see the heel and toe prints? Do you see the tracks of all four feet? Are the tracks in a straight line like those of the cat? What is the size of the track, the length, the breadth?

2. What do coons eat and how do they get their food? Which of our crops are they likely to damage? What other damage do they do? Have you ever heard coons cry or whistle during August nights in the cornfields?

3. Why do raccoons like to live near the water? What do they find of interest there? How do they prepare their meat before eating it? How does a coon handle its meat while eating it?

4. What kind of fur has the coon? Why does it need such a heavy covering? Describe the color of the fur. Describe the tail. Of what use is such a large and bushy tail to this animal?

5. Describe the coon's face. How is it marked? What is its expression? Describe the eyes, ears, and nose. Has it teeth resembling those of the cat and dog?

6. Describe the coon's feet. How many toes on the front feet? How many on the hind feet? How does this differ from the cat and dog? How do the front and hind feet differ in appearance? Can both be used as hands?

7. How do coons arrange themselves for a nap in a tree? How do they cover the head? How is the tail used? Do you think this bushy tail used in this way would help to keep the animal warm in winter? Do coons sleep most by day or by night?

8. At what time of year are coons fattest? Leanest? Why? Do they ever come out of their nests in winter? Do they live together or singly in winter?

9. At what time of year are the young coons born? Do you know how they look when they are young? How are they cared for by their parents?

10. Are the coon's movements slow or fast? What large animal is a near relative of the coon?

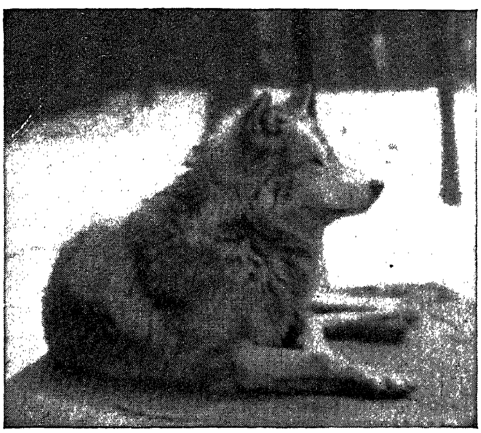
THE WOLF

The study of the wolf should precede the lessons on the fox and the dog. After becoming familiar with the habits of wolves, the pupils will be much better able to understand the nature of the dog and its life as a wild animal. In most localities, the study of the wolf must, of course, be a matter of reading, unless the pupils have an opportunity to study the animal in zoological gardens.

It might be well to begin this lesson on the wolf with a talk about the gray wolves which our ancestors had to contend with, and also with stories of the coyote or prairie wolf which has learned to adapt itself to civilization and flourishes in the regions west of the Rocky Mountains, despite men and dogs. Literature is rich in wolf stories. Although Kipling's famous Mowgli Stories belong to the realm of fiction, yet they contain interesting accounts of the habits of the wolves of India, and are based upon the hunter's and tracker's knowledge of these animals. We have many thrillingly interesting stories in our own literature which deal with our native wolves. Some of the best are noted in the suggested reading at the end of this section.

E. H. McCleery

Wolves, seldom seen now, once ranged over many parts of North America



Leonard K. Beyer

A captive wolf

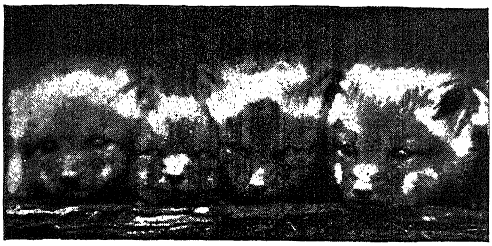
From some or all of these stories, the pupils should get information about the habits of the wolves. This information may be incorporated in an essay or an oral exercise and should cover the following points: Where do the wolves live? On what do they feed? How do they get their prey? How do they call to each other? Description of the den where the young are reared. The wolf's cleverness in eluding hunters and traps.

Suggested Reading — *Animal Heroes, Lives of the Hunted*, and *Wild Animals I Have Known*, all by Ernest Thompson Seton; *Watched by Wild Animals*, by Enos A. Mills; also, readings on page 214.

THE FOX

Do we not always, on a clear morning of winter, feel a thrill that must have something primitive in its quality at seeing certain tracks in the snow that somehow suggest wildness and freedom! Such is the track of the fox. Although it is somewhat like that of a small dog, yet it is very different. The fox has longer legs than most dogs of his weight, and there is more of freedom in his track and more of strength and agility expressed in it. His gait is usually an easy lope; this places the imprint of three feet in a line, one ahead of another, but the fourth is off a little at one side, as if to keep the balance.

The fox lives in a den or burrow. The only fox home which I ever saw was a rather deep cave beneath the roots of a stump, and there was no burrow or retreat beyond it. However, foxes often select woodchuck burrows, or make burrows of their own, and if they are caught within, they can dig rapidly, as many a hunter can attest. The mother usually selects an open



Red fox cubs

place as a den for the young foxes; often an open field or sidehill is chosen for this. The den is carpeted with grass and is a very comfortable place for the fox puppies.

The face of the red fox shows plainly why he has been able to cope with man, and thrive despite and because of him. If ever a face showed cunning, it is his. Its pointed, slender nose gives it an expression of extreme cleverness, while the width of the head between the upstanding, triangular ears gives room for a brain of power. In color the fox is russet-red, the hind quarters being grayish. The legs are black outside and white inside; the throat is white, and the broad, triangular ears are tipped with black. The glory of the fox is his " brush," as the beautiful, bushy tail is called. This is red, with black toward the end and is white-tipped. This tail is not merely for beauty, for it affords the fox warmth during the winter, as anyone who has observed the way it is wrapped around the sleeping animal may see. But this bushy tail is a disadvantage, if it becomes bedraggled and heavy with snow and sleet, when the hounds are giving close chase to its owner. The silver fox and the black fox are color phases of the red fox.

The fox is an inveterate hunter of the animals of the field; meadow mice, rabbits, woodchucks, frogs, snakes, and grasshoppers are all acceptable food; he is also destructive of birds. His fondness for the latter has given him a bad reputation with the farmer because of his attacks on poultry. Not only will he raid hen-roosts if he can force entrance, but he catches many fowls in the summer when they are wandering through the fields. The way he carries the heavy burden of his larger prey shows his cleverness: he slings a hen or a goose over his shoulders, keeping the head in his mouth to steady the burden. Mr. Cram says, in *American Animals:*

" Yet, although the farmer and the fox are such inveterate enemies, they manage to benefit each other in a great many ways quite unintentionally. The fox destroys numberless field mice and woodchucks for the farmer and in return the farmer supplies him with poultry, and builds convenient bridges over streams and wet places, which the fox crosses oftener than the farmer, for he is as sensitive as a cat about getting his feet wet. On the whole, I am inclined to believe that the fox gets the best part of the exchange, for, while the farmer shoots at him on every occasion, and hunts him with dogs in the winter, he has cleared the land of wolves and panthers, so that foxes are probably safer than before any land was ploughed."

The bark of the fox is a high, sharp yelp, more like the bark of the coyote than of the dog. There is no doubt a considerable range of meaning in the fox's language, of which we are ignorant. He growls when angry, and when pleased he smiles like a dog and wags his beautiful tail.

Many are the wiles of the fox to mislead dogs following his track: he often retraces his own steps for a few yards and then makes a long sidewise jump; the dogs go on, up to the end of the trail pocket, and try in vain to get the scent from that point. Sometimes he walks along the top rails of fences or takes the high and dry ridges where the scent will not remain; he often

Verne Morton

The attentive ears and bright eyes of these fox cubs show a keen interest in their surroundings follows roads and beaten paths and also goes around and around in the midst of a herd of cattle or sheep so that his scent is hidden; he crosses streams on logs and invents various other devices too numerous and intricate to describe. When chased by dogs, he naturally runs in a circle, probably so as not to be too far from home. If there are young ones in the den, the father fox leads the hounds far away, into the next county if possible. Perhaps one of the most clever tricks of the fox is to make friends with the dogs. I have known of two instances where a dog and fox were daily companions and playfellows.

The young foxes are born in the spring. They are gray and woolly at first and are fascinating little creatures, being exceedingly playful and active. Their parents are very devoted to them, and during all their puppyhood the mother fox is a menace to the poultry of the region, because the necessity of feeding her rapidly growing litter is upon her.

Suggested Reading — *Biography of a Silver Fox*, by Ernest Thompson Seton; *The Fall of the Year*, by Dallas L. Sharp; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals*; *The Pet Book*, by Anna B. Comstock; *Red Fox*, by Charles G. D. Roberts; *Skinny, the Gray Fox*, by Agnes A. Atkinson; *Sprite, the Story of a Red Fox*, by Ernest H. Baynes; *Wild Animals I Have Known*, by Ernest Thompson Seton; also, readings on page 214.

LESSON 62

The Fox

Leading Thought — The red fox is so clever that it has been able, in many parts of our country, to maintain itself despite dogs and men.

Method — This lesson is likely to be given largely from hearsay or reading. However, if the school is in a rural district, there will be plenty of hunters' stories afloat, from which may be elicited facts concerning the cunning and cleverness of the red fox. In such places there is also the opportunity in winter to study fox tracks upon the snow. The lesson may well be given when there are fox tracks for observation. The close relationship between foxes and dogs should be emphasized.

Observations — 1. Describe the fox's track. How does it differ from the track of a small dog?

2. Where does the fox make its home? Describe the den. Describe the den in which the young foxes live.

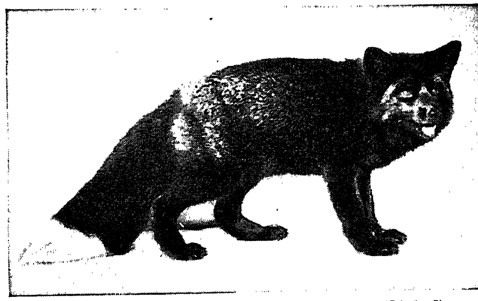
3. Describe the red fox, its color and form, as completely as you can. What is the expression of its face? What is there peculiar about its tail? What is the use of this great bushy tail in the winter?

4. What is the food of the fox? How does it get its food? Is it a day or a night hunter? How does the fox benefit the farmer? How does it injure him? How does the fox carry home its heavy game, such as a goose or a hen?

5. Have you ever heard the fox bark? Did it sound like the bark of a dog? How does the fox express anger? Pleasure?

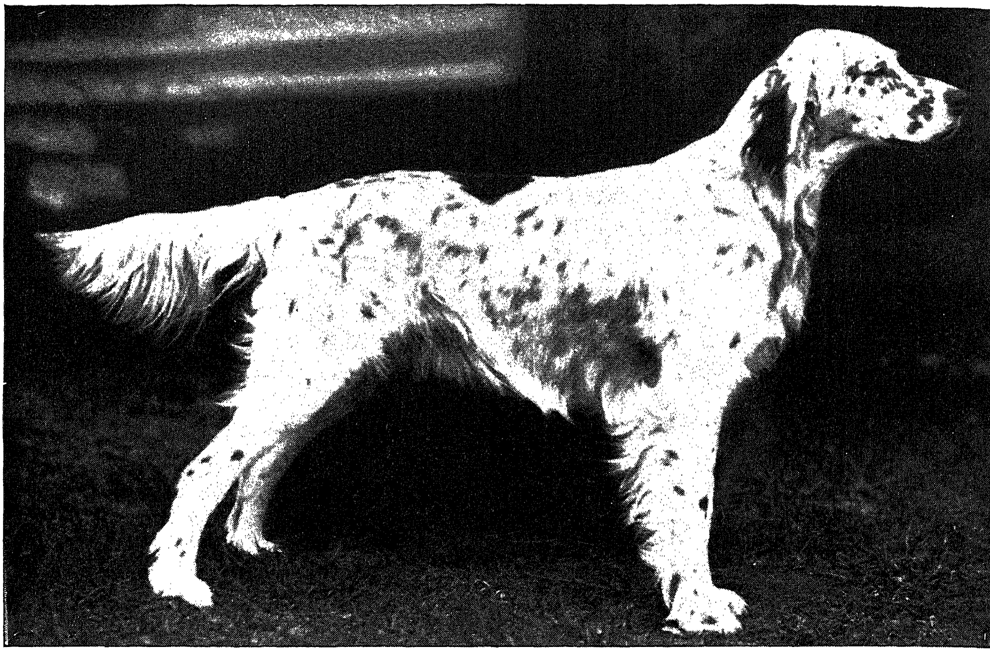
6. When chased by dogs, in what direction does the fox run? Describe all of the tricks which you know by which the fox throws the dog off the scent.

7. When are the young foxes born? How many in a litter? What color are they? How do they play with each other? How do they learn to hunt?



U. S. Bureau of Biol. Survey

Silver fox



National Sportsman

English setter. This is the famous Brownie's Spot, field trial winner and bench show champion

DOGS

Not only today but in ancient days, before the dawn of history, the dog was the companion of man. Whether the wild species from whence he sprang was wolf or jackal or some other similar animal, we do not know, but we do know that many types of dogs have been tamed independently by savages, in the region where their untamed relatives run wild. As the whelps of wolves, jackals, and foxes are all easily tamed, and are most interesting little creatures, we can understand how they became companions to the children of the savage and barbarous peoples who hunted them.

In the earliest records of cave dwellers, in the picture writing of the ancient Egyptians and of other ancient peoples, we find record of the presence and value of the dog. But man, in historical times, has been able to evolve breeds that vary more in form than do the wild species of the present. There are 200 distinct breeds of dogs known today, and many of these have been bred for special purposes. The paleontologists, moreover, assure us that there has been a decided advance in the size and quality of the dog's brain since the days of his savagery; thus, he has been the companion of man's civilization also. It is not, therefore, to be wondered at that the dog is now the most companionable, and has the most human qualities and intelligence of all our domesticated animals.

Dogs run down their prey; it is a necessity, therefore, that they be equipped with legs that are long, strong, and muscular. The cat, which jumps for her prey, has much more delicate legs but has powerful hips to enable her to leap. The dog's feet are much more heavily padded than those of the cat, because in running he must not stop to save his feet. Hounds often return from a chase with bleeding feet, despite the heavy pads, but the wounds are usually cuts between the toes. The claws are heavy and are not retractile; thus, they afford a protection to the feet when running, and they are also used for digging out game which burrows into the ground. They are not used for grasping prey like those of the cat and are used only incidentally in fighting, while the cat's claws are the most important weapons in her armory. It is an interesting fact that Newfoundland dogs, which are such

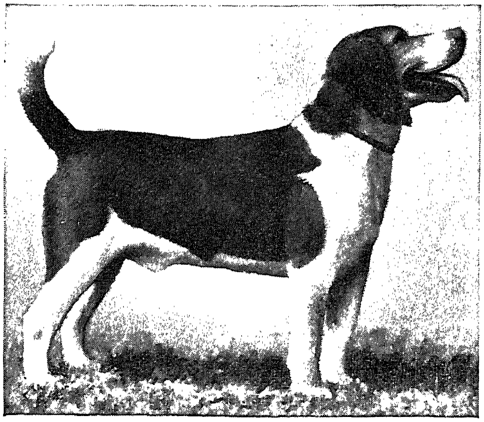
U. S. Dept. Agriculture

Boston terrier. This small popular breed is one of the few to originate in America. It is very companionable and highly intelligent

famous swimmers, have their toes somewhat webbed.

The dog's body is long, lean, and very muscular, a fat dog being usually pampered and old. The coat is of hair and is not of fine fur like that of the cat. It is of interest to note that the Newfoundland dog has an inner coat of fine hair comparable to that of the mink or muskrat. When a dog is running, his body is extended to its fullest length; in fact, it seems to "lie flat," the outstretched legs heightening the effect of extreme muscular effort of forward movement. A dog is master of several gaits; he can run, walk, trot, bound, and crawl.

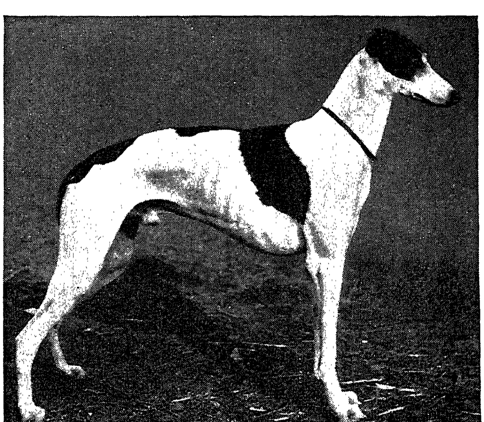
The iris of the dog's eye is usually of



U. S. Dept. Agriculture

Beagle. These hounds hunt individually, in pairs, or in packs; they are used chiefly for hunting rabbits

a beautiful brown, although this varies with breeds; in puppies, the iris is usually blue. The pupil is round like our own; and although dogs probably cannot see as well in the dark as the cat, they see well at night and in daylight they have keen sight. The nose is so much more efficient than the eyes, that it is on the sense of smell the dog depends for following his prey and for recognizing friend and foe. The damp, soft skin that covers the nose has in its dampness the conditions for carrying the scent to the wide nostrils; these are situated at the most forward part of the face, and thus may be lifted in any



U. S. Dept. Agriculture

Greyhound. This swiftest of all large dogs hunts by sight

St. Bernard. These dogs stand about thirty inches high and have an average weight of 175 *pounds*

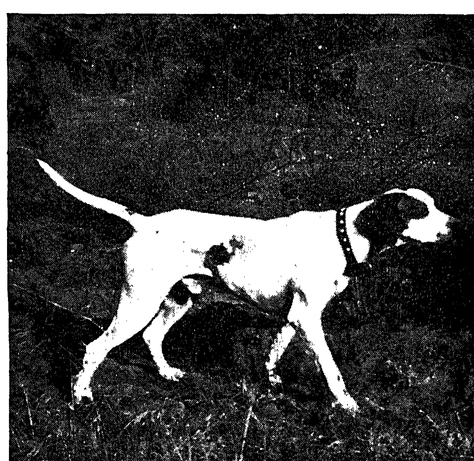
direction to receive the marvelous impressions, so completely beyond our comprehension. Think of being able to scent the track of a fox made several hours previously, and not only to scent it, but to follow it by scent for many miles without ever having a glimpse of the fleeing foe! In fact, while running, the dog's attention seems to be focused entirely upon the sense of smell, for I have seen hounds pass within a few rods to the windward of the fox they were chasing, without observing him at all. Furthermore, according to E. H. Baynes, the dog's sense of smell is keen enough to distinguish the scent of the particular creature he is hunting from that of all others, and to distinguish the scent of several animals from that of only one. He knows the difference between foot scent and body scent, and he can immediately tell the scent of a wounded animal from that of a dead one. He can tell, moreover, the direction in which foot scent leads, and some dogs, at least, can follow a particular trail no matter how many other scents have been superimposed upon it. It has been said that the sense of smell in dogs, and especially in hounds, is so acute that the amount of odor required to stimulate the nose is too slight to be expressed. When the nose of a dog becomes dry it is a sign of illness.

A light fall of damp snow gives the dog the best conditions for following a track by scent. A hound, when on the trail, will run until exhausted. There are many authentic observations which show that hounds have followed a fox for twenty-four hours without food, and probably with little rest.

Because the dog's sense of smell is so important to him, he should never be punished by being struck over the nose. Nor should he be struck at all about the head and ears, lest his hearing be damaged. A dog is so sensitive to inflections and tones of voice that a severe word is usually punishment enough; if it seems necessary to strike him, he should be struck only on the foreshoulders and sides. A folded newspaper is good for the purpose.

The dog's weapons for battle, like those of the wolf, are his tushes; with these he holds and tears his prey; with them he seizes the woodchuck or other small animal through the back and shakes its life out. In fighting a larger animal, the dog leaps against it and often incidentally tears its flesh with his strong claws; but he does not strike a blow with his foot like the cat, nor can he hold his quarry with it.

Dogs' teeth are especially fitted for their work. The incisors are small and sharp; the



H. M. Isenhower

Pointer. These dogs are called pointers because of their habit of pointing at the concealed game birds they have scented. This is Isenhower's Flaro, a champion canine teeth or tushes are very long, but there are bare spaces on the jaws so that they are able to cross past each other; the molar teeth are not adapted for grinding, like the teeth of a cow, but are especially fitted for cutting, as may be noted if we watch the way a dog gnaws bones, gnawing with the back teeth first on one side and then on the other. In fact, a dog does not seem to need to chew anything, but simply needs to cut his meat in small enough pieces so that he can gulp them down without chewing. His powers of digesting unchewed food are something that the hustling American may well envy.

Mr. and Mrs. J. W. Page

Beagle pups. Beagles are small models of foxhounds; they are not so swift as foxhounds, but seem to have a keener sense of smell

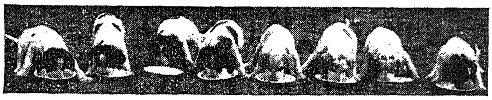
Of all domestic animals, the dog is most humanly understandable in expressing emotions. If delighted, he leaps about giving ecstatic little barks and squeals, his tail in the air and his eyes full of happy anticipation. If he wishes to be friendly, he looks at us interestedly, comes over to smell of us in order to assure himself whether he has ever met us before, and then wags his tail as a sign of good faith. If he wishes to show affection, he leaps upon us and licks our face or hands with his soft, deft tongue and follows us jealously. When he stands at attention he holds his tail stiff in the air, and looks up with one ear lifted as if to say, " Well, what's doing? " When angry, he growls and shows his teeth and the tail is held rigidly out behind, as if to convince us

Helen F. Hill

English springer spaniel. No other family of dogs contains so many recognized breeds as the spaniel family — seven hunting and two toy breeds. Formerly these dogs were trained to flush or " spring " the game so that swifter dogs or falcons could catch it; today they are popular as all-purpose dogs

The Seeing Eye, Inc.

A Seeing Eye dog. The training of dogs to lead the blind began in the United States; the same methods have now become popular in Europe. The Seeing Eye has headquarters in New York City that it is really a continuation of his backbone. When afraid, he whines and lies flat upon his belly, often looking beseechingly up toward his master as if begging not to be punished; or he crawls away out of sight. When ashamed, he drops his tail between his legs and with drooping head and sidewise glance slinks away. When excited, he barks and every bark expresses high nervous tension.



H. M. Isenhower

English pointer pups

Almost all dogs that chase their prey bark when so doing. This action would at first sight seem foolish, in that it reveals their whereabouts to their victims and also adds an incentive to flight. These dogs have been trained through many generations and have been selected because of various peculiarities; a good fox hound, coon hound, or rabbit hound barks in order to tell the hunter, not only where it is but what it is doing. A certain kind of bark may indicate to the hunter that the game is " treed " or chased into a hole.

Most breeds of dogs have an acute sense of hearing. When a dog bays at the moon or howls when he hears music, it is simply a reversion to the wild habit of howling to call together the pack or in answer " to the music of the pack." It is interesting that our music, which is the flower of our civilization, should awaken the sleeping ancestral traits in the canine breast. But perhaps that, too, is why we respond to music, because it awakens in us the strong, primitive emotions, and for the time enables us to free ourselves from all conventional shackles and trammels.

Suggested Reading — *The Book of Dogs*, by James G. Lawson; *Call of the Wild*, by Jack London; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals; The Pet Book*, by Anna B. Comstock; *Polaris, the Story of an Eskimo Dog*, by Ernest H. Baynes; *The Story of Scotch*, by Enos A. Mills; *Stickeen; the Story of a Dog*, by John Muir; *Wild Animals I Have Known, Animal Heroes*, and *Lives of the Hunted*, all by Ernest Thompson Seton; *A Friend in the Dark*, by Ruth A. Knight; also, readings on page 214.

LESSON 63

Dogs

Leading Thought — The dog is a domesticated descendant of wolflike animals and has retained certain of the habits and characteristics of his ancestors.

Method — For the observation lesson it would be well to have at hand a well-disposed dog which would not object to being handled; a collie or a hound would be preferable. Many of the questions should be given to the pupils to answer from observations at home, and the lesson should be built upon the experience of the pupils with dogs.

Observations — 1. Why are the legs of the dog compared with those of the cat long and strong in proportion to the body?

2. Compare the feet of the cat with those of the dog and note which has the heavier pads. Why is this of use to each?

3. Which has the stronger and heavier

Leonard K. Beyer

Collie. This breed of dogs shows great intelligence in the herding of various kinds of domestic animals; it has long been used in Scotland, but its popularity has spread to many other countries. The one pictured here is not today the show type claws, the dog or the cat? Can the dog retract his claws so that they are not visible, as does the cat? Of what use is this arrangement to the dog? Are the front feet just like the hind feet? How many toe impressions show in the track of the dog?

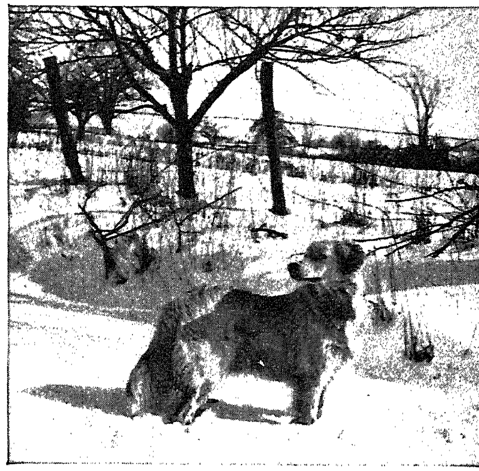
4. What is the general characteristic of the body of the dog? Is it soft like that of the cat, or lean and muscular? What is the difference between the hair covering of the dog and the cat? What is the attitude of the dog when running fast? How many kinds of gaits has he?

Klondike Jack. The dog that pulled four hundred fifty pounds five hundred miles through the White Horse Pass in the winter of the first gold excitement in Alaska

5. In general, how do the eyes of the dog differ from those of the cat? Does he rely as much upon his eyes for finding his prey as does the cat? Can a dog see in the dark? What is the color of the dog's eyes?

6. Study the ear of the dog; is it covered? Is this outer ear movable, is it a flap, or is it cornucopia-shaped? How is this flap used when the dog is listening? Roll a sheet of paper into a flaring tube and place the small end upon your own ear, and note if it helps you to hear better the sounds in the direction toward which the tube opens. Note how the hound lifts his long earlaps, so as to make a tube for conveying sounds to his inner ear. Do you think that dogs can hear well?

7. What is the position of the nose in the dog's face? Of what use is this? Describe the nostrils; are they placed on the foremost point of the face? What is the condition of the skin that surrounds them? How does this condition of the nose aid the dog? What other animals have it? Does the dog recognize his friends or become acquainted with strangers by means of his sight or of his powers of smelling?



Mr. and Mrs. J. W. Page

English setter. This breed originated in England from a cross between a field spaniel and a pointer

8. How long after a fox or rabbit has passed can a hound follow the track? Does

St. Bernard. This breed of huge dogs was developed by monks in the Swiss Alps to aid in the rescue of people lost in the mountains he follow it by sight or by smell? What are the conditions most favorable for retaining the scent? The most unfavorable? How long will a hound follow a fox trail without stopping for rest or food? Do you think the dog is your superior in ability to smell?

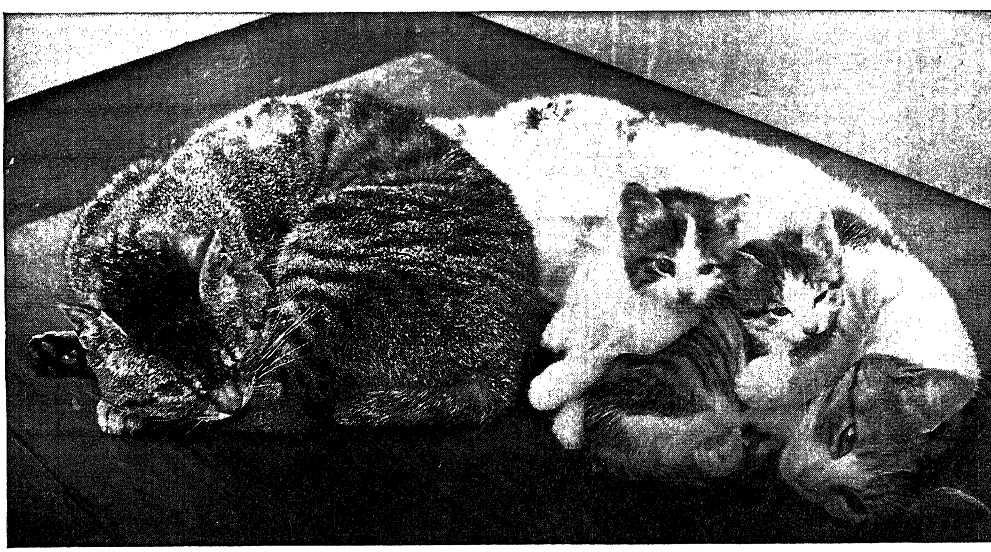
9. How does a dog seize and kill his prey? How does he use his feet and claws when fighting? What are his especially strong weapons? Describe a dog's teeth and explain the reason for the bare spaces on the jaw next to the tushes. Does the dog use his tushes when chewing? What teeth does he use when gnawing a bone? Make a diagram of the arrangement of the dog's teeth.

10. How by action, voice, and especially by the movement of the tail does the dog express the following emotions: delight, friendliness, affection, attention, anger, fear, shame, excitement? How does he act when chasing his prey? Why do wolves and dogs bark when following the trail? Do you think of a reason why dogs often howl at night or when listening to music? What should we feed to our pet dogs? What should we do to make them comfortable in other ways?

11. Tell or write a story of some dog of which you know by experience or hearsay. Of what use was the dog to the pioneer? How are dogs used in the Arctic regions? In Holland?

12. How many breeds of dogs do you know? Describe these breeds as follows: The length of the legs as compared with the body; the general shape of the body, head, ears, nose; color and character of hair on head, body, and tail.

13. Find if you can the reasons which have led to the developing of the following breeds: Newfoundland, St. Bernard, mastiffs, hounds, collies, spaniels, setters, pointers, bulldogs, terriers, and pugs.



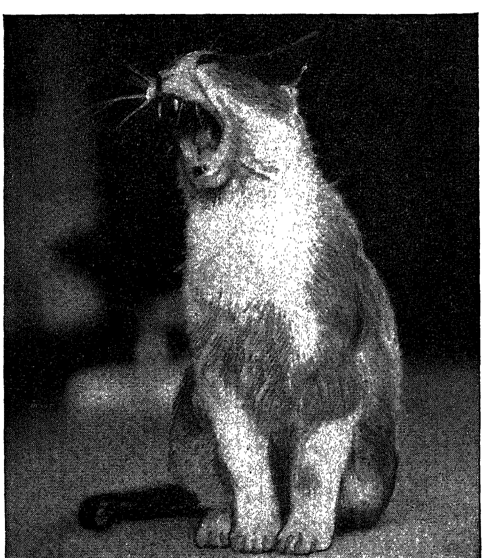
Verne Morton

A cat family

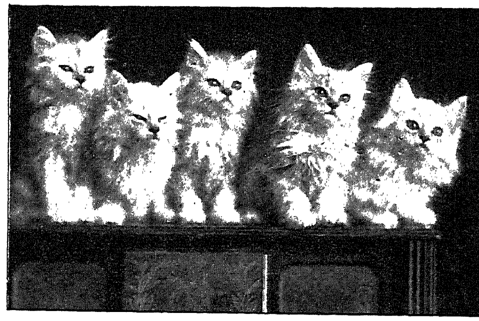
THE CAT

Of all people, the writer should regard the cat sympathetically, for when she was a baby of five months she was adopted by a cat. My self-elected foster-mother was Jenny, a handsome black and white cat, which at that time lost her first litter of kittens, through the attack of a savage cat from the woods. She was as Rachel crying for her children, when she seemed suddenly to comprehend that I, although larger than she, was an infant. She haunted my cradle, trying to give me milk from her own breasts; and later she brought half-killed mice and placed them enticingly in my cradle, coaxing me to play with them, a performance which pleased me much more than it did my real mother. Jenny always came to comfort me when I cried, rubbing against me, purring loudly, and licking me with her tongue in a way to drive mad the modern mother, wise as to the sources of children's internal parasites. This maternal attitude toward me lasted as long as Jenny lived, which was until I was nine years old. Never during those years did I lift my voice in wailing, that she did not come to comfort me; and even today I can remember how great that comfort was, especially when my naughtiness was the cause of my weeping, and when, therefore, I felt that the whole world, except Jenny, was against me.

Jenny was a cat of remarkable intelligence and was very obedient and useful. Coming down the kitchen stairs one day, she played with the latch, and someone who heard her opened the door. She did this several times, when one day she chanced to push down the latch, and thus



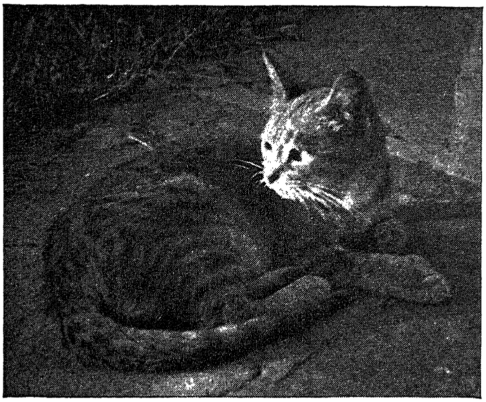
"*Folks are so tiresome!*"



Kittens

opened the door herself. After that, she always opened it herself. A little later, she tried the trick on other doors, and soon succeeded in opening all the latched doors in the house, by thrusting one front leg through the handle, and thus supporting her weight and pressing down with the foot of the other on the thumb-piece of the latch. I remember that guests were greatly astonished to see her coming thus swinging into the sitting room. Later she tried the latches from the other side, jumping up and trying to lift the hook; but now, her weight was thrown against the wrong side of the door for opening, and she soon ceased this futile waste of energy; but for several years, she let herself into all the rooms in this clever manner, and taught a few of her bright kittens to do the same.

A pet cat enjoys long conversations with favored members of the household. She will sit in front of her mistress and mew, with every appearance of answering the questions addressed her; and since the cat and the mistress each knows her own part of the conversation, it is perhaps more typical of society chatter than we might like to confess. Of our language, the cat learns to understand the call to food, its own name, "Scat," and "No, No," probably inferring the meaning of the latter from the tone of voice. On the other hand, we understand when it asks to go out, and its polite recognition to the one who opens the door. I knew one cat which invariably thanked us when we let him in as well as out. When the cat is hungry, it mews pleadingly; when happy in front of the



Marion E. Wesp

On the doorstep

fire, it looks at us sleepily out of half-closed eyes and gives a short mew expressive of affection and content; or it purrs, a noise which we do not know how to imitate and which expresses perfectly the happiness of intimate companionship. When frightened the cat yowls, and when hurt it squalls shrilly; when fighting, it is like a savage warrior in that it howls a war-song in blood-curdling strains, punctuated with a spitting expressive of fear and contempt; and unfortunately, its love song is scarcely less agonizing to the listener. The cat's whole body enters into the expression of its emotions. When feeling affectionate toward its mistress, it rubs against her gown, with tail erect, and vibrating with a purr which seems fundamental. When angry, it lays its ears back and lashes its tail back and forth, the latter being a sign of excitement; when frightened, its hair stands on end, especially the hair of the tail, making that expressive appendage twice its natural size; when caught in disobedience, the cat lets its tail droop, and when running lifts it in a curve.

While we feed cats milk and scraps from our own table, they have never become entirely civilized in their tastes. They always catch mice and other small animals and prove pestiferous in destroying birds. Jenny was wont to bring her quarry, as an offering, to the front steps of our home every night; one morning we found seven mice, a cotton-tail rabbit and two snakes, which represented her night's catch. The cat never chases its prey like the dog. It discovers the haunts of its victims and then lies in ambush, flattened out as still as a statue and all its feet beneath it, ready to make the spring. The weight of the body is a factor which enters into the blow with which the cat strikes down and stuns its victim, which it later kills by gripping the throat with the strong tushes. It carries its victims as it does its kittens, by the back.

The cat's legs are not long compared with the body, and it runs with a leaping gallop; the upper legs are armed with powerful muscles. It walks on the padded toes, five on the front feet and four on the hind feet. The cat needs its claws to be sharp and hooked, in order to seize and hold its prey, so they are kept safely sheathed when not thus used. If the claws struck the earth during walking, as do the dog's, they would soon become dulled. When sharpening its claws it reaches high up against a tree or post, and strikes them into the wood with a downward scratch; this act is probably more for exercising the muscles which control the claws than for sharpening them.

John W. Decker

Anticipation

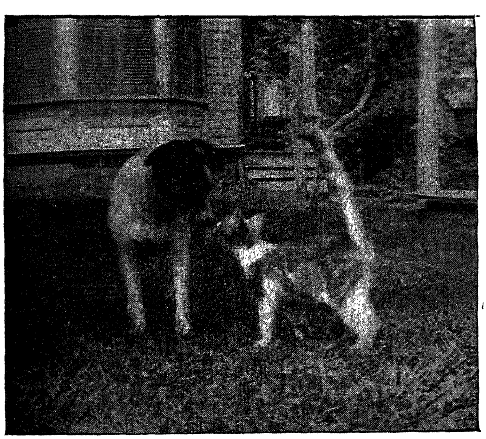
The cat's track is in a single line as if it had only two feet, one set directly ahead of the other. It accomplishes this by setting its hind feet exactly in the tracks made by the front feet. The cat can easily leap upward, landing on a window-sill five feet from the ground. The jump is made with the hind legs and the alighting is done silently on the front feet.

Cats' eyes are adapted better than ours for seeing in the dim light; in the daytime the pupil is simply a narrow, up and down slit; under excitement, and at night, the pupil covers almost the entire eye. At the back of the eye is a reflecting surface, which catches such light as there is, and by reflecting it enables the cat to use it twice. It is this reflected light which gives the peculiar green glare to the eyes of all the cats when seen in the dark. Some night-flying moths have a like arrangement for utilizing the light, and their eyes glow like living coals. Of course, since the cat is a night hunter, this power of multiplying the rays of light is of great use. The iris of the eye is usually yellow, but in kittens it may be blue or green.

The cat's teeth are peculiarly fitted for its needs. The six doll-like incisors of the upper and lower jaw are merely for scraping meat from bones. The two great tushes, or canines, on each jaw, with a bare place behind so that they pass each other freely, are sharp, and are for seizing and carrying prey. The cat is able to open its mouth as wide as a right angle, in order

Marion E. Wesp

An aristocrat



Amicable advances

better to hold and carry prey. The back teeth, or molars, are four on each side in the upper jaw and three below. They are sharp-edged wedges made for cutting meat fine enough so that it may be swallowed.

The tongue is covered with sharp papillæ directed backwards, also used for rasping juices from meat. The cat's nose is moist, and her sense of smell very keen, as is also her sense of hearing. The ears rise like two hollow half-cones on either side of the head and are filled with sensitive hairs; they ordinarily open forward, but are capable of movement. The cat's whiskers consist of from twenty-five to thirty long hairs set in four lines, above and at the sides of the mouth; they are connected with sensitive nerves and are therefore true feelers. The cat's fur is very fine and thick, and is also sensitive, as can readily be proved, by trying to stroke it the wrong way. While the wild cats have gray or tawny fur, variously mottled or shaded, the more striking colors we see in the domestic cats are the result of man's breeding.

Cats are very cleanly in their habits. Puss always washes her face directly after eating, using one paw for a washcloth and licking it clean after she rubs her face.

She cleans her fur with her rough tongue and also by biting; and she promptly buries objectionable matter. The mother cat is very attentive to the cleanliness of her kittens, licking them clean from nose tip to tail tip. The ways of the mother cat with her kittens do much to sustain the assertions of Mr. Seton and Mr. Long that young animals are trained and educated by their parents. The cat brings half-dazed mice to her kittens, that they may learn to follow and catch them with their own

This cat has been trained to be friendly with birds

little claws. When she punishes them, she cuffs the ears by holding one side of the kitten's head firm with the claws of one foot, while she lays on the blows with the other. She carries her kittens by the nape of the neck, never hurting them. She takes them into the field when they are old enough, and shows them the haunts of mice, and does many things for their education and welfare. The kittens meantime train themselves to agility and dexterity, by playing rough and tumble with each other, and by chasing every small moving object, even to their own tails.

The cat loves warmth and finds her place beneath the stove or at the hearthside. She likes some people, and dislikes others, for no reason we can detect. She can be educated to be friendly with dogs and with birds. In feeding her, we should give her plenty of sweet milk, some cooked meat, and fish, of which she is very fond; and we should keep a bundle of catnip to make her happy, for even the larger cats of the wilderness seem to have a passionate liking for this herb. The cat laps milk with her rough tongue, and when eating meat, she turns the head this way and that, to cut the tough muscle with her back teeth.

Cats Should Be Trained to Leave Birds Alone

Every owner of a cat owes it to the world to train Puss to leave birds alone. If this training is begun during kittenhood, by switching the culprit every time it even looks at a bird, it will soon learn to leave them severely alone. I have tried this many times, and I know it is efficacious, if the cat is intelligent. We have never had a cat whose early training we controlled, that could ever be induced even to watch birds. If a cat is not thus trained as a kitten, it is likely to be always treacherous in this respect. But in case any one has a valuable cat which is given to catching birds, I strongly advise the following treatment which has been proved practicable by a friend of mine. When a cat has made the catch, take the bird away and sprinkle it with red pepper, and then give it back. One such treatment as this resulted in making one cat, which was an inveterate bird hunter, run and hide every time he saw a bird thereafter. Any persons taking cats with them to their summer homes, and abandoning them there to prey upon the birds of the vicinity, and to become poor, half-starved, wild creatures, ought to be arrested and fined. It is not only cruelty to the cats, but it is positive injury and damage to the community, because of the slaughter of many beneficial and beautiful birds which it entails.

Suggested Reading — *Animal Heroes*, by Ernest Thompson Seton; *Baby Animals on the Farm*, by Kate E. Agnew and Margaret Coble; *The Blot: Little City Cat*, by Phyllis Crawford; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals; The Pet Book*, by Anna B. Comstock; also, readings on page 214.

LESSON 64
The Cat

Leading Thought — The cat was made a domestic animal before man wrote histories. It gets prey by springing from ambush and is fitted by form of body and teeth to do this. It naturally hunts at night and has eyes fitted to see in the dark.

Method — This lesson may be used in primary grades by asking a few questions at a time and allowing the children to make their observations on their own kittens at home, or a kitten may be brought to school for this purpose. The upper grade work consists of reading and retelling or writing exciting stories of the great, wild, savage cats, like the tiger, lion, leopard, lynx, and panther.

Observations — 1. How much of Pussy's language do you understand? What does she say when she wishes you to open the door for her? How does she ask for something to eat? What does she say when she feels like conversing with you? How does she cry when hurt? When frightened? What noise does she make when fighting? When calling other cats? What are her feelings when she purrs? When she spits? How many things which you say does she understand?

2. How else than by voice does she express affection, pleasure, and anger? When she carries her tail straight up in the air is she in a pleasant mood? When her tail "bristles up" how does she feel? What is it a sign of, when she lashes her tail back and forth?

3. What do you feed to cats? What do they catch for themselves? What do the cats that are wild live upon? How does the cat help us? How does she injure us?

4. How does a cat catch her prey? Does she track mice by the scent? Does she catch them by running after them as a dog does? Describe how she lies in ambush. How does she hold the mouse as she pounces upon it? How does she carry it home to her kittens?

5. Study the cat's paws to see how she holds her prey. Where are the sharp claws? Are they always in sight like a dog's? Does she touch them to the ground when she walks? Which walks more silently, a dog or a cat? Why? Describe the cat's foot, including the toe-pads. Are there as many toes on the hind feet as on the front feet? What kind of track does the cat make in the snow? How does she set her feet to make such a track? How does she sharpen her claws? How does she use her claws for climbing? How far have you ever seen a cat jump? Does she use her front or her hind feet in making the jump? On which feet does she alight? Does she make much noise when she alights?

6. What is there peculiar about a cat's eyes? What is their color? What is the color of kittens' eyes? What is the shape of the pupil in daylight? In the dark? Describe the inner lid which comes from the corner of the eye.

7. How many teeth has Puss? What is the use of the long tushes? Why is there a bare space behind these? What does she use her little front teeth for? Does she use her back teeth for chewing or for cutting meat?

8. How many whiskers has she? How long are they? What is their use? Do you think Puss has a keen sense of smell? Why do you think so? Do you think she has a keen sense of hearing? How do the shape and position of the ears help in listening? In what position are the ears when Puss is angry?

9. How many colors do you find in our domestic cats? What is the color of wild cats? Why would it not be beneficial to the wild cat to have as striking colors as our tame cats? Compare the fur of the cat with the hair of the dog. How do they differ? If a cat chased her prey like the dog do you think her fur would be too warm a covering?

10. Describe how the cat washes her face. How does she clean her fur? How does her rough tongue help in this? How does the mother cat wash her kittens?

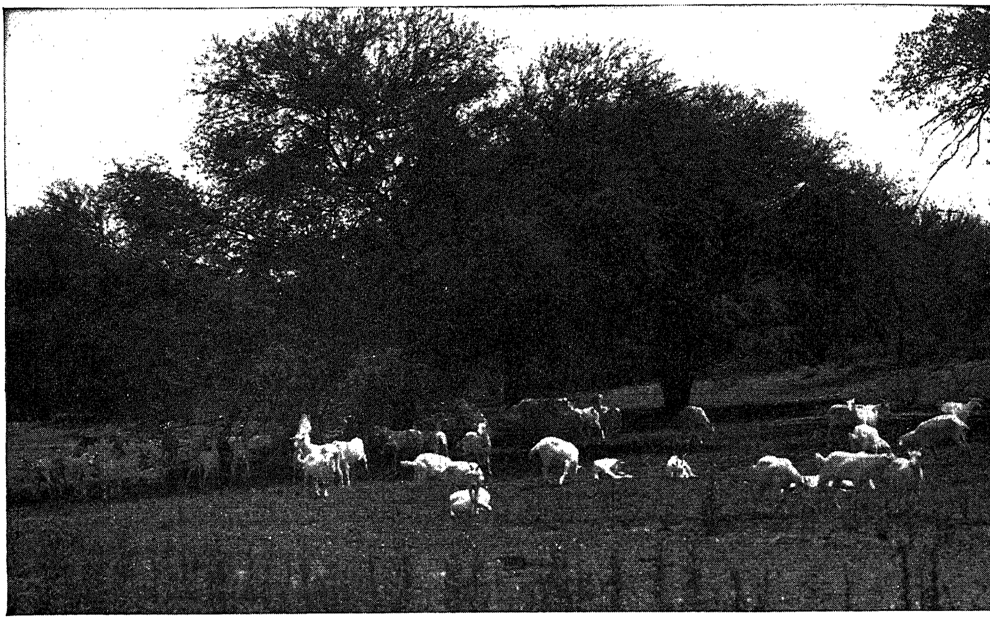
11. How does a little kitten look when a day or two old? How long before its eyes open? How does the cat carry her kittens? How does a kitten act when it is being carried? How does the mother

cat punish her kittens? How does she teach them to catch mice? How do kittens play? How does the exercise they get in playing fit them to become hunters?

12. How should cats be trained not to touch birds? When must this training begin? Why should a person be punished for injury to the public who takes cats to summer cottages and leaves them there to run wild?

13. Where in the room does Puss best like to lie? How does she sun herself? What herb does she like best? Does she like some people and not others? What strange companions have you known a cat to have? What is the cat's chief enemy? How should we care for and make her comfortable?

14. Write or tell stories on the following subjects: (1) The Things Which My Pet Cat Does; (2) The Wild Cat; (3) The Lion; (4) The Tiger; (5) The Leopard; (6) The Panther and the Mountain Lion; (7) The Lynx; (8) The History of Domestic Cats; (9) The Different Races of Cats, describing the Manx, the Persian, and the Angora Cats.



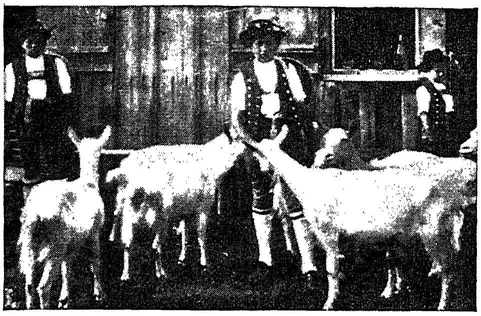
A. A. Wright

A herd of goats by the Nueces River, Texas

THE GOAT

Little do we in America realize the close companionship that has existed in older countries, from time immemorial, between goats and people. This association began when man was a nomad, and took with him in his wanderings his flocks, of which goats formed the larger part. He then drank their milk, ate their flesh, wove their hair into raiment, or made cloth of their pelts, and used their skins for water bags. Among peoples of the East all these uses continue to the present day. In the streets of Cairo, old Arabs may be seen with goatskins filled with water upon their backs; and in any city of western Asia or southern Europe, flocks of goats are driven along the streets to be milked in sight of the consumer.

In order to understand the goat's peculiarities of form and habit, we should consider it as a wild animal, living upon the mountain heights amid rocks and snow and scant vegetation. It is marvelously sure-footed, and on its native mountains it can climb the sharpest crags and leap chasms. This peculiarity has been seized upon by showmen who often exhibit goats which walk on the tight rope with ease, and even turn themselves upon it without falling. The instinct for climbing still lingers in the domestic breeds, and in the country the goat may be seen on top of stone piles or other objects, while, in city suburbs, its form may be discerned on the roofs of shanties and other low buildings.

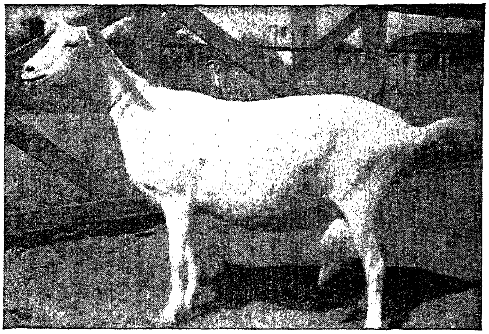


U. S. Dept. Agriculture

Saanen goats in Switzerland

It is a common saying that a goat will eat anything, and much sport is made of this peculiarity. This fact has more meaning for us when we realize that wild goats live in high altitudes, where there is little plant life, and are, therefore, obliged to find sustenance on lichens, moss, and such scant vegetation as they can find.

The goat is closely allied to the sheep, differing from it in only a few particulars; its horns rise from the forehead curving over backward and do not form a spiral like those of the ram; its covering is usually of hair, and the male has a beard from which we get the name goatee; the goat has no gland between the toes, and it does have a rank and disagreeable odor. In a wild state, it usually lives a little higher up the mountains than do the sheep, and it is a far more intelligent animal. Mary Austin says: "Goats lead naturally by reason of a quicker instinct, forage more freely and can find water on their own account, and give voice in case of alarm.



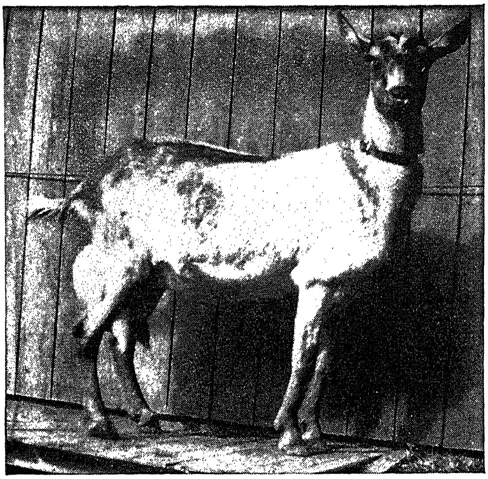
Saanen doe

Goat leaders exhibit jealousy of their rights to be first over the stepping-stones or to walk the teetering log bridges at the roaring creeks." On the great plains, it is a common usage to place a few goats in a flock of sheep, because of the greater sagacity of these animals as leaders, and also as defenders in case of attack.

Goats' teeth are arranged for cropping herbage and especially for browsing. There are six molar teeth on each side of each jaw; there are eight lower incisors and none above. The goat's sense of smell is very acute; the ears are movable and the sense of hearing is keen; the eyes are full and very intelligent; the horns are somewhat flattened and angular, are often knobbed somewhat in front, and curve backward above the neck; they are, however, very efficient as weapons of defense. The legs are strong, though not large, and are well fitted for leaping and running.

N. Y. Agr. Exp. Station, Geneva

Toggenburg goat. This Swiss breed, developed by a careful selection of animals for many years, has attained a very definite standard of size, color, and conformation



N. Y. Agr. Exp. Station, Geneva

French alpine doe. Alpines are sturdy, and have been bred for high production of fine-flavored milk

The feet have two hoofs, that is, the animal walks upon two toenails. There are two smaller toes behind and above the hoofs. The goat can run with great rapidity. The tail of the goat is short like that of the deer, and does not need to be amputated like that of the sheep. Although the normal covering of the goat is hair, there are some species which have a more or less woolly coat. When angry the goat shakes its head, and defends itself by butting with the head, also by striking with the horns, which are very sharp. Goats are very tractable and make affectionate pets when treated with kindness; they display far more affection for their owner than do sheep.

Our famous Rocky Mountain goat, although it belongs rather to the antelope family, is a large animal, and is the special prize of the hunter; however, it still holds its own in the high mountains of the Rocky and Cascade Ranges. Both sexes have slender black horns, white hair, and black feet, eyes, and nose. Owen Wister says of this animal: "He is white, all white, and shaggy, and twice as large as any goat you ever saw. His white hair hangs long all over him like a Spitz dog's or an Angora cat's; and against its shaggy white mass the blackness of his hoofs and horns, and nose looks particularly black. His legs are thick, his neck is thick, everything about him is thick, save only his thin black horns. They're generally about six (often more than nine) inches long, they spread very slightly, and they curve slightly backward. At their base they are a little rough, but as they rise they become cylindrically smooth and taper to an ugly point. His hoofs are heavy, broad and blunt. The female is lighter than the male, and with horns more slender, a trifle. And (to return to the question of diet) we visited the pasture where the herd (of thirty-five) had been, and found no signs of grass growing or grass eaten; there was no grass on that mountain. The only edible substance was a moss, tufted, stiff and dry to the touch. I also learned that the goat is safe from predatory animals. With his impenetrable hide and his disemboweling horns he is left by the wolves and mountain lions respectfully alone."

Milch Goats — Many breeds of these have been developed, and the highest type is, perhaps, found in Switzerland. The Swiss farmers have found the goat particularly adapted to their high mountains and have used it extensively; thus, goats developed in the Saane and Toggenburg valleys have a world-wide reputation. Above these valleys the high mountains are covered with perpetual snow, and winter sets in about November 1, lasting until the last of May. The goats are kept with the cows in barns and fed upon hay; but as soon as the snow is gone from the valleys and the lower foothills, the cattle and goats are sent with the herders and boy assistants to the grazing grounds. A bell is put upon the cow that leads the herd so as to keep it together and the boys, in their gay peasant dresses, are as happy as the playful calves and goats to get out in the spring sunshine. The herds follow the receding snows up the mountains until about midsummer, when they reach the high places of scanty vegetation; then they start on the downward journey, returning to the home and stables about November 1. The milk from goats is mixed with that from cows to make cheese, and this cheese has a wide reputation; some of the varieties are Roquefort, Schweitzer, and Altenburger. Although the cheese is excellent, the butter made from goat's milk is inferior to that made from the cow's. The milk, when the animals are well taken care of, is exceedingly nourishing; it is thought to be the best milk in the world for children. Usually, the trouble with goat's milk is that the animals are not kept clean, nor is care taken in milking. Germany has produced many distinct and excellent breeds of milch goats; the Island of Malta, Spain, England, Ireland, Egypt, and Nubia have each developed noted breeds. Of all these, the Nubias give the most milk, sometimes yielding from four to six quarts a day, while an ordinary goat is considered fairly good if it yields two quarts a day.

THE MOHAIR GOATS — There are two noted breeds of goats whose hair is used extensively for weaving into fabrics; one of these is the Cashmere and the other the Angora. The Cashmere goat has long, straight, silky hair for an outside coat and has a winter undercoat of very delicate wool. There are not more than two or three ounces of this wool upon one goat, and this is made into the famous Cashmere shawls; ten goats furnish barely enough of this wool for one shawl. The Cashmere goats are grown most largely in Tibet, and the wool is shipped from the high tableland to the Valley of Cashmere, where it is made into shawls. It requires the work of several people for a year to produce one of these famous shawls.

The Angora goat has a long, silky, and very curly fleece. These goats were first discovered in Angora, a city of Asia Minor south of the Black Sea, and some 200 miles southeast from Constantinople. The Angora goat is a beautiful and delicate animal, and furnishes most of the mohair which is made into the cloths known as mohair, alpaca, camel's hair, and many other fabrics. The Angora goat has been introduced into America, in California, Texas, Arizona, and to some extent in the Middle West. It promises to be a very profitable industry. (See Farmers' Bulletin *The Angora Goat*, United States Department of Agriculture.)

The skins of goats are used extensively; morocco, gloves, and many other articles are made from them. In the Orient, the skin of the goat is used as a bag in which to carry water and wine.

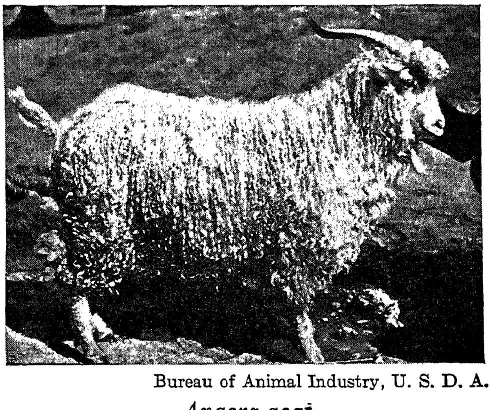
SUGGESTED READING — *Farm Animals*, by James G. Lawson; *Mountain Neighbors*, by Edith M. Patch and Carroll L. Fenton; *The Pet Book*, by Anna B. Comstock; also, some of the readings on page 214.

LESSON 65

THE GOAT

LEADING THOUGHT — Goats are among our most interesting domesticated animals, and their history is closely interwoven with the history of the development of civilization. In Europe, their milk is made into cheese that has a world-wide fame; and from the hair of some of the species, beautiful fabrics are woven. The goat is naturally an animal of the high mountains.

METHOD — A span of goats harnessed to a cart is second only to ponies, in a child's estimation; therefore, the beginning of this lesson may well be a span of goats thus employed. The lesson should not be given unless the pupils have an opportunity for making direct observations on the animal's appearance and habits. There should be some oral and written work in English done with this lesson.



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Angora goat

Following are topics for such work: "The Milch Goat of Switzerland," "How Cashmere Shawls Are Made," "The Angora Goat," "The Chamois."

OBSERVATIONS — 1. Do you think that goats like to climb to high points? Are they fitted to climb steep, inaccessible places? Can they jump off steep places in safety? How does it happen that the goat is sure-footed? How do its legs and feet compare with those of the sheep?

2. What does the goat eat? Where does it find its natural food on mountains? How are the teeth arranged for cutting its food? Does a goat chew its cud like a cow?

3. What is the covering of the goat? Describe a billy goat's beard. Do you suppose this is for ornament? For what is goat's hair used?

4. Do you think the goat has a keen sense of sight, of hearing, and of smell? Why? Why did it need to be alert and keen when it lived wild upon the mountains? Do you think the goat is intelligent? Give instances of this.

5. Describe the horns. Do they differ from the horns of the sheep? How does a goat fight? Does he strike head on, like the sheep, or sidewise? How does he show anger?

6. What noises does a goat make? Do you understand what they mean?

7. Describe the goat, its looks and actions. Is the goat's tail short at first or does it have to be cut off like the lamb's tail? Where and how is goat's milk used? What kinds of cheese are made from it? For what is its skin used? Is its flesh ever eaten?

Everyone knows the gayety of young kids, which prompts them to cut the most amusing and burlesque capers. The goat is naturally capricious and inquisitive, and one might say crazy for every species of adventure. It positively delights in perilous ascensions. At times it will rear and threaten you with its head and horns, apparently with the worst intentions, whereas it is usually an invitation to play. The bucks, however, fight violently with each other; they seem to have no consciousness of the most terrible blows. The ewes themselves are not exempt from this vice.

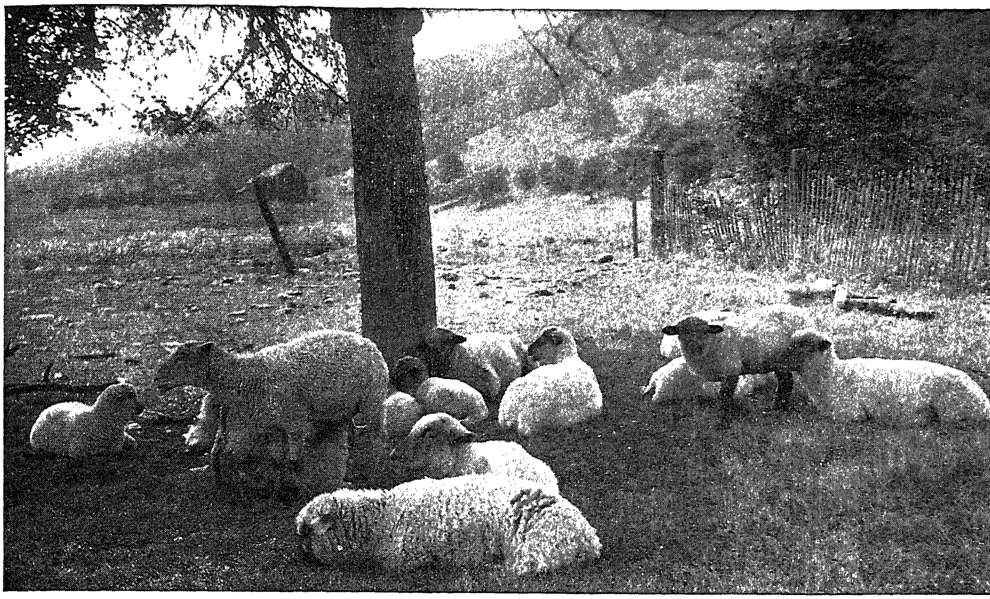
They know very well whether or not they have deserved punishment. Drive them out of the garden, where they are forbidden to go, with a whip and they will flee without uttering a sound; but strike them without just cause and they will send forth lamentable cries.

— "OUR DOMESTIC ANIMALS,"
CHARLES WILLIAM BURKETT

THE SHEEP

The earliest important achievement of ovine intelligence is to know whether its own notion or another's is most worth while, and if the other's, which one? Individual sheep have certain qualities, instincts, competences, but in the man-herded flocks these are superseded by something which I shall call the flock mind, though I cannot say very well what it is, except that it is less than the sum of all their intelligences. This is why there have never been any notable changes in the management of flocks since the first herder girt himself with a wallet of sheep-skin and went out of his cave-dwelling to the pastures. — "THE FLOCK," MARY AUSTIN

Both sheep and goats are at home on mountains, and sheep especially thrive best in cool, dry locations. As wild animals, they were creatures of the mountain crag and chasm, although they frequented more open places than the mountain goats, and their wool was developed to protect them from the bitter cold of high altitudes. They naturally gathered in flocks, and sentinels were set to give warning of the approach of danger; as soon as the signal came, they made their escape,



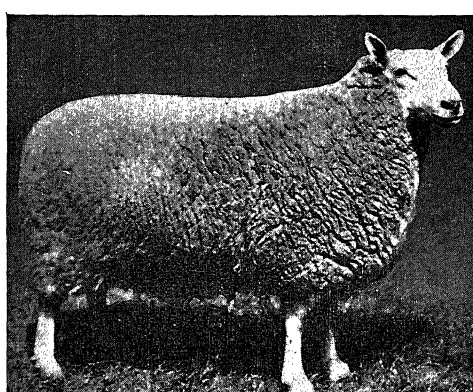
Verne Morton

Sheep at rest

not in the straight away race like the deer, but in following the leader over rock, ledge, and precipice to mountain fastnesses where neither wolf nor bear could follow. Thus, the instinct of following the leader blindly came to be the salvation of the individual sheep.

The teeth of the sheep are like those of the goat, eight incisors below and none on the upper row, and six grinding teeth at the back of each side of each jaw. This arrangement of teeth on the small, delicate, pointed jaws enables the sheep to crop herbage where cattle would starve; it can cut the small grass off at its roots, and for this reason, where vast herds of sheep range, they leave a desert behind them. This fact brought about a bitter feud between the cattle and sheep men in the far West. In forests, flocks of sheep completely kill all underbrush, and now they are not permitted to run in government reserves.

The sheep's legs are short and delicate below the ankle. The upper portion is greatly developed to help the animal in leaping, a peculiarity to which we owe the " leg of lamb " as a table delicacy. The hoof is cloven, that is, the sheep walks upon two toes; it has two smaller toes above and behind these. There is a little gland between the front toes that secretes an oily substance, which perhaps serves in preventing the hoof from becoming too dry. The ears are large and are moved to catch better the direction of sound. The eyes are peculiar; in the sunlight the pupil is a mere slit, while the iris is yellow or brownish, but in the dark, even of the stable, the pupils enlarge, almost covering the eye. The ewes either lack horns or have small ones, but the



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Cheviot sheep

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Ewe with her lamb

horns of wild rams are large, placed at the side of the head and curled outward in a spiral. These horns are perhaps not so much for fighting the enemy as rival rams. The ram can strike a hard blow with head or horns, coming at the foe head on, while the goat always strikes sidewise. So fierce is the blow of the angry sheep that an ancient instrument of war, fashioned like a ram's head and used to knock down walls, was called a battering ram. A sheep shows anger by stamping the ground with the front feet. The habit of rumination enables the sheep to feed in a flock and then retire to some place to rest and chew the cud, a performance peculiarly amusing in the sheep.

Sheep under attack and danger are silent; ordinarily they keep up a constant, gentle bleating to keep each other informed of their whereabouts; they also give a peculiar call when water is discovered, and another to inform the flock that there is a stranger in the midst; they also give a peculiar bleat, when a snake or other enemy which they conquer is observed. Their sense of smell is very acute.

Lambs quickly become true members of the herd. Mary Austin says, "Young lambs are principally legs, the connecting body being simply a contrivance for converting milk into more leg, so you understand how it is that they will follow the flock in two days and are able to take the trail in a fortnight, traveling four and five miles a day, falling asleep on their feet and tottering forward in the way." The older lambs have games which they play untiringly, and which fit them to become active members of the flock; one is the regular game of "Follow My Leader," each lamb striving to push ahead and attain the place of leader. In playing this the head lamb leads the chase over most difficult places, such as logs, stones, and brooks; thus is a training begun which later in life may save the flock. The other game is peculiar to stony pastures; a lamb climbs to the top of a boulder and its comrades gather around and try to butt it off; the one which succeeds in doing this climbs the rock and is "it." This game leads to agility and sure-footedness. A lamb's tail is long and is most expressive of lambkin bliss, when feeding time comes; but, alas! it has to be cut off so that later it will not become matted with burrs and filth. In southern Russia there is a breed of sheep with large, flat, fat tails which are esteemed as a great table delicacy. This tail becomes so cumbersome that wheels are placed beneath it, so that it trundles along behind its owner.

In the Rocky Mountains we have a noble species of wild sheep which is likely

Mutual contentment

to become extinct soon. The different breeds of domesticated sheep are supposed to have been derived from different wild species. Of the domesticated varieties, we have the Merinos, which originated in Spain and which give beautiful, long, fine wool for our fabrics; but their flesh is not very attractive. The Merinos have wool on their faces and legs and have wrinkled skins. The English breeds of sheep have been especially developed for mutton, although their wool is valuable. Some of these like the Southdown, Shropshire, and Dorset, give a medium length

Verne Morton

Rams in pasture

of wool, while the Cotswold has very long wool, the ewes having long strings of wool over their eyes in the fashion of "bangs."

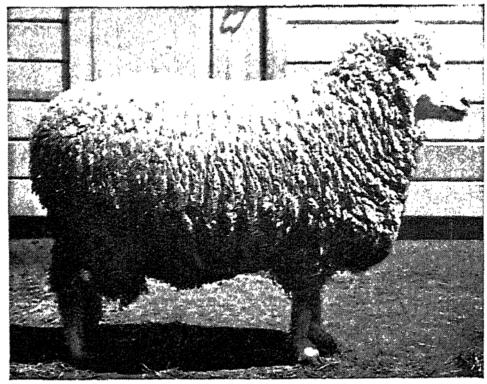
The dog is the ancient enemy of sheep; and even now, after hundreds of years of domestication, some of our dogs will revert to savagery and chase and kill sheep. This, in fact, has been one of the great drawbacks to sheep-raising in the eastern United States. The collie, or sheep dog, has been bred so many years as the special caretaker of sheep, that a beautiful relationship has been established between these dogs and their flocks.

SUGGESTED READING — *Baby Animals on the Farm*, by Kate E. Agnew and Margaret Coble; *Farm Animals*, by James G. Lawson; *Lives of the Hunted*, by Ernest Thompson Seton; *The Pet Book*, by Anna B. Comstock; also, some of the readings on page 214.

LESSON 66

THE SHEEP

LEADING THOUGHT — Sheep live naturally in high altitudes. When attacked by



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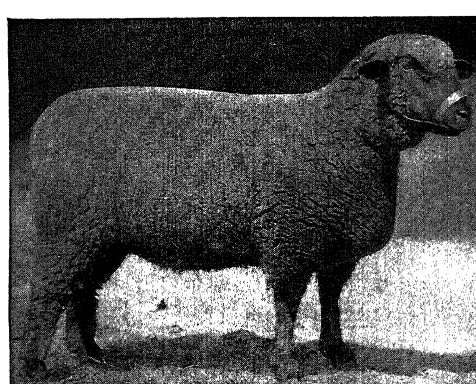
Corriedale ram

enemies, they follow their leader over difficult and dangerous mountain places.

METHOD — The questions of this lesson should be given to the pupils and the observations should be made upon the sheep in pasture or stable. Much written work may be done in connection with this lesson. The following topics are suggested for themes: "The Methods by Which Wool Is Made into Cloth," "The Rocky Mountain Sheep," "The Sheep-herders of California and Their Flocks," "The True Story of a Cosset Lamb."

OBSERVATIONS — 1. What is the chief characteristic that separates sheep from other animals? What is the difference between wool and hair? Why is wool of special use to sheep in their native haunts? Is there any hair on sheep?

2. Where do the wild sheep live? What



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Hampshire ewe

is the climate in these places? Does wool serve them well on this account? What sort of pasturage do sheep find on mountains? Could cows live where sheep thrive? Describe the sheep's teeth and how they are arranged to enable it to crop vegetation closely. What happens to the vegetation on the range when a great flock of sheep passes over it? Why are sheep not allowed in our forest preserves?

3. What are the chief enemies of sheep in the wilderness? How do the sheep escape them? Describe the foot and leg of the sheep and explain how they help the animal to escape its enemies. We say of certain men that they "follow like a flock of sheep." Why do we make this comparison? What has this habit of following the leader to do with the escape of sheep from wolves and bears?

4. How do sheep fight? Do both rams and ewes have horns? Do they both fight? How does the sheep show anger? Give your experience with a cross cosset lamb.

5. Do you think that sheep can see and hear well? What is the position of the sheep's ears when it is peaceful? When there is danger? How do the sheep's eyes differ from those of the cow?

6. Does the sheep chew its cud like the cow? Describe the action as performed by the sheep. How is this habit of cud chewing of use to the wild sheep?

7. Describe a young lamb. Why has it such long legs? How does it use its tail to express joy? What happens to this tail later? What games have you seen lambs play? Tell all the stories of lambs that you know.

8. How much of sheep language do you understand? What is the use to the wild flock of the constant bleating?

9. For what purposes do we keep sheep? How many breeds of sheep do you know? What are the chief differences between the English breeds and the Merinos? Where and for what purposes is the milk of sheep used?

10. Have you ever seen a collie looking after a herd of sheep? If so, describe his actions. Did you ever know of dogs killing sheep? At what time of day or night was this done? Did you ever know of one dog attacking a flock of sheep alone?

THE HORSE

There was once a little animal no bigger than a fox,
And on five toes he scrambled over Tertiary rocks.
They called him Eohippus, and they called him very small,
And they thought him of no value when they thought of him at all.

Said the little Eohippus, I am going to be a horse!
And on my middle finger nails to run my earthly course!
I am going to have a flowing tail! I am going to have a mane!
And I am going to stand fourteen hands high on the Psychozooic plain!

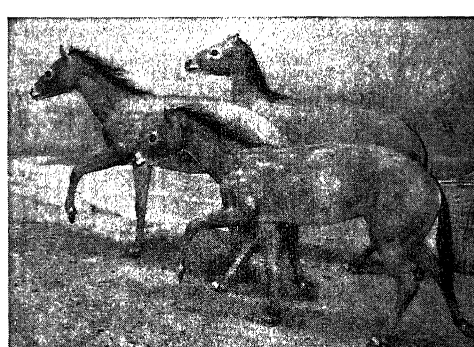
— Mrs. Stetson

It was some millions of years ago that Eohippus lived out in the Rocky Mountain Range; its forefeet had four toes and the splint of the fifth; the hind feet had three toes and the splint of the fourth. Eohippus was followed down the geologic ages by the Orohippus and the Mesohippus and various other hippuses, which showed in each age a successive enlargement and specialization of the middle toe and the minimizing and final loss of the others. This first little horse with many toes lived when the earth was a damp, warm place and when animals needed toes to spread out to prevent them from miring in the mud. But as the ages went on, the earth grew colder and drier, and a long leg ending in a single hoof was very serv-

Marion E. Wesp

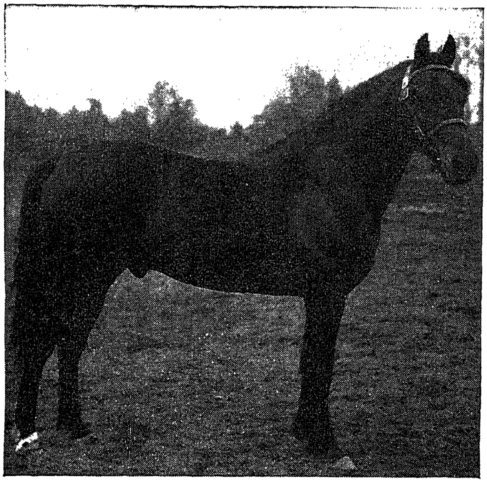
Mares and colts in shady pasture

iceable in running swiftly over the dry plains. According to the story read in the fossils of the rocks, our little American horses migrated to South America, and also trotted dry-shod over to Asia in the Mid-pliocene age, arriving there sufficiently early to become the companion of prehistoric man. In the meantime, horses were first hunted by savage man for their flesh, but were later ridden. At present, there are wild horses in herds on the plains of Tartary; and there are still sporadic herds of mustangs on the great plains of our own country, although for the most part they are branded and belong to someone, even though they live like wild horses; these American wild horses are supposed to be descendants of those brought over centuries ago by the Spaniards. The Shetland ponies are also wild in the islands north of Scotland, and the zebras, the most truly wild of all, roam the plains of Africa. In a state of wildness, there is always a stallion at the head of a herd of mares, and he has to win his position and keep it by superior strength and prowess. Fights between stallions are terrible to witness, and often result in the death of one of the participants. The horse is well armed for battle; his powerful teeth can inflict deep wounds and he can kick and strike hard with the front feet; still more efficient is the kick made with both hind feet while the weight of the body is borne on the front feet, and the head of the horse is turned so as to aim well the terrible blow. There are no wild beasts of prey which will not slink away to avoid a herd of horses. After attaining their growth in the herd with their mothers, the young males are forced by the leader to leave and go off by themselves; in turn, they must by their own strength and attractions win their following of mares. However, there are times and places where many of these herds join, making large bands wandering together.



Field Museum of Natural History

Ancestors of the horse — a restoration



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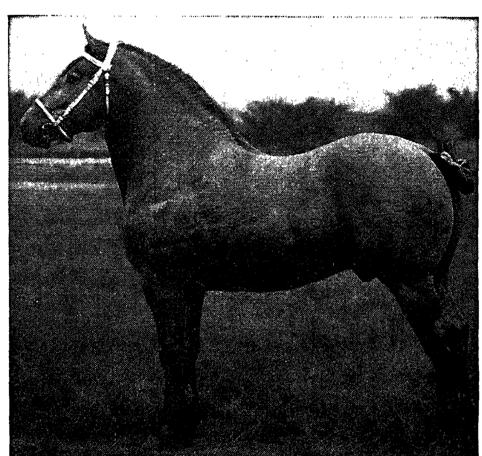
Morgan horse

The length of the horse's leg was evidently evolved to meet the need for flight before fierce and swift enemies, on the great ancient plains. The one toe, with its strong, sharp hoof, makes a fit foot for such a long leg, since it strikes the ground with little waste of energy and is sharp enough not to slip, but it is not a good foot for marshy places; a horse will mire where a cow can pass in safety. The development of the middle toe into a hoof results in lifting the heel and wrist far up the leg, making them appear to be the knee and elbow, when compared with the human body.

The length of neck and head are necessary in order than an animal with such length of leg as the horse may be able to graze. The head of the horse tells much of its disposition; a perfect head should be not too large; it should be broad between the eyes and high between the ears, while below the eyes it should be narrow. The ears, if lopped or turned back, denote a treacherous disposition; they should point upward or forward. If the ears are laid back it is a sign that the horse is angry; sensitive, quick-moving ears indicate a high-strung, sensitive animal. The eyes are placed so that the horse can see in front, at the side, and behind, the last being necessary in order to aim a kick. Hazel eyes are usually preferred to dark ones, and they should be bright and prominent. The nostrils should be thin-skinned, wide-flaring, and sensitive; in the wild stage, scent was one of the horse's chief aids in detecting the enemy. The lips should not be too thick and the lower jaw should be narrow where it joins the head.

The horse's teeth are peculiar; there are six incisors on each jaw; behind them is a bare space called the bar, of which we have made use for placing the bit. Back of the bar, there are six molars or grinders on each side of each jaw. At the age of about three years, canine teeth or tushes appear behind the incisors; these are more noticeable in males, and never seem to be of much use. Thus, the horse has on each jaw, when full-grown, six incisors, two canines, and twelve molars, making forty teeth in all. The incisors are prominent and enable the horse to bite the grass more closely than can the cow. The horse when chewing does not have the sidewise motion of the jaws peculiar to the cow and sheep.

The horse's coat is, when rightly cared for, glossy and beautiful; but if the horse is allowed to run out in the pasture all winter, the coat becomes very shaggy, thus reverting to the condition of wild horses which stand in need of a warmer coat for winter; the hair is shed every year. The mane and the forelock are useful in protecting the head and neck from flies; the



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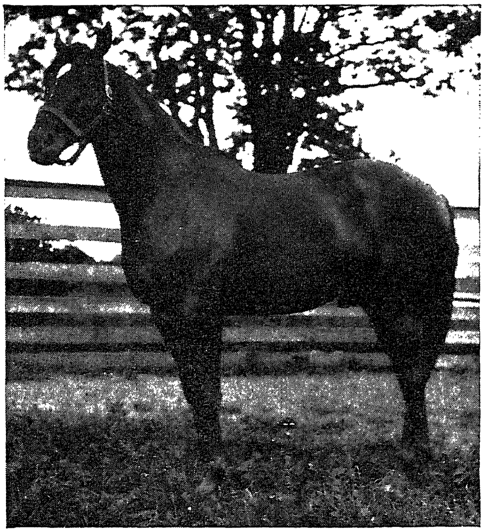
Percheron draft horse

tail also is an efficient fly-brush. The mane and tail have thus a practical value, and they also add greatly to the animal's beauty. To dock a horse's tail for purposes of ornament is as absurd as the sliced ears and welted cheeks of savages; and horses thus mutilated suffer greatly from the attacks of flies.

Owing to the fact that wild horses made swift flight from enemies, the colts could not be left behind at the mercy of wolves. Thus it is that the colt, like the lamb, is equipped with long legs from the first, and can run very rapidly; as a runner, it could not be loaded with a big compound stomach full of food, like the calf, and therefore must needs take its nourishment from the mother at frequent intervals. The colt's legs are so long that it must spread the front legs wide apart in order to reach the grass with its mouth. When the colt or the horse lies down out of doors and in perfect freedom, it lies flat upon the side. In lying down, the hind quarters go first, and in rising, the front legs are thrust out first.

The horse has several natural gaits and some that are artificial. Its natural methods of progression are the walk, the trot, the amble, and the gallop. When walking there are always two or more feet on the ground and the movement of the feet consists in placing successively the right hind foot, the right fore foot, left hind foot, left fore foot, right hind foot, etc. In trotting, each diagonal pair of legs is alternately lifted and thrust forward, the horse being unsupported twice during each stride. In ambling, the feet are moved as in the walk, only differing in that a hind foot or a fore foot is lifted from the ground before its fellow fore foot or hind foot is set down. In a canter, the feet are landed on the ground in the same sequence as in a walk but much more rapidly; and in the gallop, the spring is made from the fore foot and the landing is on the diagonal hind foot, and just before landing the body is in the air and the legs are all bent beneath it.



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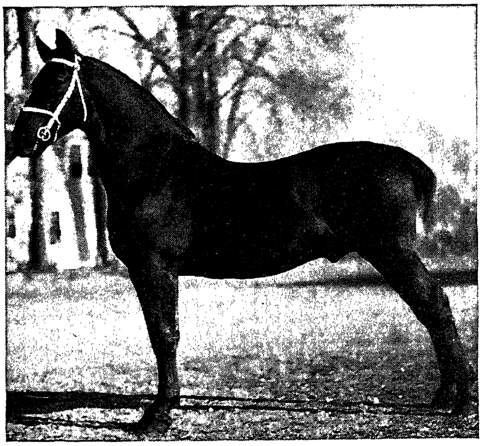
Man o' War. A famous race horse and the father of famous racers



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Carriage stallion

An excellent horseman once said to me, "The whip may teach a horse to obey the voice, but the voice and hand control the well-broken horse," and this epitomizes the best horse training. He also said, "The horse knows a great deal, but he is too nervous to make use of his knowledge when he needs it most. It is the horse's feelings that I rely on. He always has the use of his feelings and the quick use of them." It is a well-known fact that those men who whip and scold and swear at their horses are meantime showing to the world that they are fools in this particu-

A herd of ponies in the Isle of Shetland guarded by a sheep dog

lar business. Many of the qualities which we do not like in our domesticated horses were most excellent and useful when the horses were wild; for instance, the habit of shying was the wild horse's method of escaping the crouching foe in the grass. This habit as well as many others is better controlled by the voice of the driver than by a blow from the whip.

Timothy hay, or hay mixed with clover, form good, bulky food for the horse, and oats and corn are the best concentrated food. Oats are best for driving-horses and corn for the working team. Dusty hay should not be fed to a horse; but if unavoidable, it should always be dampened before feeding. A horse should be fed with regularity, and should not be used for a short time after having eaten. If the horse is not warm, it should be watered before feeding, and in the winter the water should have the chill taken off. The frozen bit should be warmed before being placed in the horse's mouth; if anyone doubts the wisdom of this, let him put a frozen piece of steel in his own mouth. The cruel use of the tight-drawn over checkrein should not be permitted, although a moderate check is often needed and is not cruel. When the horse is sweating, it should be blanketed immediately if hitched outside in cold weather; but in the barn the blanket should not be put on until the perspiration has stopped steaming. The grooming of a horse is a part of its rights, and its legs should receive more attention during this process than its body, a fact not always well understood.

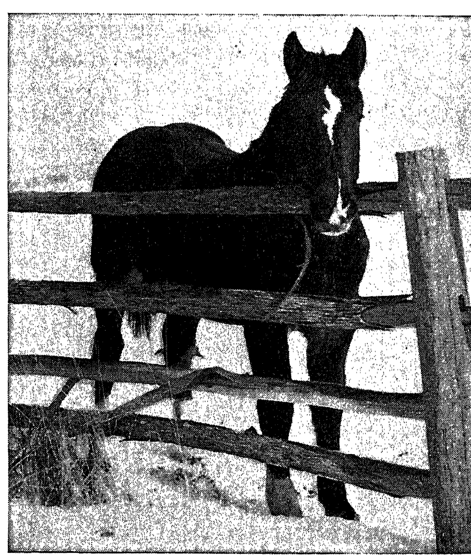
The breeds of horses may always be classified more or less distinctly as follows: racers or thoroughbreds; the saddle horse, or hunter; the coach horse; the draft horse; and the pony. For a description of breeds see dictionaries or cyclopedias. Of the draft horses, the Percherons, Shires, and Clydesdales are most common; of the carriage and coach horses, the English hackney and the French and German coach horses are famed examples. Of the roadster breeds, the American trotter, the American saddle horse and the English thoroughbred are most famous.

Suggested Reading — *Baby Animals on the Farm*, by Kate E. Agnew and Margaret Coble; *Before the Dawn of History*, by Charles R. Knight; *Farm Animals*, by James G. Lawson; *Jinny: The Story of a Filly*, by Bert C. Thayer; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals*; *The Pet Book*, by Anna B. Comstock; *Wild Animals I Have Known*, by Ernest Thompson Seton; also, some of the readings on page 214.

LESSON 67

The Horse

Leading Thought — The horse as a wild animal depended largely upon its



Marion E. Wesp

Percheron colt

strength and fleetness to escape its enemies, and these two qualities have made it of greatest use to man.

METHOD — Begin this study of the horse with the stories of wild horses. "The Pacing Mustang" in *Wild Animals I Have Known* is an excellent story to show the habits of the herds of wild horses. Before beginning actual study of the domestic horses, ask for oral or written English exercises descriptive of the lives of the wild horses. After the interest has been thus aroused the following observations may be suggested, a few at a time, to be made incidentally in the street or in the stable.

OBSERVATIONS—1. Compare the length of the legs of the horse with its height. Has any other domestic animal legs as long in proportion? What habits of the ancestral wild horses led to the development of such long legs? Do you think the length of the horse's neck and head corresponds to the length of its legs? Why?

2. Study the horse's leg and foot. The horse walks on one toe. Which toe do you think it is? What do we call the toenail of the horse? What advantage is this sort of foot to the horse? Is it best fitted for running on dry plains or for marshy land? Does the hoof grow as our nails do? Do you know whether there were ever any horses with three toes or four toes on each foot? Make a sketch of the horse's front and hind leg and label those places which correspond to our wrist, elbow, shoulder, hand, heel, knee, and hip.

3. Where are the horse's ears placed on the head? How do they move? Do they flap back and forth like the cow's ears when they are moved, or do they turn as if on a pivot? What do the following different positions of the horse's ears indicate: When lifted and pointing forward? When thrown back? Can you tell by the action of the ears whether a horse is nervous and high-strung or not?

4. What is the color of the horse's eyes? The shape of the pupil? What advantage does the position of the eyes on the head give to the wild horse? Why do we put blinders on a horse? Can you tell by the expression of the eye the temper of the horse?

5. Look at the mouth and nose. Are the nostrils large and flaring? Has the horse a keen sense of smell? Are the lips thick or thin? When taking sugar from the hand, does the horse use teeth or lips?

6. Describe the horse's teeth. How many front teeth? How many back teeth? Describe the bar where the bit is placed. Are there any canine teeth? If so, where? Do you know how to tell a horse's age by its teeth? Can a horse graze the grass more closely than a cow? Why? When it chews does it move the jaws sidewise like the cow? Why? Why did the wild horses not need to develop a cud-chewing habit?

7. What is the nature of the horse's coat in summer? If the horse runs in the pasture all winter, how does its coat change? When does the horse shed its coat? What is the use of the horse's mane, forelock, and tail? Do you think it is treating the horse well to dock its tail?

8. Why do colts need to be so long-legged? How does a colt have to place its front legs in order to reach down and eat the grass? Does the colt need to take its food from the mother often? How does it differ from the calf in this respect? How has this difference of habit resulted in a difference of form in the calf and colt?

9. When the horse lies down which part goes down first? When getting up which rises first? How does this differ from the method of the cow? When the horse lies down to sleep does it have its legs partially under it like the cow?

10. In walking which leg moves first? Second? Third? Fourth? How many gaits has the horse? Describe as well as you can all of these gaits.

11. Make a sketch of a horse showing the parts. (See Webster's Unabridged.) When we say a horse is fourteen hands high what do we mean?

12. In fighting, what weapons does the horse use and how?

13. In training a horse, should the voice or the whip be used more? What qualities should a man have to be a good horse trainer? Why is shying a good quality in

wild horses? How should it be dealt with in the domestic horse?

14. What sort of feed is best for the horse? How and when should the horse be watered? Should the water be warmed in cold weather? Why? Should the bit be warmed in winter before putting it in a horse's mouth? Why? Should a tight over checkrein be used when driving? Why not? When the horse has been driven until it is sweating what are the rules for blanketing it when hitched out of doors and when hitched in the barn? What is your opinion of a man who lets his horse stand waiting in the cold, unblanketed? If horses were kept out of doors all the time would this treatment be so cruel and dangerous? Why not? Why should dusty hay be dampened before it is fed to a horse? Why should a horse be groomed? Which should receive more attention, the legs or the body?

15. How many breeds of horses do you know? What is the use of each? Describe as well as you can the characteristics of the following: the thoroughbred, the hackney, and other coach horses; the American trotter, the Percheron, the Clydesdale.

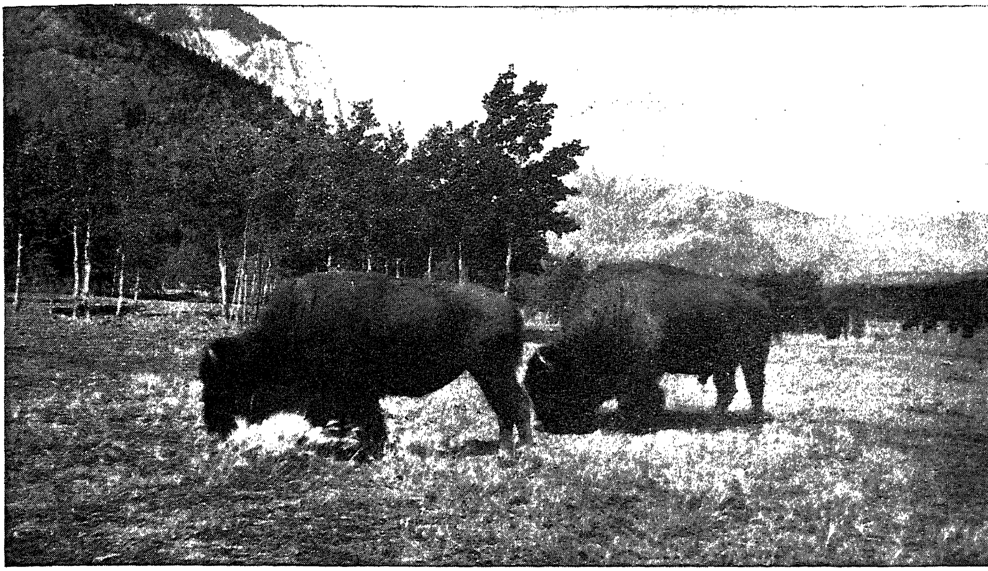
16. Write English themes on the following subjects: "The Prehistoric Horses of America," "The Arabian Horse and Its Life with Its Master," "The Bronchos and Mustangs of the West," "The Wild Horses of Tartary," "The Zebras of Africa," "The Shetland Ponies and the Islands on Which They Run Wild."

Many horses shy a good deal at objects they meet on the road. This mostly arises from nervousness, because the objects are not familiar to them. Therefore, to cure the habit, you must get your horse accustomed to what he sees, and so give him confidence. . . . Be careful never to stop a horse that is drawing a vehicle or load in the middle of a hill, except for a rest; and if for a rest, draw him across the hill and place a big stone behind the wheel, so that the strain on the shoulder may be eased. Unless absolutely necessary never stop a horse on a hill or in a rut, so that when he starts again it means a heavy tug. Many a horse has been made a jibber and his temper spoilt by not observing this rule. — "A COUNTRY READER," H. B. M. BUCHANAN.

CATTLE

That in numbers there is safety is a basic principle in the lives of wild cattle, probably because their chief enemies, the wolves, hunted in packs. It has often been related that, when the herd is attacked by wolves, the calves are placed at the center of the circle made by the cattle, standing with heads out and horns ready for attack from every quarter. But when a single animal, like a bear or tiger, attacks any of the herd, they all gather around it in a narrowing circle of clashing horns, and many of these great beasts of prey have thus met their death. The cow is as formidable as the bull to the enemy, since her horns are strong and sharp and she tosses her victim, unless it is too large. The heavy head, strong neck, and short massive horns of the bull are not so much for defense against enemies as against rival bulls. The bull not only tosses and gores his victim, but kneels or tramples upon it. Both bull and cow have effective weapons of defense in the hind feet, which kick powerfully. The buffalo bull of India will attack a tiger single-handed, and usually successfully. It is a strange thing that all cattle are driven mad by the smell of blood, and weird stories are told of the stampeding of herds from this cause, on the plains of our great West.

Cattle are essentially grass and herbage eaters, and their teeth are peculiarly arranged for this. There are eight front teeth on the lower jaw, and a horny pad opposite them on the upper jaw. Back of these on each jaw there is a bare place and six grinding teeth on each side. As a cow crops



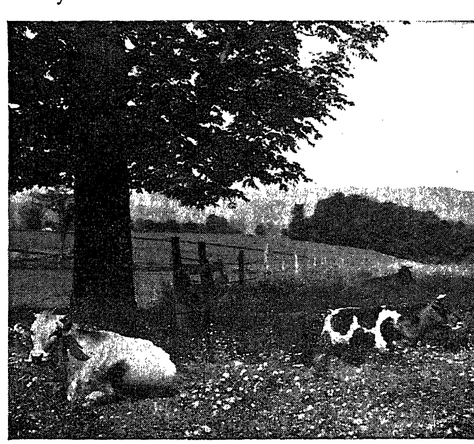
John L. Rich

Bison or American buffalo. The original wild cattle of America

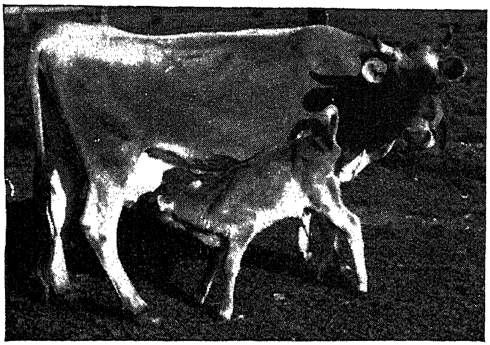
the herbage, her head is moved up and down to aid in severing the leaves, and the peculiar sound of the tearing of the leaves thus made is not soon forgotten by those who have heard it. In the wild or domesticated state the habit of cud-chewing is this: The cattle graze mornings and evenings, swallowing the food as fast as cropped, and storing it in their ruminating stomachs. During the heat of the day, they move to the shade, preferably to the shady banks of streams, and there in quiet the food is brought up, a small portion at a time, and chewed with a peculiar sidewise movement of the jaws and again swallowed. There is probably no more perfect picture of utter contentment than a herd of cows chewing their cuds in the shade, or standing knee-deep in the cool stream on a summer's day. The cattle in a herd keep abreast and move along when grazing, heads in the same direction.

Connected with the grazing habit, is that of the hiding of the newborn calf by its mother; the young calf is a wabbly creature and ill-fitted for a long journey; so the mother hides it, and there it stays "frozen" and will never stir unless actually touched. As the mother is obliged to be absent for some time grazing with the herd, the calf is obliged to go without nourishment for a number of hours, and so it is provided with a large compound stomach which, if filled twice a day, suffices to insure health and growth. The cow, on the other hand, giving her milk out only twice a day, needs a large udder in which to store it. The size of the udder is what has made the cow useful to us as a milch animal.

A fine cow is a beautiful creature, her soft yellow skin beneath the sleek coat of



Cows in pasture. A Jersey and a Holstein.



Marion E. Wesp

A very young Jersey calf gets its breakfast

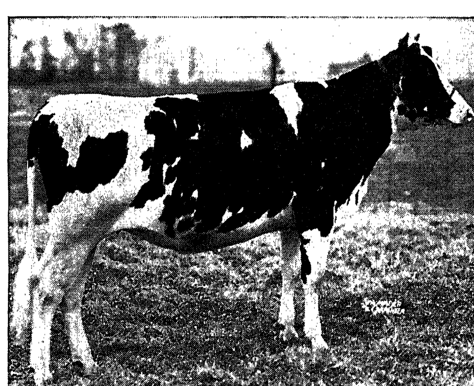
short hair, the well-proportioned body, the mild face, crowned with spreading, polished horns and illuminated with large gentle eyes, are all elements of beauty which artists have recognized, especially those of the Dutch school. The ancients also admired bovine eyes, and called their most beautiful goddess the ox-eyed Juno.

The cow's ears can be turned in any direction, and her sense of hearing is keen; so is her sense of smell, aided by the moist, sensitive skin of the nose; she always sniffs danger and also thus tests her food. Although a cow if well kept has a sleek coat, when she is allowed to run out of doors during the winter her hair grows long and shaggy as a protection. The cow walks on two toes, or as we say has a split hoof. She has two lesser toes above and behind the hoofs which we call dewclaws. The part of her leg which seems at first glance to be her knee is really her wrist or ankle. Although short-legged, the cow is a good runner, as those who have chased her can bear witness. She can walk and gallop, and has a pacing trot; she is a remarkable jumper, often taking a fence like a deer; she also has marvelous powers as a swimmer, a case being on record where a cow swam five miles. But a cow would be ill-equipped for comfort if it were not for her peculiar tail, which is made after the most approved pattern of fly-brushes, and is thus used. Woe betide the fly she hits with it, if the blow is as efficient as that which she incidentally bestows on the head of the milker. It is to get rid of flies that the cattle, and especially the buffaloes, wallow in the mud and thus coat themselves with a fly-proof armor.

There is a fairly extensive range of emotions expressed in cattle language, from the sullen bellow of the angry animal to the lowing which is the call of the herd, and the mooing which is meant for the calf; and there are many other bellowings and mutterings which we can partially understand.

Every herd of cows has its leader, who has won the position by fair fight. Add a new cow to the herd, and there is at once a trial of strength, to adjust her to her proper place; and in a herd of cows, the leader leads; she goes first and no one may say her nay. In fact, each member of the herd has her place in it; and that is why it is so easy to teach each cow in a herd to take her own stanchion in the stable. In a herd of forty cows which I knew, each cow took her stanchion, no matter in what order she happened to enter the stable.

A cow at play is a funny sight; her tail is lifted aloft like a pennant and she kicks as lightly as if she were made of rubber. She is also a sure-footed beast, as anyone can attest who has seen her running down the rocky mountainsides of the Alps at a headlong pace and never making a mistake. In lying down, the cow first kneels with the front legs, or rather drops on her wrists, then the hindquarters go down, and the front follow. She does not lie flat



E. S. Harrison

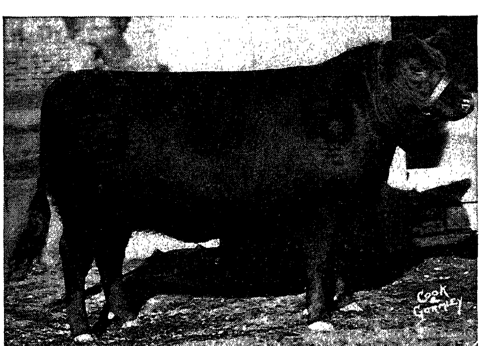
Cornell Ormsby Esteem. Holstein heifer, an all-American yearling on her side when resting, like the horse when at ease, but with her legs partially under her. In getting up, she rests upon her wrists and then lifts the hindquarters.

The Usefulness of Cattle

When man emerged from the savage state, his first step toward civilization was domesticating wild animals and training them for his own use. During the nomad stage, when tribes wandered over the face of the earth, they took their cattle along. From the first, these animals have been used in three capacities: first, for carrying burdens and as draft animals; second, as meat; third, as givers of milk. They were also used in the earlier ages as sacrifices to the various deities, and in Egypt, some were held sacred.

As beasts of burden and draft animals, oxen are still used in many parts of the United States. For logging, especially in pioneer days, oxen were far more valuable than horses. They are patient and will pull a few inches at a time, if necessary, a tedious work which the nervous horse refuses to endure. Cows, too, have been used as draft animals, and are so used in China today, where they do most of the plowing; in these Oriental countries milk is not consumed to any extent, so the cow is kept for the work she can do. In ancient times in the East, white oxen formed a part of royal processions.

Because of two main uses of cattle by civilized man, he has bred them in two



Animal Husbandry Dept., Cornell U.

Glen Carnock's Jessie 9th. Angus heifer ready for the show ring

Eugene J. Hall

Lady Fairfax. A prize winning Hereford cow. Herefords are one of the leading breeds of beef cattle

directions; for producing beef, and for milk. The beef cattle are chiefly Aberdeen-Angus, Galloway, Shorthorn or Durham, and Hereford; the dairy breeds are the Jersey, Guernsey, Ayrshire, Holstein-Friesian and Brown Swiss. The beef animal is, in cross section, approximately like a brick set sidewise. It should be big and full across the loins and back, the shoulders and hips covered heavily with flesh, the legs stout, the neck thick and short, and the face short; the line of the back is straight, and the stomach line parallel with it. Very different is the appearance of the milch cow. Her body is oval, instead of being approximately square in cross-section. The outline of her back is not straight, but sags in front of the hips, which are prominent and bony. The shoulders have little flesh on them; and if looked at from above, her body is wedge-shaped, widening from shoulders backward. The stomach line is not parallel with the back bone, but slants downward from the shoulder to the udder. The following are the points that indicate a good milch cow: Head high between the eyes, showing large air passages and indicating strong lungs. Eyes clear, large, and placid, indicating good disposition. Mouth large, with a muscular lower jaw, showing ability to chew efficiently and rapidly. Neck thin and fine, showing veins through the skin. Chest deep and wide, showing plenty of room for heart and lungs. Abdomen large but well supported, and increasing in size toward the rear. Ribs well spread, not meeting the spine like the peak of a roof, but the spine must be prominent, revealing to the touch the separate vertebræ. Hips much broader than the shoulders. Udder large, the four quarters of equal size, and not fat; the "milk veins" which carry the blood from the udder should be large and crooked, passing into the abdomen through large openings. Skin soft, pliable, and covered with fine, oily hair. She should have good digestion and great powers of assimilation. The milch cow is a milk-making machine, and the more fuel (food) she can use, the greater her production.

E. S. Harrison

Cornell Ollie Catherine. A prize-winning Holstein cow

The physiological habits of the beef and milch cattle have been changed as much as their structure. The food given to the beef cow goes to make flesh; while that given to the milch cow goes to make milk, however abundant her food. Of course, there are all grades between the beef and the milch types, for many farmers use dual herds for both. However, if a farmer is producing milk it pays him well to get the best possible machine to make it, and that is always a cow of the milch type.

A Geography Lesson

All the best breeds of cattle have been evolved in the British Isles and in Europe north of Italy and west of Russia. All our domesticated cattle were developed from wild cattle of Europe and Asia. The cattle which roam in our rapidly narrowing grazing lands of the far West are European cattle. America had no wild cattle except the bison. In geography supplementary readers, read about Scotland, England, the Channel Islands, the Netherlands, France, and Switzerland and the different kinds of cattle developed in these countries.

How to Produce Good Milk

There are four main ingredients of milk — fat, protein, sugar, and ash. The fat is for the purpose of supplying the animal with fat, which may be used as such, or which may be converted into energy. The protein supplies the material from which muscle tissue is built. The sugar provides a source of energy. The protein and sugar considered together form what we know as curd, which is the main ingredient of cheese; however, cheese, to be good, should contain a full amount of butter fat. The ash which may be seen as residue when milk is burned, builds up the bone of the animal.

Jersey cows produce a milk containing a higher per cent of fat than any other common dairy breed in the United States. The Holstein cows produce a large flow of milk with a low per cent of fat. The quantity of sugar is relatively constant, while the protein increases with the fat but not in direct proportion.

The dairy barn should have concrete floors and metal equipment to aid in keeping the surroundings clean. The production of clean milk requires that the cows be brushed or groomed each day; that their udders be washed before each milking, preferably with individual washcloths saturated in a mild chlorine solution. As soon as the milk is drawn from the udder, it should be taken to a dairy house where it should be strained into sterilized cans. The milk should then be cooled immediately, and kept at a low temperature until it is ready to be used. Milk absorbs odors or flavors very readily, and therefore should never be kept in the dairy barn itself. A pure quality of milk that may be safely consumed raw must be produced by healthy cows, cared for by healthy attendants under sanitary conditions. Pasteurization of milk destroys bacteria and makes it possible to keep the milk sweet for several days if stored in a refrigerator.

Milk to be legally sold in New York State must possess three per cent of butter fat. For upper grades or first-year work in the high school, there could not be a more profitable exercise than teaching the pupils the use of the Babcock milk tester.

The Care of the Milch Cow

It is impossible to overestimate the importance of teaching the pupils in rural districts the proper care of milch cattle for the production of milk. The milch cow is a perfect machine, and should be regarded as such in producing milk. First, she should have plenty of food of the right kind, that is, well-balanced ration. Second, she should have a warm, clean stable and be supplied with plenty of good fresh air. A cold stable makes it necessary to provide much more food for the cow; a case on record shows that when a barn was opened up in cold weather for necessary repairing, the amount of milk from the cows stabled in it decreased ten per cent in twenty-four hours. There should be a protected place for drinking, if the cattle must be turned out of the barn for water in winter; it is far better to have the water piped into the barn, although the herd should be given a few hours each day in the open air. A dog should never be used for driving cows. To be profitable, a cow should give milk ten months of the year at least. Calves should be dehorned when they are a few days old by putting caustic potash on the budding horns, thus obviating the danger of damaging the cow by dehorning.

In a properly run dairy, a pair of scales stands near the can for receiving the milk; and as the milk from each cow is brought in, it is weighed and the amount set down opposite the cow's name on a "milk sheet" that is tacked on the wall nearby. At the end of each week the figures on the milk sheet are added, and the farmer knows just how much milk each cow is giving him, and whether there are any in the herd that are not paying their board.

Suggested Reading — *Baby Animals on the Farm*, by Kate E. Agnew and Margaret Coble; *Farm Animals*, by James G. Lawson; *The Pet Book*, by Anna B. Comstock; *Better Dairy Farming*, by E. S. Savage and L. A. Maynard; *Feeds and Feeding*, by L. A. Maynard; also, some of the readings on page 214.

LESSON 68

The Cow

Leading Thought — Certain characteristics which enable the cow to live successfully as a wild animal have rendered her of great use to us as a domestic animal.

Method — Begin the lesson by leading the pupils to understand the peculiar adaptation of cattle for success as wild animals. This will have to be done largely by reading and asking for oral or written work on the following topics: "The Aurochs," "Wild Cattle of the Scottish Highlands," "The Buffaloes of the Orient," "The American Bison," "The Cowboys of the West and Their Work with Their Herds," "The Breeds of Beef Cattle, Where They Came From, and Where Developed," "The Breeds of Milch Cattle, Their Origin and Names." The following questions may be given out a few at a time and answered as the pupils have opportunity for observation.

Observations — 1. What are the characteristics of a fine cow? Describe her horns, ears, eyes, nose, and mouth. Do you think she can hear well? What is the attitude of her ears when she is listening? Do you think she has a keen sense of smell? Is her nose moist? Is her hair long or short? Smooth or rough?

2. The cow walks on two toes. Can you see any other toes which she does not walk on? Why is the cow's foot better adapted than that of the horse for walking in mud and marshes? What do we call the two hind toes which she does not walk on? Can you point out on the cow's leg those parts which correspond with our elbow, wrist, knee, and ankle? Is the cow

a good runner? Is she a good jumper? Can she swim?

3. For what use was the cow's tail evidently intended? How do the wild buffaloes and bison get rid of attacks of flies?

4. How much of cattle language do you understand? How does the cow express pleasure? Lonesomeness? Anger? How does the bull express anger? What does the calf express with the voice?

5. Is there always a leader in a herd of cows? Do certain cows of the herd always go first and others last? Do the cows readily learn to take each her own place in the stable? How is leadership of the herd attained? Describe cattle at play.

6. At what time of day do cattle feed in the pasture? When and where do they chew the cud? Do they stand or lie to do this? Describe how a cow lies down and gets up.

7. How do wild cattle defend themselves from wolves? From bears or other solitary animals?

8. For what purposes were cattle first domesticated? For how many purposes do we rear cattle today?

9. Name and give brief descriptions of the different breeds of cattle with which you are familiar. Which of these are beef and which milch types?

10. What are the distinguishing points of a good milch cow? Of a good beef animal? What does the food do for each of these? Which part of the United States produces most beef cattle? Which the most milch cattle?

11. What do we mean by a balanced ration? Do you know how to compute one? What is the advantage of feeding cattle a balanced ration?

12. What must be the per cent of butter fat in milk to make it legally salable in your state? How many months of the year should a good cow give milk?

13. Should a dog be used in driving dairy cows? Why not?

14. Why is a cool draughty barn an expensive place in which to keep cattle? Why is a barn not well ventilated a danger?

15. Why is the dehorning of cattle practiced? When and how should a calf be dehorned?

16. Why should milk not be strained in the barn? Why is it profitable for the dairy farmer to keep his stable clean and to be cleanly in the care of milk? How does the food of cows affect the flavor of the milk? Why should a farmer keep a record of the number of pounds of milk which each cow in his dairy gives each day?

17. For what are oxen used? Wherein are they superior to horses as draft animals? Do you know of any place where oxen are used as riding animals?

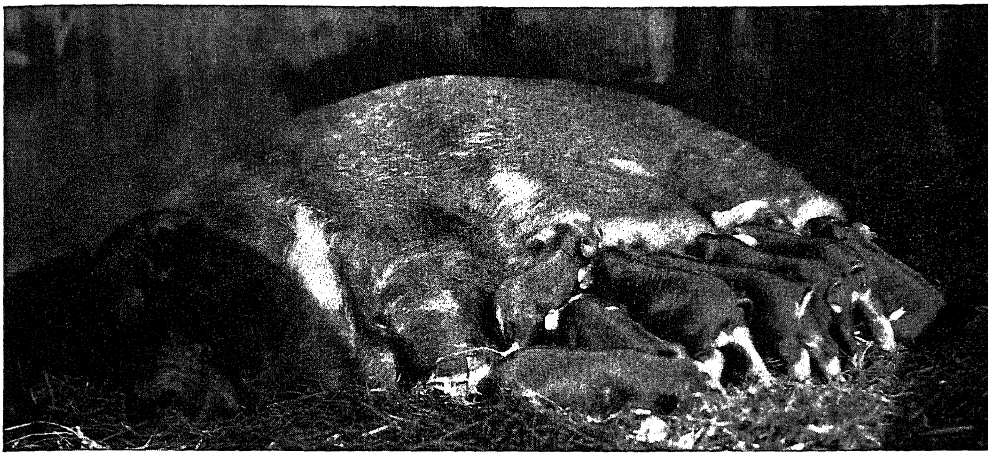
18. How many industries are dependent upon cattle?

19. Give oral or written exercises on the following themes: "How the Best Butter Is Made"; "The Use of Bacteria in Butter"; "How Dairy Cheese Is Made"; "How Fancy Cheeses Are Made."

THE PIG

I wander through the underbresh,
Where pig tracks pintin' to'rds the crick,
Is picked and printed in the fresh
Black bottom-lands, like wimmern prick
Their pie-crusts with a fork. — Riley

By a forest law of William the First of England in the eleventh century, it was ordained that any that were found guilty of killing the stag or the roebuck or the wild boar should have their eyes put out. This shows that the hunting of the wild boar in England was considered a sport of gentlemen in an age when nothing was



Bureau of Animal Industry, U. S. D. A.

Breakfast, cafeteria style

considered sport unless it was dangerous. The wild hog of Europe is the ancestor of our common domesticated breeds, although the Chinese domesticated their own wild species, even before the dawn of history.

The wild hog likes damp situations where it may wallow in the water and mud; but it also likes to have, close by, woods, thicket, or underbrush, to which it can retire for rest and also when in danger. The stiff, bristling hairs which cover its thick skin are a great protection when it is pushing through thorny thickets. When excited or angry, these bristles rise and add to the fury of its appearance. Even in our own country the wild hogs of the South whose ancestors escaped from domestication have reverted to their original savagery, and are dangerous when infuriated. The only recorded instance when our great national hunter, Theodore Roosevelt, was forced ignominiously to climb a tree, was after he had emptied his rifle into a herd of "javelins," as the wild pigs of Texas are called; the javelins are the peccaries, which are the American representatives of the wild hog.

That the hog has become synonymous with filth is the result of the influence of man upon this animal, for of all animals, the pig is naturally the neatest, keeping its bed clean, often in the most discouraging and ill-kept pens. The pig is sparsely clothed with bristles and hairs, which yield it no protection from the attacks of flies and other insects. Thus it is that the pig, in order to rid itself of these pests, has learned to wallow in the mud. However, this is in the nature of a mud bath, and is for the purpose of keeping the body free from vermin. The wild hogs of India make for themselves grass huts, thatched above and with doors at the sides, which shows that the pig, if allowed to care for itself, understands well the art of nest building.

One of the most interesting things about a pig is its nose; this is a fleshy disc with nostrils in it and is a most sensitive organ of feeling; it can select grain from

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Razorback. A hog of no definite breed, which is allowed to roam at will in some of the southern states

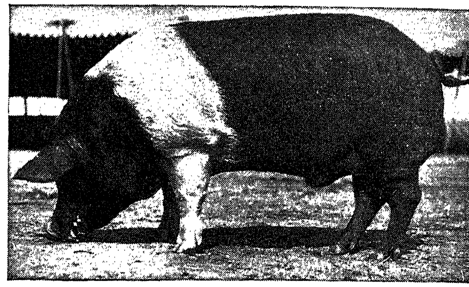
Duroc-Jersey boar

chaff, and yet it is so strong that it can root up the ground in search for food. " Root " is a pig word, and was evidently coined to describe the act of the pig when digging for roots; the pig's nose is almost as remarkable as the elephant's trunk, and the pig's sense of smell is very keen; it will follow a track almost as well as a dog. There are more instances than one of a pig being trained as a pointer for hunting birds, and showing a keener sense of smell and keener intelligence in this capacity than do dogs. French pigs are taught to hunt for truffles, which are fungi growing on tree roots, a long way below the surface of the ground; the pig detects their presence through the sense of smell.

The pig has a full set of teeth, having six incisors, two canines, and seven grinding teeth on each jaw; although in some cases there are only four incisors on the upper jaw. A strange thing about a pig's teeth is the action of the upper canines, or tushes, which curve upward instead of downward; the lower canines grind up against them, and are thus sharpened. The females have no such development of upper tushes as do the males; these tushes, especially the upper ones, are used as weapons; with them, the wild boar slashes out and upward, inflicting terrible wounds, often disabling horses and killing men. Professor H. F. Button describes the fighting of hogs thus: " To oppose the terrible weapons of his rival, the boar has a shield of skin over his neck and shoulders, which may become two inches thick, and so hard as to defy a knife. When two of these animals fight, each tries to keep the tushes of his opponent against the shield, and to get his own tushes under the belly or flank of the other. Thus, each goes sidewise or in circles, which has given rise to the expression, ' to go sidewise like a hog to war.' "

Eugene J. Hall

Poland China hog



Bureau of Animal Industry, U. S. D. A.

Hampshire boar

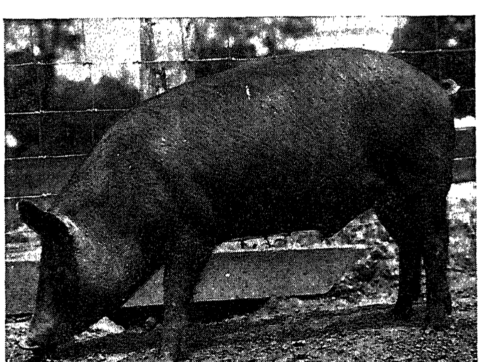
When, as a small girl, I essayed the difficult task of working buttonholes, I was told if I did not set my stitches more closely together, my buttonhole would look like a pig's eye, a remark which made me observant of that organ ever after. But though the pig's eyes are small, they certainly gleam with intelligence, and they take in all that is going on which may in any way affect his pigship.

The pig is the most intelligent of all the farm animals, if it is only given a chance; it has excellent memory and can be taught tricks readily; it is affectionate and will follow its master around like a dog. Anyone who has seen a trained pig at a show picking out cards and counting must grant that it has brains. We stuff it so with fattening food, however, that it does not have a chance to use its brain, except now and then when it breaks out of the sty and we try to drive it back. Under these circumstances, we grant the pig all the sagacity usually imputed to the one who once possessed swine and drove them into the sea. Hunters of wild hogs proclaim that they are full of strategy and cunning, and are exceedingly fierce.

The head of the wild hog is wedge-shaped with pointed snout, and this form enables the animal to push into the thick underbrush along the river banks whenever it is attacked. But civilization has changed this bold profile of the head, so that now in many breeds there is a hollow between the snout and eyes, giving the form which we call "dished." Some breeds have sharp, forward-opening ears, while others have ears that lop. The wild pig of Europe and Asia has large, open ears extending out wide and alert on each side of the head.

The covering of the pig is a thick skin beset with bristling hairs; when the hog is excited, the bristles rise and add to the fury of its appearance. The bristles aid in protecting the animal when it is pushing through thorny thickets. The pig's querly tail is merely an ornament, although the tail of the wart hog of Africa, if pictures may be relied upon, might be used in a limited fashion as a fly-brush.

When the pig is allowed to roam in the woods, it lives on roots, nuts, and especially acorns and beech nuts; in the autumn it becomes very fat through feeding upon the latter. The mast-fed bacon of the semi-wild hogs of the southern states is considered the best of all. But



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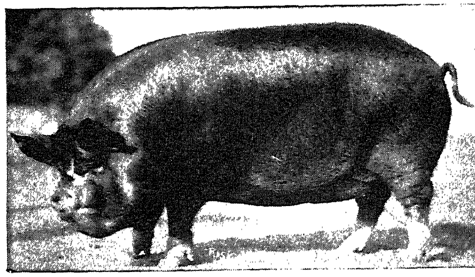
Tamworth barrow, a bacon type



Bureau of Animal Industry, U. S. D. A.

A champion Berkshire sow

almost anything, animal or vegetable, that comes in its way is eaten by the hog, and it has been long noted that the hog has done good service on our frontier as a killer of rattlesnakes. The pig is well fitted for locomotion on either wet or dry soil, for the two large hoofed toes enable it to walk well on dry ground and the two hind toes, smaller and higher up, help to sustain it on marshy soil. Although the pig's legs are short, it is a swift runner unless it is too fat. The razor-backs of the South are noted for their fleetness.

We understand somewhat the pig's language: the constant grunting, which is a sound that keeps the pig herd together, the complaining squeal of hunger, the satisfied grunt signifying enjoyment of food, the squeal of terror when seized, and the nasal growl when fighting. But there is much more to the pig's conversation than this; I knew a certain lady, a lover of animals, who once undertook to talk pig language as best she could imitate it, to two of her sows when they were engaged in eating. They stopped eating, looked at each other a moment and forthwith began fighting, each evidently attributing the lady's remark to the other, and obviously it was of an uncomplimentary character.

The pig's ability to take on fat was evidently a provision, in the wild state, for storing up from mast fat that should help sustain the animal during the hardships of winter; and this characteristic is what makes swine useful for our own food. Pigs, to do best, should be allowed to have pasture and plenty of fresh green food. Their troughs should be kept clean and they

ANIMALS OF ZOOS AND PARKS

1. Rhinoceros. *From two Greek words which mean "nose" and "horn" we have the word "rhinoceros." Note the hornlike projection on the nose of this African animal which is shown in the picture; a form in Asia differs slightly in appearance.* Range: *Tropical portions of Asia and Africa.*

2. Hippopotamus. *This thick-skinned, short-legged, four-toed animal is at home in the rivers of Africa. It feeds chiefly on grass and aquatic plants. The word "hippopotamus" is derived from two Greek words which mean "river" and "horse."*

3. Kangaroo. *The short forelegs and the powerful hind legs which it uses for jumping give the kangaroo a unique appearance. By means of great leaps, this animal travels rapidly. The immature young are carried in an external pouch. There are various kinds of kangaroos; the red kangaroo is shown in the picture.*

4. Zebra. *These swift, wild animals of Africa are members of the horse family; their unique color arrangement, of dark stripes on a tawny background, is definitely characteristic of them. The colt in the picture is one week old.*

5. Malay Tiger. *The range of this large member of the cat family extends throughout most of Asia from southern Siberia south to Java and Sumatra. In color, a Malay tiger is tawny with black cross stripes. The male, much larger than the female, may reach a length of ten feet including the tail.*

6. Polar Bear. *Found in Arctic regions, this white bear is to be seen on ice floes as well as swimming about in the water; it may weigh as much as* 1500 *pounds and reach a length of* 9 *feet.*

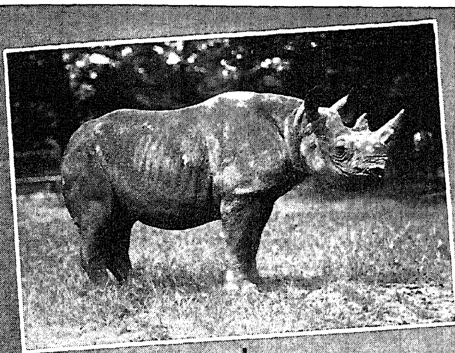
7. Nubian Giraffe. *This uniquely spotted African mammal may reach a height of twenty feet. By means of a very long neck and a grasping tongue, it can easily secure for its food leaves from trees. While it may remind one somewhat of a horse, it is really, to some extent, like a cow; it chews a cud.*

8. Bactrian or Two-humped Camel. *Long ago the camel was domesticated by man and is to this day an important beast of burden in northern Africa and western Asia. It is especially adapted to withstand the hardships of the deserts; it can go without drinking water for several days because certain portions of its stomach serve as water reservoirs. Water can be taken in large quantities and then used as needed. There is a one-humped camel known as the Arabian or dromedary camel.*

9. Wapiti or American "Elk." *This American mammal is incorrectly called "elk"; that title really belongs to our moose, which is a true elk. The wapiti's range is now restricted chiefly to more remote regions of the western United States and Canada; but formerly the animal was found also in the central and eastern United States. In color, it is chestnut red in summer and rather grayish in winter.*

10. Virginia or White-tailed Deer. *Only the males possess antlers; these are of solid bone, are directed forwards with the prongs upward, and are shed every spring. These deer were formerly very common in the plains and forests of the central and southern United States; but now they are abundant in only certain of the wilder portions of their former range. Their food consists of buds, leaves, tender bark, and various other forms of plant life.*

Photographs by New York Zoological Society



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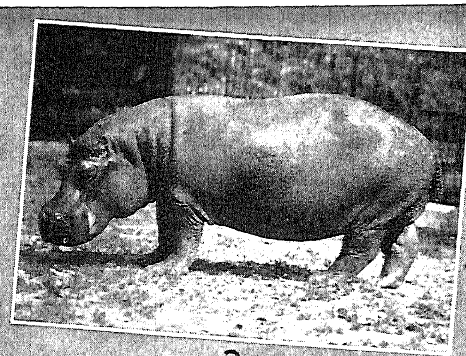

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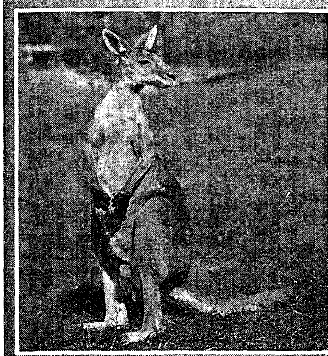

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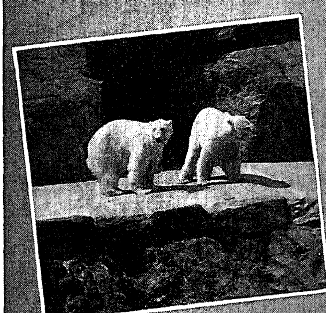

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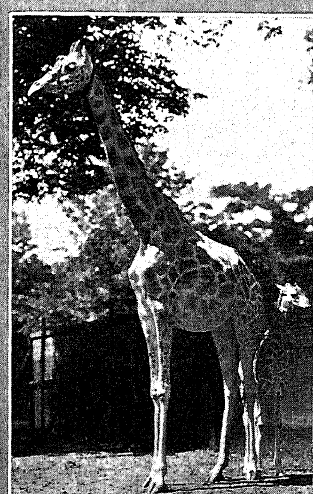

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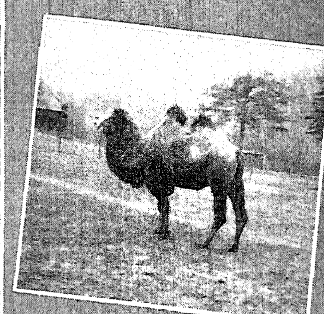

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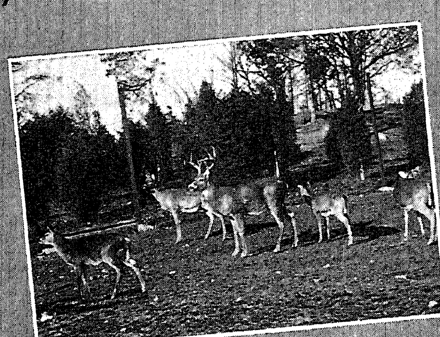

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should have access to ashes, and above all, they should have plenty of pure water; and as the pig does not perspire freely, access to water where it can take its natural mud baths helps to keep the body cool and the pig healthy in hot weather.

The breeds of hogs most common in America are the Berkshire, which are black and white markings, and have ears extending erect; the Poland China, which are black and white with drooping ears;

Marion E. Wesp

A family meal

the Duroc-Jersey, which are red or chestnut with drooping ears; the Yorkshire and Cheshire, which are white with erect ears; and the Chester White, which are white with drooping ears. The Poland China and Duroc-Jersey are both pure American breeds.

Suggested Reading — *Baby Animals on the Farm*, by Kate E. Agnew and Margaret Coble; *Farm Animals*, by James G. Lawson; *Mother Nature Series*, by Fannie W. Dunn and Eleanor Troxell, Book 1, *Baby Animals; The Pet Book*, by Anna B. Comstock; also, some of the readings on page 214.

LESSON 69

The Pig

Leading Thought — The pig is something more than a source of pork. It is a sagacious animal and naturally cleanly in its habits when not made prisoner by man.

Method — The questions in this lesson may be given to the pupils a few at a time, and those who have access to farms or other places where pigs are kept may make the observations, which should be discussed when they are given to the class. Supplementary reading should be given the pupils, which may inform them as to the habits and peculiarities of the wild hogs. Theodore Roosevelt's experience in hunting the wart hog in Africa will prove interesting reading.

Observations — 1. How does the pig's nose differ from that of other animals? What is it used for besides for smelling? Do you think the pig's sense of smell is very keen? Why do pigs root?

2. Describe the pig's teeth. For what are they fitted? What are the tushes for? Which way do the upper tushes turn? How do wild hogs use their tushes?

3. Do you think that a pig's eyes look intelligent? What color are they? Do you think the pig can see well?

4. Is the pig's head straight in front or is it dished? Is this dished appearance ever found in wild hogs? Do the ears stand out straight or are they lopped? What advantage is the wedge-shaped head to the wild hogs?

5. How is the pig covered? Do you think the hair is thick enough to keep off flies? Why does the pig wallow in the mud? Is it because the animal is dirty by nature or because it is trying to keep clean? Do the hog's bristles stand up if it is angry?

6. If the pig could have its natural food what would it be and where would it be found? Why and on what should pigs be pastured? What do pigs find in the forest to eat? What kind of bacon is considered the best?

7. On how many toes does the pig walk? Are there other toes on which it does not walk? If wading in the mud are the two hind toes of use? Do wild pigs run rapidly? Do tame pigs run rapidly if they are not too fat? Do you think the pig can swim? Do you think that the pig's tail is of any use or merely an ornament?

8. What cries and noises do the pigs make which we can understand?

9. How do hogs fight each other? When the boars fight, how do they attack or ward off the enemy? Where do we get the expression "going sidewise like a hog to war"?

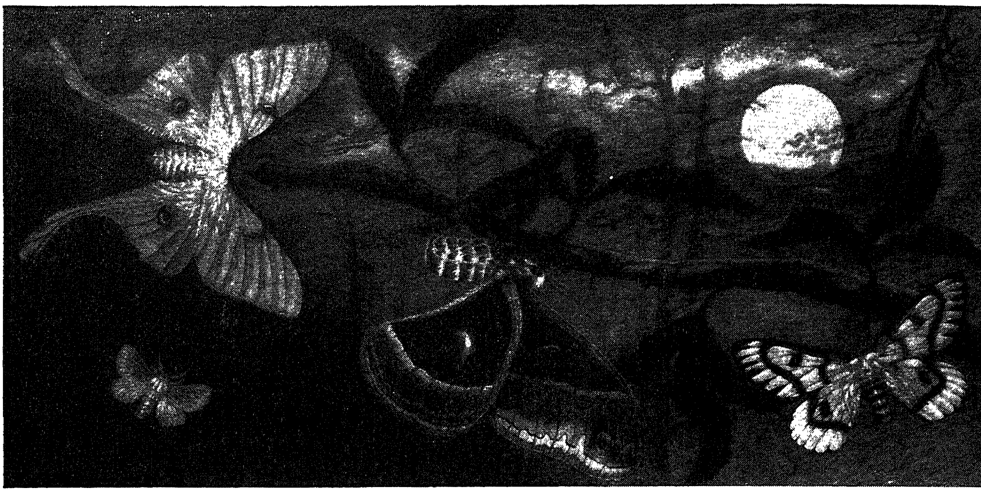
10. How many breeds of pigs do you know? Describe them.

11. What instances have you heard that show the hog's intelligence?

12. Give an oral or written English exercise on one of the following topics: "The Antiquity of Swine; How They Were Regarded by the Ancient Egyptians, Greeks, and Romans" (see encyclopedia); "The Story of Hunting Wild Hogs in India"; "The Razor-Back Hogs of the South"; "The Wart Hog of Africa"; "Popular Breeds of Hogs."

The nice little pig with a querly tail,
All soft as satin and pinky pale
Is a very different thing by far
Than the lumps of iniquity big pigs are.
— NONSENSE RHYME

INSECTS



Wood engraving by Anna Botsford Comstock

Luna moth *Cecropia moth* *Juno moth*
Flannel-moth

Insects are among the most interesting and available of all living creatures for nature-study. The lives of many of them afford more interesting stories than are found in fairy lore; many of them show exquisite colors; and, most important of all, they are small and are, therefore, easily confined for observation.

About us on every side are myriads of tiny creatures that commonly pass unnoticed, and even when we observe them, we usually think them unworthy of serious consideration. But all life is linked together in such a way that no part of the chain is unimportant. Frequently the action of some of these minute beings seriously affects the material success or failure of a great commonwealth. The introduction and spread of a single species of insect (the cottony-cushion scale) in California threatened the destruction of the extensive orchards of that state; thousands of trees perished. The introduction of a few individuals of a particular kind of lady-bug (*Rodōlia cardinālis*), which feeds upon this pest and multiplies rapidly, soon checked the pest, and averted the disaster.

But insects are of interest to us for other reasons than the influence they may have upon our material welfare; the study of them is a fruitful field for intellectual growth. It is not a small matter to be able to view intelligently the facts presented by the insect world, to know something of what is going on around us. And so extensive and complex is this field that no one gains more than a mere smattering concerning it.

We know as yet comparatively little about the minute structure of insects; the transformations and habits of the greater number of species have not been studied; and the blood-relationship of the various groups of insects is very imperfectly understood. If, therefore, one would learn something of the action of the laws that govern the life and development of organized beings, and at the same time experience the pleasure derived from original investigation, he cannot find a better field than is offered by the study of insects.

But it is not necessary that one should have the tastes and leisure required for careful scientific investigation in order to profit by this study. It can be made a recreation, a source of entertainment when we are tired, a pleasant occupation for our thoughts when we walk. Any one can find out something new regarding insect architecture — the ways in which these creatures build nests for themselves or for their young. It is easy to observe remarkable feats of engineering, wonderful industry, unremitting care of young, tragedies, and even war and slavery.

The abundance of insects makes it easy to study them. They can be found whereever man can live, and at all seasons. This abundance is even greater than is commonly supposed. The number of individuals in a single species is beyond computation: who can count the aphids or the scale-insects in a single orchard, or the bees in a single meadow?

Not only are insects numerous when we regard individuals, but the number of species is far greater than that of all other animals taken together. The number of species in a single family is greater in several cases than the number of stars visible in a clear night.

The word *insect* is often applied incorrectly to any minute animal; but the term should be restricted to those forms possessing six legs and belonging to the class, Hexapoda. The name *Hexapoda* is from two Greek words: *hex*, six; and *pous*, foot. It refers to the fact that the members of this order differ from other arthropods in the possession of only six feet. Thus spiders, which have eight legs, are not insects.

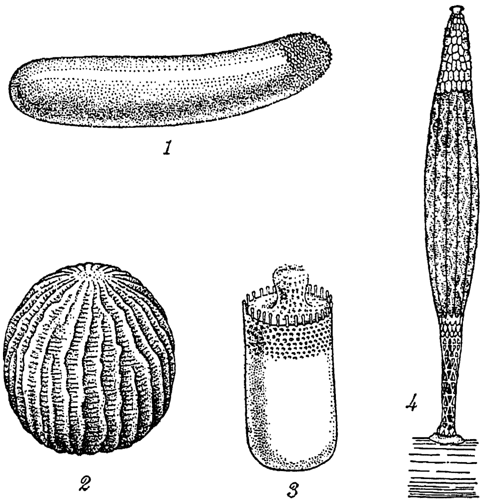
Insects breathe by means of a system of air-tubes (tracheæ) which extend through the body. This is true even in the case of those that live in water and are supplied with gill-like organs (the tracheal gills). The head is distinct from the thorax, and bears a single pair of antennæ; in these respects they are allied to the millipedes and centipedes although they are apparently more closely related to a small group of animals known as symphylids.

Insects can be easily distinguished by the number of their feet, and usually, also by the presence of wings.

While the young pupils should not be drilled in insect anatomy as if they were embryo zoologists, yet it is necessary for the teacher who would teach intelligently to know something of the life stories, habits, and structure of the common insects.

Nearly all insects in the course of their lives undergo remarkable changes in form. Thus the butterfly, which delights us with its airy flight, was at one time a caterpillar; and the busy bee lived first the life of a clumsy grub. Generally speaking, insects develop from eggs. The word egg brings before most of us the picture of the egg of the hen or of some other bird. But insect eggs are often far more beautiful than those of any bird; they are of widely differing forms and are often exquisitely colored; the shells may be ornately ribbed and pitted, are sometimes adorned with spines, and are as beautiful to look at through a microscope as the most artistic piece of mosaic.

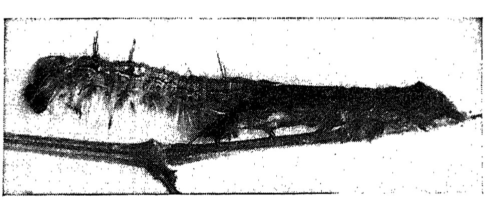
From the eggs, larvæ (*singular, larva*) issue. These larvæ may be caterpillars, or the creatures commonly called worms, or perhaps maggots or grubs. The larval stage is devoted to feeding and to growth. It is the chief business of the larva to eat diligently and to attain maturity as soon as possible; for often the length of the larval period depends more upon food than upon lapse of time. All insects have their skeletons on the outside of the body; that is, the outer covering of the body is chitinous, and the soft and inner parts are attached to it and supported by it. This skin is so firm that it cannot stretch to accommodate the increasing size of the growing insect, so from time to time it is shed. But before this is done, a new skin is formed beneath the old one. After the old skin bursts open and the insect crawls forth, the new skin is sufficiently soft and elastic to allow for the increase in the size of the insect. Soon the new skin becomes hardened like the old one, and after a time is shed. This shedding of the skin is called molting.



Eggs of insects: 1, *the tree-cricket,* Œcanthus nigricornus; 2, *the White Mountain butterfly,* Œnis semidea; 3, *stinkbug,* Piezosterum subulatum; 4, *water-measurer,* Hydrometra martini

Some insects shed their skins only four or five times during the period of attaining their growth, while other species may molt twenty times or more.

After the larva has attained its full growth it changes its skin and its form, and becomes a pupa. The pupa stage is ordinarily one of inaction, except that very wonderful changes take place within the body itself. Usually the pupa has no power of moving around, but in many cases it can squirm somewhat, if disturbed. The pupa of the mosquito is active and is an exception to the rule. The pupa is usually an oblong object and seems to be without head, feet, or wings;



M. V. Slingerland

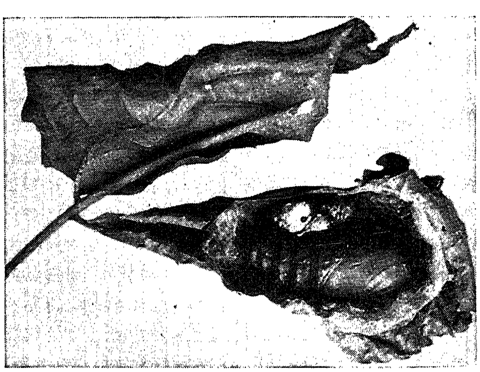
The forest tent-caterpillar shedding its skin

M. V. Slingerland

Full-grown caterpillar of the luna moth

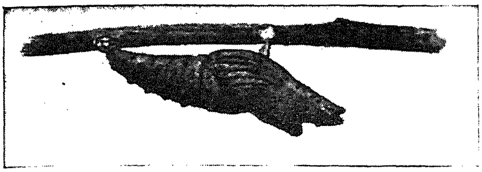
but if it is examined closely, especially in the case of butterflies and moths, the antennæ, wings, and legs may be seen, folded down beneath the pupa skin.

Many larvæ, especially among the moths, weave about themselves a covering of silk which serves to protect them from their enemies and the weather during the helpless pupa period. This silken covering is called a cocoon. The larvæ of butterflies do not make a silken cocoon, but the pupa is suspended to some object by a silken knob, sometimes by a halter of silk, and remains entirely naked. The pupa of a butterfly is called a chrysalis. Care should be taken to have the children use the words pupa, chrysalis, and cocoon understandingly.



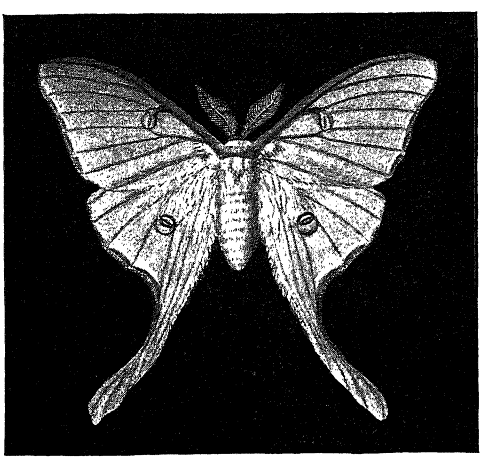
M. V. Slingerland

A luna cocoon cut open, showing the pupa



A butterfly chrysalis

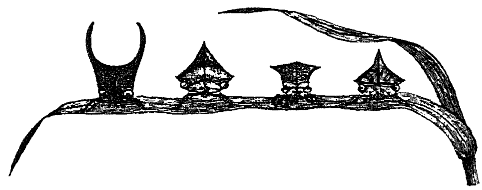
After a period varying from days to months, depending upon the species of insect and the climate, the pupa skin bursts open and from it emerges the adult insect, often equipped with large and beautiful wings and always provided with six legs and a far more complex structure of the body than characterized it as a larva. The insect never grows after it reaches this adult stage and therefore never molts. Some people seem to believe that a small fly will grow into a large fly, and a small beetle into a large beetle; but after an insect attains its perfect wings it does not grow larger. Many adult insects take very little food, although some continue to eat in order to support life. The adult stage is ordinarily shorter than the larval stage; it seems a part of nature's economic plan that the grown-up insects should live only long enough to lay eggs, and thus secure the continuation of the species. Insects having the four distinct stages in their growth, egg, larva, pupa, and adult, are said to undergo *complete metamorphosis*.



A luna moth

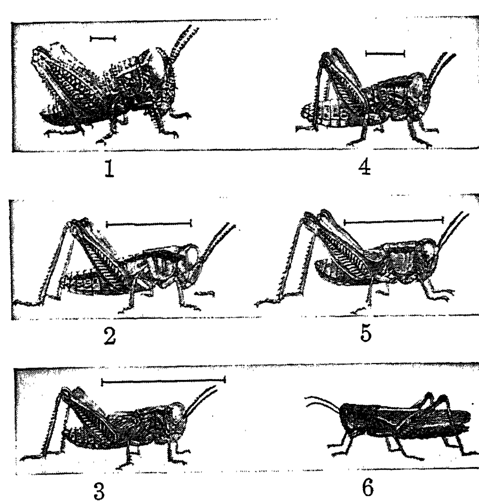
The delicate, exquisite green of the luna's wings is set off by the rose-purple, velvet border of the front wings, and the white fur on the body and inner edge of the hind wings. Little wonder that it has been called the "Empress of the Night." The long swallow tail of the hind wings gives the moth a most graceful shape, and at the same time probably affords it protection from observation. During the daytime the moth hangs, wings down, beneath the green leaves, and these long projections of the hind wings folded together resemble a petiole, making the insect look very much like a large leaf

But not all insects pass through an inactive pupa stage. With some insects, like the grasshoppers, the young, as soon as they are hatched, resemble the adult forms



Insect brownies; tree hoppers as seen through a lens

in appearance. These insects, like the larvæ, shed their skins to accommodate their growth, but they continue to feed and move about actively until the final molt when the perfect insect appears. Such insects are said to have *incomplete metamorphosis*, which simply means that the form of the body of the adult insect is not greatly different from that of the young; the dragonflies, crickets, grasshoppers, and bugs are of this type. It must be remembered that while many people refer to all insects as bugs, the term bug is cor-



The grasshopper is an example of incomplete metamorphosis

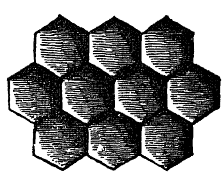
1, nymph, first stage; 2, nymph, second stage; 3, nymph, third stage; 4, nymph, fourth stage; 5, nymph, fifth stage; 6, adult rectly applied only to one group of insects. This group includes such forms as stinkbugs, squash bugs, plant lice, and tree hoppers. The young of insects with an incomplete metamorphosis are called nymphs instead of larvæ.

Summary of the Metamorphoses of Insects

Kinds of Metamorphosis	*Names of Stages*
I. Complete metamorphosis (example, butterfly)	Egg. Larva. Pupa. (Among the moths the pupa is sometimes enclosed in a cocoon.) Adult or winged insect.
II. Incomplete metamorphosis (example, grasshopper)	Egg. Nymph (several stages). Adult, or imago.

The Structure of Insects

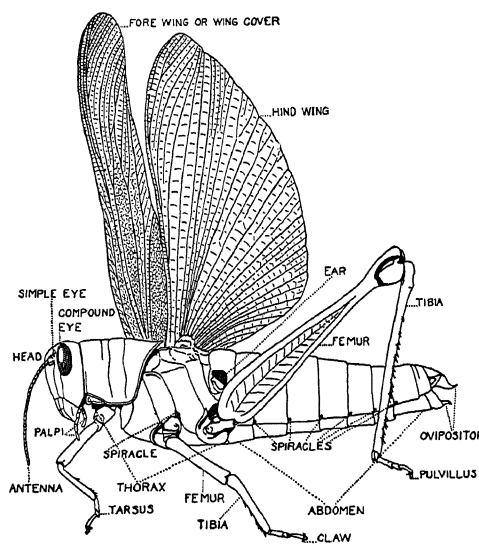
The insect body is made up of ringlike segments which are grown together. These segments are divided into groups according to their use and the organs which they bear. Thus the segments of an insect's body are grouped into three regions: the head, the thorax, and the abdomen. The head bears the eyes, the antennæ, and the mouth-parts. On each side



A part of the compound eye, enlarged, of an insect

of the head of the adult insect may be seen the compound eyes; these are so called because they are made up of many small eyes set together, much like the cells of the honeycomb. These compound eyes are not found in larvæ of insects with complete metamorphosis, such as caterpillars, maggots, and beetle grubs. In addition to the compound eyes, many adult insects possess simple eyes; these are placed between the compound eyes and are usually three in number. Often they cannot be seen without the aid of a lens.

The antennæ or feelers are composed of many segments and are inserted in front of the eyes or between them. They vary greatly in form. In some insects they are mere threads; in others, like the silkworm moths, they are large, feather-like organs.



May Gyger

Grasshopper, with the parts of the external anatomy named

The mouth-parts of insects vary greatly in structure and in form, being adapted to the life of the insect species to which they minister. Some insects have jaws fitted for seizing their prey, others for chewing leaves; others have a sucking tube for getting the juices from plants or the blood from animals, and others long delicate tubes for sipping the nectar from flowers.

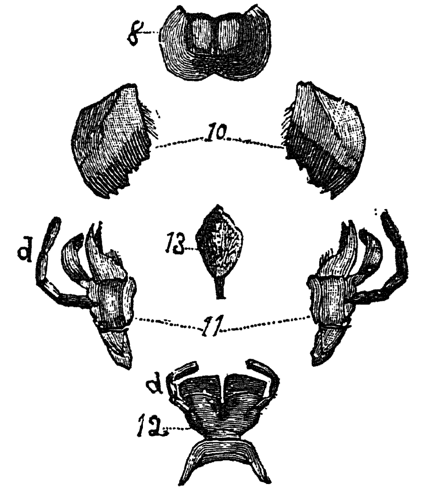
M. V. Slingerland

A sphinx moth with the sucking tongue unrolled

In the biting insects, the mouth-parts consist of an upper lip, the labrum, an under lip, the labium, and two pairs of jaws between them. The upper pair of jaws is called the mandibles and the lower pair, the maxillæ (*singular maxilla*). There may be also within the mouth one or two tonguelike organs. Upon the maxillæ and upon the lower lip there may also be feelers, which are called palpi (*singular palpus*). The jaws of insects, when working, do not move up and down, as do ours, but move sidewise like shears. In many of the insects, children can observe the mandibles and the palpi without the aid of a lens.

The thorax is the middle region of the insect body. It is composed of three of the body segments more or less firmly joined together. The segment next the head is called the prothorax, the middle one, the mesothorax, and the hind one, the metathorax. Each of these segments bears a pair of legs and, in the winged insects, the second and third segments bear the wings.

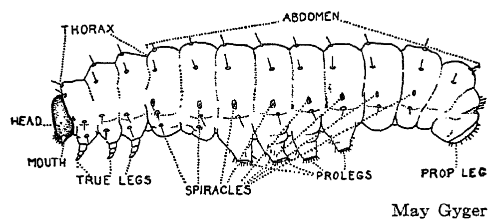
The mouth of the tree hopper, shown here extending beneath the body, is a long, three-jointed sucking tube



The mouth-parts of a grasshopper, enlarged and named

8, upper lip or labrum; 10, mandibles or upper jaws; 11, maxillae or lower jaws; 12, under lip or labium; 13, tongue; d, palpi

Each leg consists of two small segments next to the body, next to them a longer segment, called the femur, beyond this a segment called the tibia, and beyond this the tarsus or foot. The tarsus is made up of a number of segments, varying from one to six, the most common number being five. The last segment of the tarsus usually bears one or two claws.



May Gyger

A caterpillar, with the parts of the external anatomy named

While we have little to do with the internal anatomy of insects in elementary nature-study, the children should be taught something of the way that insects breathe. The child naturally believes that the insect, like himself, breathes through the mouth, but as a matter of fact insects breathe through their sides. If we examine almost any insect carefully, we can find along the sides of the body a series of openings. These are called the spiracles, and through them the air passes into the insect's body. The number of spiracles varies greatly in different insects. There is, however, never more than one pair on a single segment of the body, and they do not occur on the head. The spiracles, or breathing pores, lead into a system of air tubes which are called tracheæ (*tra'-ke-ee*), which permeate the insect's body and thus carry the air to every smallest part of its anatomy. The blood of the insect bathes these thin-walled air tubes and thus becomes purified, just as our blood becomes purified by bathing the air tubes of our lungs. Thus, although the insects do not have localized breathing organs, like our lungs, they have, if the expression may be permitted, lungs in every part of their little bodies.

SUGGESTED READING — *Elementary Lessons on Insects*, by James G. Needham; *Field Book of Insects*, by Frank E. Lutz; *Hand Book for the Curious*, by Paul G. Howes; *Insect Life*, by John Henry Comstock; *Insect Ways*, by Clarence M. Weed; *An Introduction to Entomology*, by John Henry Comstock; *A Manual for the Study of Insects*, by John Henry Comstock, Anna B. Comstock, and Glenn W. Herrick; *Nature Study and Science*, by Gilbert H. Trafton; *Our Insect Friends and Foes and Spiders*, published by the National Geographic Society; *Parade of the Animal Kingdom*, by Robert Hegner; additional references are to be found in the bibliography in the back of this Handbook, under various headings: Insects and Other Invertebrates, Animals in General, Nature-Study in General, Textbooks and Readers, Nature Poetry, Magazines and Periodicals, Books for Parents and Teachers. Many state and federal bulletins give additional information.

SUMMARY OF STRUCTURE OF AN INSECT

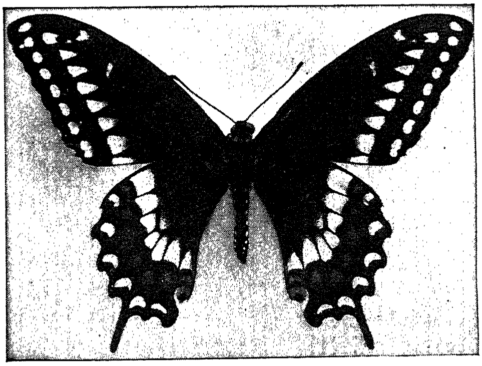
- Head
  - Antennæ.
  - Compound eyes.
  - Simple eyes or ocelli.
  - Mouth-parts
    - Labrum, or upper lip.
    - Mandibles, or upper jaws.
    - Maxillæ, or lower jaws, and maxillary palpi.
    - Labium and labial palpi.
- Thorax
  - Prothorax and first pair of legs.
  - Mesothorax and
    - second pair of legs.
    - first pair of wings.
  - Metathorax and
    - third pair of legs.
    - second pair of wings.
  - Wing
    - veins.
    - cells.
  - Leg
    - Two small segments called coxa and trochanter.
    - Femur.
    - Tibia.
    - Tarsus and claws.
- Abdomen
  - The abdomen bears
    - ears (in locusts only)
    - spiracles.
    - ovipositor.

INSECTS OF THE FIELDS AND WOODS

Some insects go through all the stages of their development on land; these are the insects of fields and woods. This group includes some of the most interesting and beautiful of insects. They are especially well adapted for nature-study because specimens are constantly available. The insects presented from page 301 to page 400 are common examples of this group.

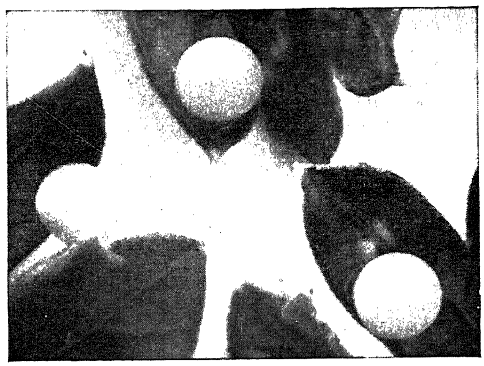
THE BLACK SWALLOWTAIL BUTTERFLY

This graceful butterfly is a very good friend to the flowers, being a most efficient pollen-carrier. It haunts the gardens and sips nectar from all the blossom cups held out for its refreshment; and it is found throughout almost all parts of the United States. The grace of its appearance is much enhanced by the " swallowtails," two projections from the hind margins of the hind wings. The wings are velvety black with three rows of yellow spots across them, the outer row being little crescents set in the margin of the wing; and each triplet of yellow spots is in the same cell of the wing between the same two veins. The hind wings are more elaborate, for between the two inside rows of yellow spots, there are exquisite metallic blue splashes, more vivid and more sharply outlined toward the inside of the wing and shading off to black at the outside. And just above the inner angle of the hind wing is an orange eyespot with a black center. On the lower surface of the wings, most of the yellow spots are replaced with orange.



M. V. Slingerland

Black swallowtail butterfly

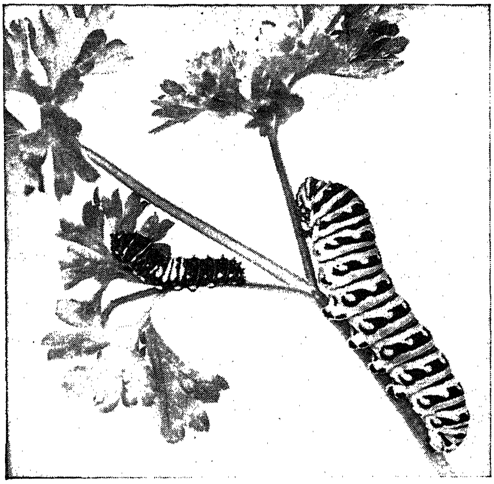


M. V. Slingerland

The eggs of the black swallowtail butterfly, enlarged

The mother butterfly is larger than her mate and has more blue on her wings, while he has the yellow markings of the hind wings much more conspicuous. She lays her eggs, which are just the color of a drop of honey, on the under surface of the leaves of the food plant. After about ten days there hatch from these eggs spiny little fellows, black and angular, each with a saddle-shaped, whitish blotch in the middle of the back. But it would take an elfin rider to sit in this warty, spiny saddle. The caterpillar has six spines on each segment, making six rows of spines the whole length of the body; the spines on the black portions are black and those on the saddle white, but they all have orange-colored bases.

When little, spiny saddle-back gets ready to change its skin to one more commodious for its increased size, it seeks



Dept. of Entomology, Cornell U.

Black swallowtail caterpillars, showing two stages of growth

some convenient spot on the leaf or stem and spins a little silken carpet from the silk gland opening in its under lip; on this carpet it rests quietly for some time, and then the old tight skin splits down the back, the head portion coming off separately. Swelling out to fill its new skin to the utmost, the caterpillar leaves its cast-off clothes clinging to the silken carpet and marches back to its supper.

But after one of these changes of skin it becomes a very different looking caterpillar, for now it is as smooth as it was formerly spiny; it is now brilliant caraway green, ornamented with roundwise stripes of velvety black; and set in the front margin of each of these stripes are six yellow spots. In shape, the caterpillar is larger toward the head; its true feet have little, sharp claws and look very different from the four pairs of prolegs and the hind prop-leg, all of which enable him to hold fast to the stem or the leaf; these fat legs are green, each ornamented with a black, velvety polka dot.

When we were children we spent hours poking these interesting creatures with straws to see them push forth their brilliant orange horns. We knew this was an act of resentment, but we did not realize that from these horns was exhaled the nauseating odor of caraway which greeted our nostrils. We incidentally discovered that they did not waste this odor upon each other, for once we saw two of the full-grown caterpillars meet on a caraway stem. Neither seemed to know that the other was there until they touched; then both drew back the head and butted each other like billy goats, whack! whack! Then both turned laboriously around and hurried off in a panic.

The scent organs of these caterpillars are really little Y-shaped pockets in the segment back of the head, pockets full of this peculiar caterpillar perfume. Under the stimulus of attack, the pocket is turned wrong side out and pushed far out making the "horns," and at the same time throwing the strong odor upon the air. This spoils the flavor of these caterpillars as bird food, so they live on in serene peace, never hiding under the leaves but trusting, like the skunk, to a peculiar power of repelling the enemy.

We must admire this caterpillar for the methodical way in which it eats the leaf: beginning near the base, it does not burn its bridges behind it by eating through the midrib, but eats everything down to the midrib; after it arrives at the tip of the leaf it finishes midrib and all on its return journey, doing a clean job, and finishing everything as it moves along.

When the caterpillar has completed its growth, it is two inches long; it then seeks some sheltered spot, the lower edge of a clapboard or fence rail being a favorite place; it there spins a button of silk which it grasps firmly with its hind prop-leg, and then, with head up, or perhaps horizontal, it spins a strong loop or halter of silk, fastening each end of it firmly to the object on which it rests. It thrusts its head through, so that the halter acts as a sling holding the insect from falling. There it sheds its last caterpillar skin, which shrinks back around the button, revealing the chrysalis, which is angular with earlike projections in front. Then comes the critical moment, for the chrysalis lets go of the button with its caterpillar feet, and, trusting to the sling for support, pushes off the shrunken skin just shed and inserts the hooks with which it is furnished firmly in the button of silk. Sometimes during this process, the chrysalis loses its hold entirely and falls to the ground, which is a fatal disaster. The chrysalis is yellowish brown and usually looks very much like the object to which it is attached, and is thus undoubtedly protected from the sight of possible enemies. Then some day it breaks open, and from it issues a crumpled mass of very damp insect velvet, which soon expands into a beautiful butterfly.

Suggested Reading — *Butterfly and Moth Book*, by Ellen Robertson-Miller; *Holiday Meadow*, by Edith M. Patch; *How to Know the Butterflies*, by John Henry Comstock and Anna B. Comstock; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals; Now for Creatures*, by Shelby Shackelford; *Scientific Living Series, Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on page 300.

LESSON 70

The Black Swallowtail Butterfly

Leading Thought — The caterpillars of the swallowtail butterflies have scent organs near the head which they thrust forth when attacked, thus giving off a disagreeable odor which is nauseating to birds.

Method — In September, bring into the schoolroom and place in the terrarium, or breeding cage, a caraway or parsley plant on which these caterpillars are feeding, giving them fresh food day by day, and allow the pupils to observe them at recess and thus complete the lesson.

The Caterpillar and Chrysalis

Observations — 1. Touch the caterpillar on the head with a bit of grass. What does it do? What color are the horns? Where do they come from? Are there two separate horns or two branches of one horn? What odor comes from these horns? How does this protect the caterpillar? Does the caterpillar try to hide under the leaves when feeding?

2. Describe the caterpillar as follows: What is its shape? Is it larger toward the head or the rear end? What is its ground color? How is it striped? How many black stripes? How many yellow spots in each black stripe? Are the yellow spots in the middle, or at each edge of the stripe?

3. How do the front three pairs of legs look? How do they compare with the prolegs? How many prop-legs are there? What is the color of the prolegs? How are they marked? Describe the prop-leg. What is its use?

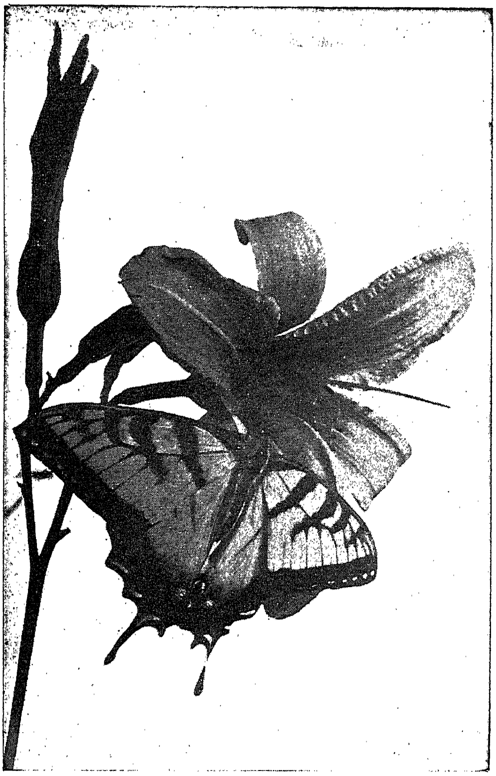
4. Observe the caterpillar eating a leaf. How does it manage so as not to waste any?

5. Have you found the egg from which the caterpillar came? What color is it? Where is it laid?

6. How does the young caterpillar look? What are its colors? How many fleshy spines has it on each segment? Are these white on the white segments and black on the black segments? What is the color of the spines at their base?

7. Watch one of these caterpillars shed its skin. How does it prepare for this? How does it spin its carpet? Where does the silk come from? Describe how it acts when shedding its skin.

At the top is a caterpillar of the black swallowtail butterfly ready to change to the chrysalis form. Below is shown a chrysalis of the black swallowtail butterfly



A tiger swallowtail butterfly visiting a lily

8. When a caterpillar is full grown, how does it hang itself up to change to a chrysalis? How does it make the silk button? How does it weave the loop or halter? How does it fasten it? When the halter is woven what does the caterpillar do with it? Describe how the last caterpillar skin is shed. How does the insect use its loop or halter while getting free from the molted skin?

9. Describe the chrysalis. What is its general shape? What is its color? Is it easily seen? Can you see where the wings are, within the chrysalis? How is the chrysalis supported?

10. How does the chrysalis look when the butterfly is about to emerge? Where does it break open? How does the butterfly look at first?

THE BUTTERFLY

1. Why is this butterfly called the black swallowtail? What is the ground color of the wings? How many rows of yellow spots on the front wings? Are they all the same shape? How are they arranged between each two veins? Describe the hind wings. What colors are on them that are not on the front wings? Describe where this color is placed. Describe the eyespot on the hind wing. Where is it? How do the markings on the lower side of the wing differ from those above? How does the ground color differ from the upper side?

2. What is the color of the body of the butterfly? Has it any marks? Has it the same number of legs as the monarch butterfly? Describe its antennæ. Watch the butterfly getting nectar from the petunia blossom and describe the tongue. Where is the tongue when not in use?

3. How does the mother butterfly differ in size and in markings from her mate?

The "caraway worms" were the ones that revealed to us the mystery of the pupa and butterfly. We saw one climb up the side of a house, and watched it as with many slow, graceful movements of the head it wove for itself the loop of silk which we called the "swing" and which held it in place after it changed to a chrysalis. We wondered why such a brilliant caterpillar should change to such a dull-colored object, almost the color of the clapboard against which it hung. Then, one day, we found a damp, crumpled, black butterfly hanging to the empty chrysalis skin, its wings "all mussed" as we termed it; and we gazed at it pityingly; but even as we gazed, the crumpled wings expanded and then there came to our childish minds a dim realization of the miracle wrought within that little, dingy, empty shell.

— "HOW TO KNOW THE BUTTERFLIES,"
COMSTOCK

American Museum of Natural History

Migrating monarch butterflies

THE MONARCH BUTTERFLY

It is a great advantage to an insect to have the bird problem eliminated, and the monarch butterfly enjoys this advantage to the utmost. Its method of flight proclaims it, for it drifts about in a lazy, leisurely manner, its glowing red making it like a gleaming jewel in the air, a very different flight indeed from the zigzag dodging movements of other butterflies. The monarch has an interesting race history. It is a native of tropic America, and has probably learned through some race instinct that by following its food plant north with the opening season, it gains immunity from special enemies other than birds, which attack it in some stage in its native haunts. Each mother butterfly follows the spring northward as it advances, as far as she finds the milkweed sprouted. There she deposits her eggs, from which hatch individuals that carry on the migration as far to the north as possible. It usually arrives in New York State early in July. As cold weather approaches, the monarchs often gather in large flocks and move back to the South. How they find their way we cannot understand, since there are among them none of the individuals which pressed northward early in the season.

The very brilliant copper-red color of the upper sides of the wings of the monarch is made even more brilliant by the contrasting black markings which outline the veins and border the wings, and also cover the tips of the front wings with a

The monarch butterfly

triangular patch; this latter seems to be an especially planned background for showing off the pale orange and white dots set within it. There are white dots set, two pairs in two rows, between each two veins in the black margin of the wings; and the fringe at the edge of the wings shows corresponding white markings. The hind wings and the front portions of the front wings have, on their lower sides, a ground color of pale yellow, which makes the insect less conspicuous when it alights and folds its wings above its back, upper surfaces together. The black veins, on the lower surface of the hind wings, are outlined with white, and the white spots are much larger than on the upper surface. The body is black, ornamented with a few pairs of white spots above and with many large white dots below. The chief distinguishing characteristic of insects is the presence of six legs; but in this butterfly the front legs are so small that they scarcely look like legs.

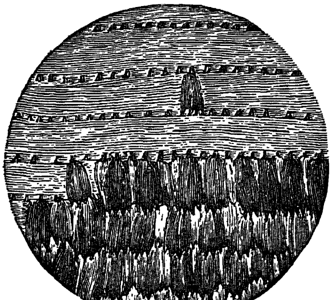
It is easy to observe the long, coiled tongue of the butterfly. If the act is done gently, the tongue may be uncoiled by lifting it out with a pin. It is very interesting to see a butterfly feeding upon nectar; this may be observed in the garden almost any day. I have also observed it indoors, by bringing in petunias and nasturtiums for my imprisoned butterflies, but they are not so likely to eat when in confinement. The antennæ are about two-thirds as long as the body and each ends in a long knob; this knob, in some form, is what distinguishes the antennæ of the butterflies from those of moths. The male monarch has a black spot upon one of the veins of the hind wing; this is a perfume pocket and is filled with what are called scent scales. These are scales of peculiar shape which cover the wing at this place and give forth an odor which we with our coarse sense of smell cannot perceive; but the lady monarch is attracted by this odor. The male monarch may be described to the children as a dandy carrying a perfume pocket to attract his sweetheart.

It is very interesting to the pupils if they are able to see a bit of the butterfly's wing through a lens or microscope; the covering of scales, arranged in such perfect

The viceroy butterfly. Note the black band on the hind wings. This band distinguishes the viceroy from the monarch, which it resembles in color and markings rows, is very beautiful and also very wonderful. The children know that they get dust upon their fingers from butterflies' wings, and they should know that each grain of this dust is an exquisite scale with notched edges and a ribbed surface.

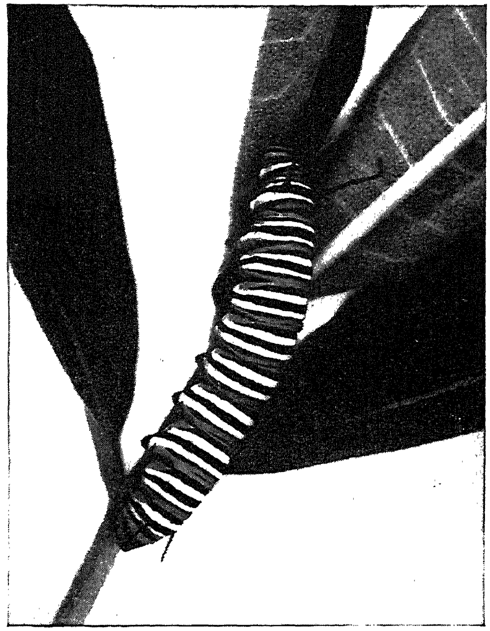
The monarch is, for some reason unknown to us, distasteful to birds, and its brilliant colors are an advertisement to all birds of discretion that here is an insect which tastes most disagreeable and which, therefore, should be left severely alone. There is another butterfly called the viceroy which has taken advantage of this immunity from bird attack on the part of the monarch and has imitated its colors in a truly remarkable way, differing from it only in being smaller in size and having a black band across the middle of the hind wing.

The milkweed caterpillar, which is the young of the monarch butterfly, is a striking object, and when fully grown is about two inches long. The milkweed is a succulent food and the caterpillar may mature in eleven days; it is a gay creature, with ground color of green and cross stripes of yellow and black. On top of the second segment, back of the head, are two long, slender, whiplash-like organs, and on the seventh segment of the abdomen is a similar pair. When the caterpillar is frightened, the whiplashes at the front of the body twitch excitedly; when it walks, they



The scales on a butterfly's wing as seen through a microscope

move back and forth. Those at the rear of the body are more quiet and not so expressive of caterpillar emotions. These filaments are undoubtedly of use in frighten-



M. V. Slingerland

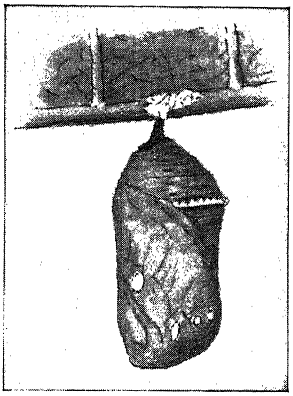
The monarch caterpillar

ing away the little parasitic flies that lay their eggs upon the backs of caterpillars; these eggs hatch into little grubs that feed upon the internal fatty portions of the caterpillar and bring about its death through weakness. I remember well when I was a child, the creepy feeling with which I beheld these black- and yellow-ringed caterpillars waving and lashing their whips back and forth after I had disturbed them; if the ichneumon flies were as frightened as I, the caterpillars were surely safe.

The caterpillar will feed upon no plant except milkweed; it feeds both day and night, with intervals of rest, and when resting hides beneath the leaf. Its striking colors undoubtedly defend it from birds, because it is as distasteful to them as is the butterfly. However, when frightened, these caterpillars fall to the ground where their stripes make them very inconspicuous among the grass and thus perhaps save them from the attack of some animals other than birds. These caterpillars, like all others, grow by shedding the skeleton skin as often as it becomes too tight.

The monarch chrysalis is, I maintain,

the most beautiful gem in Nature's jewel casket; it is an oblong jewel of jade, darker at the upper end and shading to



Monarch chrysalis. A jewel of living jade and gold

the most exquisite whitish green below; outlining this lower paler portion are shining flecks of gold. If we look at these gold flecks with a lens, we cannot but believe that they are bits of polished gold foil. There may be other gold dots also, and outlining the apex of the jewel is a band of gold with a dotted lower edge of jet; and the knob at the top, to which the silk which suspends the chrysalis is fastened, is also jet. The chrysalis changes to a darker blue-green after two days, and black dots appear in the gold garniture. As this chrysalis is usually hung to the underside of a fence rail or overhanging rock, or to a leaf, it is usually surrounded by green vegetation, so that its green color protects it from prying eyes. Yet it is hardly from birds that it hides; perhaps its little gilt buttons are a hint to birds that this jewel is not palatable. As it nears the time for the butterfly to emerge, the chrysalis changes to a duller and darker hue. The butterfly emerges about twelve days after the change to a chrysalis.

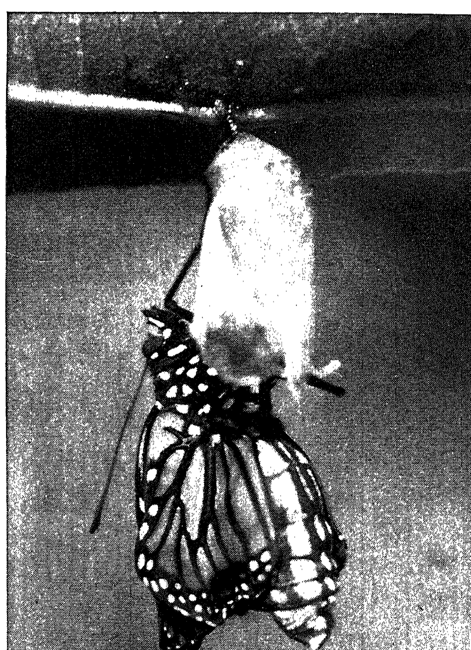
Suggested Reading — *Butterfly and Moth Book*, by Ellen Robertson-Miller; *Do You Know?* by Janet Smalley; *How to Know the Butterflies*, by John Henry Comstock and Anna B. Comstock; *Interesting Neighbors*, by Oliver P. Jenkins; *Now for Creatures*, by Shelby Shackelford; *Scientific Living Series, Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on page 300.

LESSON 71

The Monarch Butterfly

Leading Thought — The monarch butterfly migrates northward in spring and summer, moving up as the milkweed appears, so as to give food to its caterpillar; and it has often been noticed migrating back southward in the autumn in large swarms. This insect is distasteful to birds in all its stages. Its chrysalis is one of the most beautiful objects in all nature.

Method — This lesson may be given in September, while yet the caterpillars of the monarch may be found feeding upon milkweed, and while there are yet many specimens of this gorgeous butterfly to be seen. The caterpillars may be brought in on the food plant, and their habits and performances studied in the schoolroom; but care should be taken not to have the atmosphere too dry.



L. W. Brownell

Monarch butterfly emerging from the chrysalis

The Butterfly

Observations — 1. How can you tell the monarch butterfly from all others? What part of the wings is red? What portions are black? What portions are white? What are the colors and markings on the lower side of the wings? What is the color of the body and how is it ornamented?

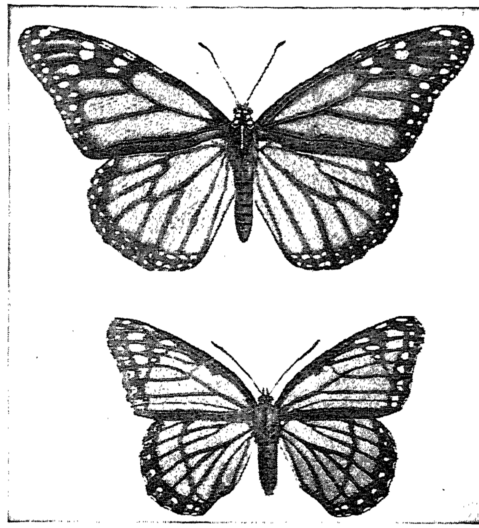
2. Is the flight of the monarch rapid, or slow and leisurely? Is it a very showy insect when flying? Are its colors more brilliant in the sunshine when it is flying than at any other time? Why is it not afraid of birds?

3. When the butterfly alights, how does it hold its wings? Do you think it is as conspicuous when its wings are folded as when they are open?

4. Can you see the butterfly's tongue? Describe the antennæ. How do they differ from the antennæ of moths? How many legs has this butterfly? How does this differ from other insects? Note if you can see any indications of front legs.

5. Is there on the butterfly you are studying a black spot near one of the veins on each hind wing? Do you know what this is? What is it for?

6. Why are the striking colors of this butterfly a great advantage to it? Do you know of any other butterfly which imitates it and thus gains an advantage?



Above, a monarch butterfly; below, a viceroy. In color and markings, except for the black bands on the hind wings of the viceroy, they are similar

The Caterpillar

1. Where did you find the monarch caterpillar? Was it feeding below or above on the leaves? Describe how it eats the milkweed leaf.

2. What are the colors and the markings of the caterpillar? Do you think these make it conspicuous?

3. How many whiplash-shaped filaments do you find on the caterpillar? On which segments are they situated? Do these move when the caterpillar walks or when it is disturbed? Of what use are they to the caterpillar?

4. Do you think this caterpillar would feed upon anything except milkweed? Does it rest, when not feeding, upon the upper or the lower surface of the leaves? Does it feed during the night as well as the day?

5. If disturbed, what does the caterpillar do? When it falls down among the grass, how do its cross stripes protect it from observation?

6. Tell all the interesting things which you have seen this caterpillar do.

The Chrysalis

1. When the caterpillar gets ready to change to a chrysalis what does it do? How does it hang up? Describe how it sheds its skin.

2. Describe the chrysalis. What is its color? How and where is it ornamented? Can you see, in the chrysalis, those parts which cover the wings of the future butterfly?

3. To what is the chrysalis attached? Is it in a position where it does not attract attention? How is it attached to the object?

4. After three or four days, how does the chrysalis change in color? Observe, if you can, the butterfly come out from the chrysalis, noting the following points: Where does the chrysalis skin open? How does the butterfly look when it first comes out?

How does it act for the first two or three hours? How does the empty chrysalis skin look?

A BUTTERFLY AT SEA

Far out at sea — the sun was high,
While veered the wind and flapped the sail;
We saw a snow-white butterfly
Dancing before the fitful gale
Far out at sea.

The little wanderer, who had lost
His way, of danger nothing knew;
Settled a while upon the mast;
Then fluttered o'er the waters blue
Far out at sea.

Above, there gleamed the boundless sky;
Beneath, the boundless ocean sheen;
Between them danced the butterfly,
The spirit-life of this fair scene,
Far out at sea.

The tiny soul that soared away,
Seeking the clouds on fragile wings,
Lured by the brighter, purer ray
Which hope's ecstatic morning brings —
Far out at sea.

Away he sped, with shimmering glee,
Scarce seen, now lost, yet onward borne!
Night comes with wind and rain, and he
No more will dance before the morn,
Far out at sea.

He dies, unlike his mates, I ween,
Perhaps not sooner or worse crossed;
And he hath felt and known and seen
A larger life and hope, though lost
Far out at sea.

— R. H. Horne

THE ISABELLA TIGER MOTH OR WOOLLY BEAR

Brown and furry,
Caterpillar in a hurry,
Take your walk
To the shady leaf or stalk,
Or what not,
Which may be the chosen spot;
No toad spy you,
Hovering bird of prey pass by you;
Spin and die,
To live again a butterfly.

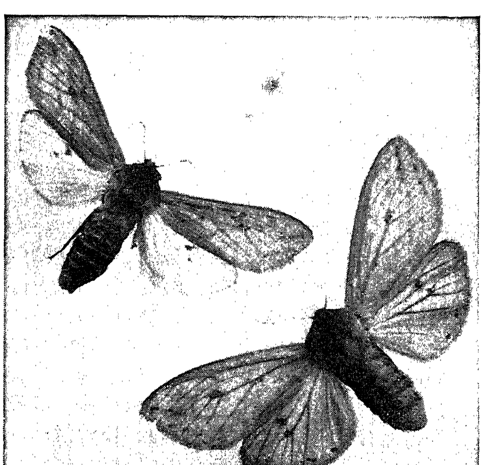
— Christina Rossetti

Many times during autumn, the children find and bring in the very noticeable caterpillar which they call the "woolly bear." It seems to them a companion of the road and the sunshine; it usually seems in a hurry, and if the children know that it is hastening to secure some safe place in which to hide during the season of cold and snow, they are far more interested in its future fate. If the caterpillar is already curled up for the winter, it will "come to" if warmed in the hand or in the sunshine.

The woolly bear is variable in appearance; sometimes five of the front segments are black, four of the middle reddish brown, and three of the hind segments black. In others only four front segments are black, six are reddish, and two are black at the end of the body; there are still other variations, so that each individual will tell its own story of color. There are really thirteen segments in this caterpillar, not counting the head; but the last two are so joined that probably the children will count only twelve. There are a regular number of tubercles on each side of each segment, and from each of these arises a little rosette of hairs; but the tubercles are packed so closely together, that it is difficult for the children to see how many rosettes there are on each side. While the body of the caterpillar looks as if it were covered with evenly clipped fur, there are usually a few longer hairs on the rear segment.

There is a pair of true legs on each of the three front segments which form the thorax, and there are four pairs of prolegs. All of the segments behind the front three belong to the abdomen, and the prolegs are on the 3rd, 4th, 5th, and 6th abdominal segments; the prop-leg is at the rear end of the body. The true legs of this caterpillar have little claws, and are as shining as if encased in patent leather; but the prolegs and prop-leg are merely prolongations of the sides of the body to assist the insect in holding to the leaf. The yellow spot on either side of the first segment is a spiracle; this is an opening leading into the air tubes within the body, around which the blood flows and is thus purified. There are no spiracles on the second and third segments of the thorax, but eight of the abdominal segments have a spiracle on either side.

The woolly bear's head is polished black; its antennæ are two tiny, yellow projections which can easily be seen with the naked eye. The eyes are too small to be thus seen; because of its minute eyes, the woolly bear cannot see very far and, therefore, it is obliged to feel its way. It does this by stretching out the front end of the body and reaching in every direction, to observe if there is anything to cling to in its neighborhood. When we try to seize the woolly bear it rolls up in a little ball, and the hairs are so elastic that we take it up with great difficulty. These



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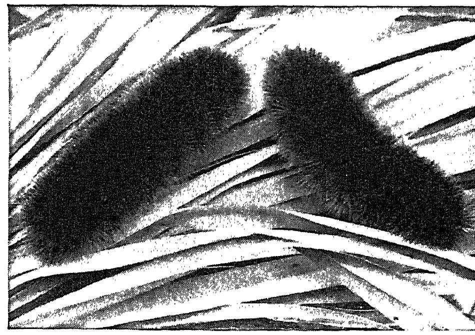
The Isabella tiger moths, the adults of the woolly bear. The larger is the female



M. V. Slingerland

Woolly bears

hairs are a protection from the attacks of birds which do not like bristles for food; and when the caterpillar is safely rolled up, the bird sees only a little bundle of bristles and lets it alone. The woolly bear feeds upon many plants: grass, clover, dandelion, and others. It does not eat very much after we find it in autumn, because its growth is completed. The woolly bear should be kept in a box which should be placed out of doors, so that it may be protected from storms but have the ordinary winter temperature. Keeping it in a warm room during the winter often proves fatal.

M. V. Slingerland

The cocoon of the woolly bear

Normally, the woolly bear does not make its cocoon until April or May. It finds some secluded spot in the fall, and there curls up in safety for the long winter nap; when the warm weather comes in the spring, it makes its cocoon by spinning silk about itself; in this silk are woven the hairs which it sheds easily at that time, and the whole cocoon seems made of felt. It seems amazing that such a large caterpillar can spin about itself and squeeze itself into such a small cocoon; and it is quite as amazing to see within the cocoon the smooth little pupa, in which is condensed all that was essential of the caterpillar. Sometimes when the caterpillars are kept in a warm room they make their cocoons in the fall, but this is not natural.

The issuing of the moth from the cocoon is an interesting lesson for the last of May. The size of the moth which comes from the cocoon seems quite miraculous compared with the size of the caterpillar that went into it. The moth is in color dull, grayish, tawny yellow with a few black dots on the wings; sometimes the hind wings are tinted with dull orange-red. On the middle of the back of the moth's body there is a row of six black dots; and on each side of the body is a similar row. The legs are reddish above and tipped with black. The antennæ are small and inconspicuous. The moths are night fliers, and the mother moth seeks some plant that will be suitable food for the little caterpillar as soon as it is hatched; here she lays her eggs.

Suggested Reading — *Do You Know?* by Janet Smalley; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*; also, readings on page 300.

LESSON 72

The Isabella Tiger Moth or Woolly Bear

Leading Thought — When we see the woolly bear hurrying along in the fall, it is hunting for some cozy place in which to pass the winter. It makes its cocoon, usually in early spring, of silk woven with its own hair. In late spring, it comes forth a yellowish moth with black dots on its wings.

Method — Have the children bring in woolly bears as they find them; place them in boxes or breeding jars which have grass or clover growing in them. The children can handle the caterpillars while they are studying them, and then they should be put back into the breeding jars and be set out of doors where they can have natural conditions; thus the entire history may be studied.

The Caterpillar

Observations — 1. How can you tell the woolly bear from all other caterpillars? Are they all colored alike? How many segments of the body are black at the front end? How many are red? How many segments are black at the rear end of the body? How many segments does this make in all?

2. Look closely at the hairs of the woolly bear. Are they set separately or in rosettes? Are any of the hairs of the body longer than others or are they all even?

3. Can you see, just back of the head, the true legs with their little sharp claws? How many are there?

4. Can you see the fleshy legs along the sides of the body? How many are there of these?

5. Can you see the prop-leg, or the hindmost leg of all? Of what use to the caterpillar are these fleshy legs?

6. Describe the woolly bear's head. How does it act when eating?

7. Can you see a small, bright yellow spot on each side of the segment just behind the head? What do you suppose this is? Can you see little openings along each side of all the segments of the body, except the second and third? What are they? Describe how the woolly bear breathes.

8. On what does the woolly bear feed? If you can find a little woolly bear, give it fresh grass to eat and see how it grows. Why does it shed its skin?

9. When the woolly bear is hurrying along, does it lift its head and the front end of its body now and then? Why does it do this? Do you think it can see far?

10. What does the woolly bear do when you try to pick it up? Do you find you can pick it up easily? Do you think that these stiff hairs protect the woolly bear from its enemies? What are its enemies?

11. Where should the woolly bear be kept in winter to make it comfortable?

The Cocoon

1. When does the woolly bear usually make its cocoon?
2. Of what material is it made? How does the woolly bear get into its cocoon?
3. What happens to it inside the cocoon?
4. Cut open a cocoon and describe how the woolly bear looks now.

The Moth

1. Where did the moth come from?
2. How did it come out of the cocoon? See if you can find the empty pupa case in the cocoon.
3. What is the color of the moth and how is it marked? Are the front and hind wings the same color?
4. What are the markings and colors of the body? Of the legs?
5. What do you think that the mother Isabella will do, if you give her liberty?

The mute insect, fix't upon the plant
On whose soft leaves it hangs, and from whose cup
Drains imperceptibly its nourishment,
Endear'd my wanderings.

— Wordsworth

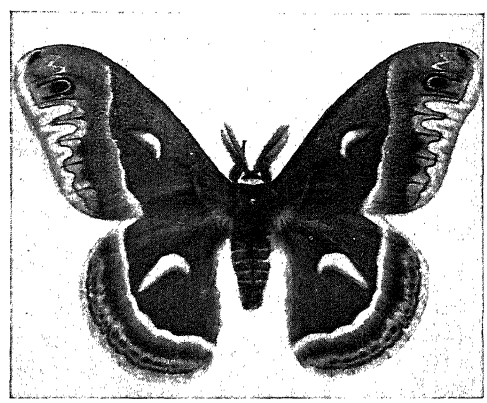
Before your sight,
Mounts on the breeze the butterfly, and soars,
Small creature as she is, from earth's bright flowers
Into the dewy clouds.

— Wordsworth

THE CECROPIA

The silkworm which gives us the silk of commerce has been domesticated for centuries in China. Because of this domestication, it is willing to be handled and is reared successfully in captivity, and has thus come to be the source of most of our silken fabrics. However, we have in America native silkworms which produce a strong and lustrous silk; but the caterpillars have proved difficult to rear in large numbers. Moreover, it would take years to domesticate them, and the amount of labor involved in the production of their silk would be so great that they are unlikely, for many years at least, to be of commercial importance.

The names of our common native silkworms are cecropia, promethea, polyphemus, and luna. In all of these species the moths are large and beautiful, attracting the attention of everyone who sees them. The caterpillars are rarely found, since their varied green colors render them inconspicuous among the leaves on which they feed. None of the caterpillars of the giant silkworms occur in sufficient numbers to injure the foliage of our trees to any extent; they simply help Nature to do a little needful pruning. All of the moths are night flyers and are, therefore, seldom seen except by those who are in-



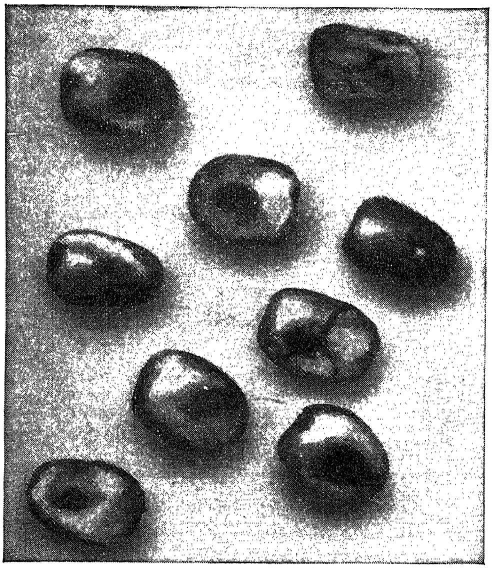
M. V. Slingerland

The cecropia moth

terested in the visitors to our street lights.

The cecropia is the largest of our giant silkworms, the wings of the moth expanding sometimes six and one-half inches. It occurs from the Atlantic Coast to the Rocky Mountains.

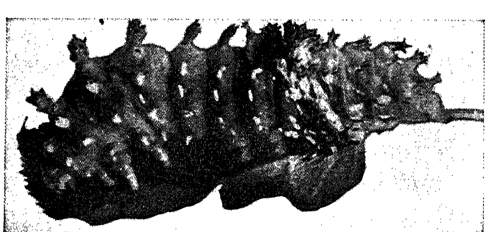
The cecropia cocoon is found most abundantly on our orchard and shade trees; it is called by the children the



M. V. Slingerland

The eggs of the cecropia moth, enlarged

"cradle cocoon," since it is shaped like a hammock and hung close below a branch, and it is a very safe shelter for the helpless creature within it. It is made of two walls of silk, the outer one being thick and paper-like and the inner one thin and firm; between these walls is a matting of loose silk, showing that the insect knows how to make a home that will protect it from winter weather. It is a clever builder in another respect, since at one end of the cocoon it spins the silk lengthwise instead of crosswise, thus making a valve through which the moth can push, when it issues in the spring. It is very interesting to watch one of these caterpillars spin its cocoon. It first makes a framework by stretching a few strands of silk, which it spins from a gland opening in the lower lip; it then makes a loose network upon the supporting strands, and then begins laying on the silk by moving its head back and forth, leaving the sticky thread in the shape of connecting M's or of figure 8's. Very industriously does it work, and after a short time it is so screened by the silk that the rest of its performance remains to us a mystery. It is especially mysterious, since the inner wall of the cocoon encloses so small a cell that the caterpillar is obliged to compress itself in order to fit within it. This achievement would be something like that of a man who should build around himself a box only a few inches longer, wider, and thicker than himself. After the cocoon is entirely finished, the caterpillar sheds its skin for the last time and changes into a pupa.



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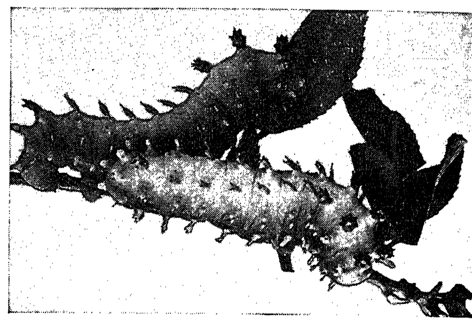
The cecropia caterpillar molting



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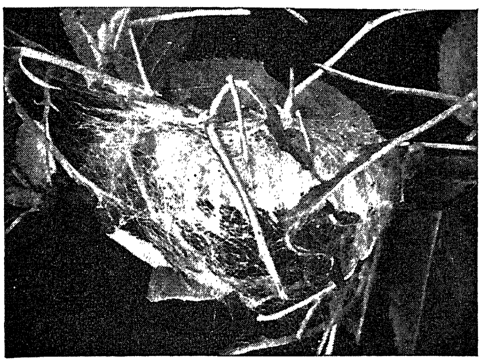
Full-grown cecropia caterpillars

Very different, indeed, does the pupa look from the brilliantly colored, warty caterpillar. It is compact, brown, oval, and smooth, with ability to move but very little when disturbed. The cases which contain the wings, which are later to be the objects of our admiration, are now folded down like a tight cape around the body; and the antennæ, like great feathers, are outlined just in front of the wing cases. There is nothing more wonderful in all nature than the changes which are worked within one of these little, brown pupa cases; for within it, processes go on which change the creature from a crawler among the leaves to a winged inhabitant of the air. When we see how helpless this pupa is, we can understand better how much the strong silken cocoon is needed for protection from enemies, as well as from inclement weather.

In spring, usually in May, after the leaves are well out on the trees, the pupa skin is shed in its turn, and out of it comes the wet and wrinkled moth, its wings all crumpled, its furry, soft body very untidy; but it is only because of this soft and crumpled state that it is able to push its way out through the narrow door into the outer world. It has, on each side of its body just back of the head, two little horny hooks that help it to work its way out. It is certainly a sorry object as it issues, looking as if it had been dipped in water and had been squeezed in an inconsiderate hand. But the wet wings soon spread, the bright antennæ stretch out, the furry covering of the body becomes dry and fluffy, and the large moth appears in all its perfection. The ground color of the wings is a dusky, grayish brown while the outer margins are clay-colored; the wings are crossed, beyond the middle, by a white band which has a broad outside margin of red. There is a red spot near the apex of the front wing, just outside of the zigzag white line; each wing bears, near its center, a crescent-shaped white spot bordered with red. But though it is so large, it does not need to eat; the caterpillar did all the eating that was necessary for the whole life of the insect; the mouth of the moth is not sufficiently perfected to take food.



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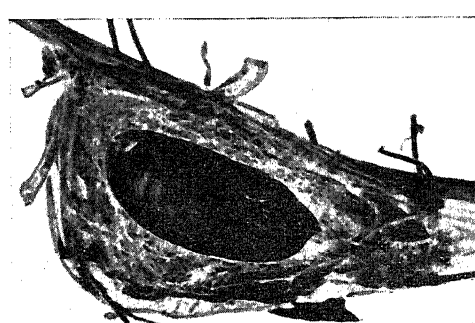
Cecropia caterpillar weaving its cocoon

M. V. Slingerland

A cecropia cocoon

When the cecropia caterpillar hatches from the egg it is about a quarter of an inch long and is black; each segment is ornamented with six spiny tubercles. Like all other caterpillars, it has to grow by shedding its horny, skeleton skin, the soft skin beneath stretching to give more room at first, then finally hardening and being shed in its turn. This first molt of the cecropia caterpillar occurs about four days after it is hatched, and the caterpillar which issues looks quite different than it did before; it is now dull orange or yellow with black tubercles. After six or seven days more of feeding, the skin is again shed and now the caterpillar appears with a yellow body; the two tubercles on the



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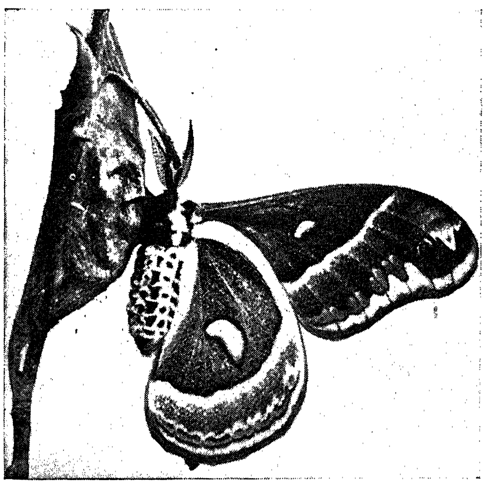
A cecropia cocoon cut open, showing the pupa within it top of each segment are now larger and more noticeable. They are blue on the first segment, large and orange-red on the second and third segments, and greenish blue with blackish spots and spines on all the other segments except the eleventh, which has on top, instead of a pair of tubercles, one large, yellow tubercle, ringed with black. The tubercles along the side of the insect are blue during this stage. The next molt occurs five or six days later; this time the caterpillar is blu-



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Just out of the cocoon

ish green in color, the large tubercles on the second and third segments being deep orange, and those on the upper part of the other segments yellow, except those on the first and last segments, which are blue. All the other tubercles along the sides are blue. After the fourth molt it appears as an enormous caterpillar, often attaining the length of three inches, and is as large through as a man's thumb; its colors are the same as in the preceding stage. There is some variation in the colors of the tubercles on the caterpillars during these different molts; in the third stage, it has been observed that the tubercles usually blue are sometimes black. After the last molt the caterpillar eats voraciously for perhaps two weeks or longer and then begins to spin its cocoon.

Suggested Reading — *Butterfly and Moth Book*, by Ellen Robertson-Miller; *Caterpillars and Their Moths*, by Ida M. Eliot and Caroline G. Soule; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, Plants and Animals; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting; Scientific Living Series*, *Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on page 300.

LESSON 73

The Cecropia

Leading Thought — The cecropia moth passes the winter as a pupa in a cocoon which the caterpillar builds out of silk for the purpose. In the spring the moth issues and lays her eggs on some tree, the leaves of which the caterpillar relishes. The full-grown caterpillars are large and green with beautiful blue and orange tubercles.

Method — It is best to begin with the cocoons, for these are easily found after the leaves have fallen. These cocoons, if kept in the schoolroom, should be thoroughly wet at least once a week. However, it is better to keep them in a box out of doors where they can have the advantage of natural moisture and temperature; and from those that are kept outside the moths will not issue until the leaves open upon the trees and provide food for the young caterpillars to eat when the eggs hatch.

The Cocoon

Observations — 1. How does the cocoon look on the outside? What is its general shape? To what is it fastened? Is it fastened to the lower or the upper side of a twig? Are there any dried leaves attached to it?

2. Where do you find cecropia cocoons? How do they look on the tree? Are they conspicuous?

3. Cut open the cocoon, being careful not to hurt the inmate. Can you see that it has an outer wall which is firm? What lies next to this? Describe the wall next to the pupa. How does this structure pro-

tect the pupa from changes of temperature and dampness?

4. Is the outside covering easy to tear? What birds have been known to tear this cocoon apart?

5. Are both ends of the cocoon alike? Do you find one end where the silk is not woven across but is placed lengthwise? Why is this so? Do you think that the moth can push out at this end better than at the other?

The Pupa

1. Take a pupa out of a cocoon carefully and place it on cotton in a wide-mouthed fruit jar where it may be observed. Can the pupa move at all? Is it unable to defend itself? Why does it not need to defend itself?

2. Can you see in the pupa the parts that will be the antennæ and the mouth?

3. Describe how the wing coverings look. Count the rings in the abdomen.

4. Why does the pupa need to be protected by a cocoon?

The Moth

1. What is the first sign that the moth is coming out of the cocoon? Can you hear the little scratching noise? What do you suppose makes it? How does the moth look when it first comes out? If it were not all soft and wet, how could it come out from so small an opening?

2. Describe how the crumpled wings spread out and dry. How does the covering of the wings change in appearance?

3. Make a water-color drawing or describe in detail the fully expanded moth, showing the color and markings of wings, body, and antennæ.

4. Do the moths eat anything?

5. If one of the moths lays eggs, describe the eggs, noting color, size, and the way they are placed.

The Caterpillar

1. On what do you find the cecropia caterpillar feeding? Describe its actions while feeding.

2. What is the color of the caterpillar? Describe how it is ornamented.

3. Can you see the breathing pores, or spiracles, along the sides of the body? How many of these on each segment? How do they help the caterpillar to breathe?

4. Describe the three pairs of true legs on the three segments just back of the head. Do these differ in form from the prolegs along the sides of the body? What is the special use of the prolegs? Describe the prop-leg, which is the hindmost leg of all.

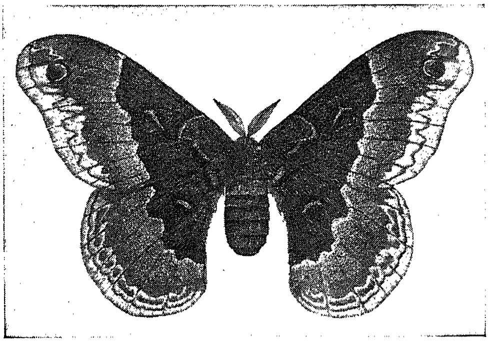
5. Do you know how many times the cecropia caterpillar sheds its skin while it is growing? Is it always the same color?

6. Watch the caterpillar spin its cocoon; describe how it begins and how it acts as long as you can see it. Where does the silk come from?

THE PROMETHEA

The promethea is not so large as the cecropia, although the female resembles the latter somewhat. It is the most common of all our giant silkworms. Its caterpillars feed upon wild cherry, lilac, ash, sassafras, buttonwood, and many other trees.

During the winter, leaves may often be seen hanging straight down from the branches of wild cherry, lilac, and ash. If these leaves are examined, they will be found to be wrapped around a silken case containing the pupa of the promethea. It is certainly a canny insect which hides itself during the winter in so good a disguise that only the very wisest of birds ever suspect its presence. When the promethea caterpillar begins to spin, it selects a leaf and covers the upper side with silk, then it covers the petiole with silk, fastening it with a strong band to the twig, so that not even most violent winter winds

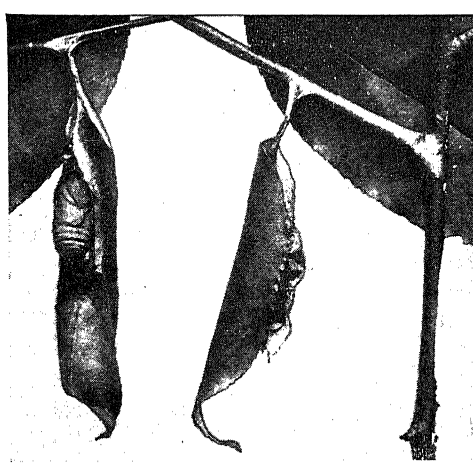


The female promethea

will be able to tear it off. Then it draws the two edges of the leaf about itself like a cloak as far as it will reach, and inside this folded leaf it makes its cocoon, which always has an opening in the shape of a conical valve at the upper end, through which the moth may emerge in the spring. This caterpillar knows more botany than some people do, for it makes no mistake in distinguishing a compound leaf from a simple one. When it uses a leaflet of hickory for its cocoon, it fastens the leaflet to the mid stem of the leaf and then fastens the stem to the twig. The male pupa is much more slender than that of the female. The moths do not issue until May or June.

The moth works its way out through the valve at the top of the cocoon. The female is a large, reddish brown moth with markings resembling somewhat those of the cecropia. The male is very different in appearance; its front wings have very graceful, prolonged tips, and both wings are almost black, bordered with ash color. The promethea moths differ somewhat in habit from the other silkworms, in that they fly during the late afternoon as well as at night. The eggs are whitish with brown stain, and are laid in rows, a good many on the same leaf.

The caterpillars, as they hatch from the eggs, have bodies ringed with black and yellow. They are sociable little fellows and live together side by side amicably, not exactly "toeing the mark" like a spelling class, but all heads in a row at the edge of the leaf where each is eating as fast as possible. When they are small, the caterpillars remain on the underside of the leaves out of sight. In about five days, the first skin is shed and the color of the caterpillar remains about the same. Four or five days later the second molt occurs, and then the caterpillar appears in a beautiful bluish green costume, with black tubercles, except four large ones on the second and third segments, and one large one on the eleventh segment, which are yellow. This caterpillar has an interesting habit of weaving a carpet of silk on which to change its skin; it seems to be better able to hold on while pushing off the old skin, if it has the silken rug to cling to. After the third molt, the color is a deeper greenish blue and the black tubercles are smaller, and the five big ones are larger and bright orange in color. After the fourth molt, which occurs after a period of about five or six days, the caterpillar appears in its last stage. It is now over two inches long, quite smooth and most prosperous looking. Its color is a beautiful, light, greenish blue, and its head is yellow. It has six rows of short, round, black tubercles. The four large tubercles at the front end of the body are red, and the large tubercle on the rear end of the body is yellow.



M. V. Slingerland

Promethea cocoons; the one on the left has been cut away to show the pupa. Note how the leaves are fastened by silk to the twigs

The Cynthia

The cynthia is a beautiful moth which has come to us from Asia; it is very large with a ground color of olive green, with lavender tints and white markings; there are white tufts of hairs on the abdomen. It builds its cocoon like the promethea, fastening the petiole to the twig; therefore the lesson indicated for the promethea will serve as well for the cynthia. The cynthia caterpillars live upon the ailanthus tree and are found only in the regions where this tree has been introduced.

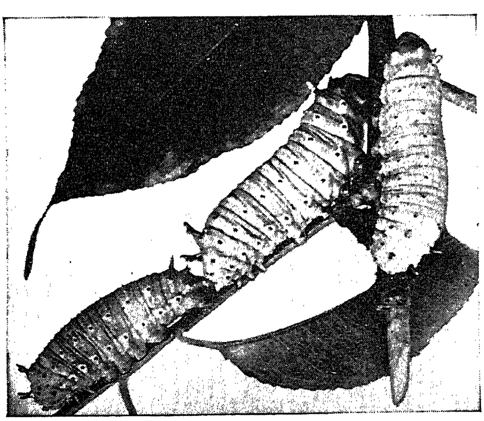
Suggested Reading — *Butterfly and Moth Book*, by Ellen Robertson-Miller; *Caterpillars and Their Moths*, by Ida M. Eliot and Caroline G. Soule; also, readings on page 300.

LESSON 74

The Promethea

Leading Thought — The promethea caterpillar fastens a leaf to a twig with silk and then makes its cocoon within this leaf. The male and female moths are very different in appearance.

Method — This work should begin in the late fall, when the children bring in these cocoons which they find dangling on the lilac bushes or wild cherry trees. Much attention should be paid to the way the leaf is fastened to the twig so it will not fall. The cocoons should be kept out of doors, so that the moths will issue



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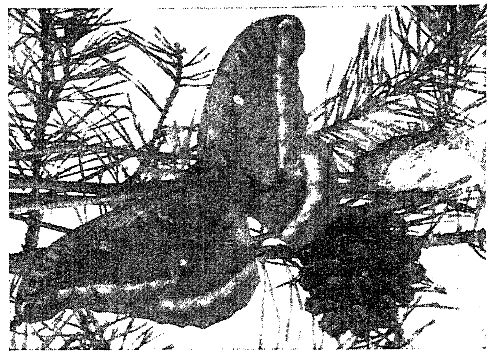
Promethea caterpillars



A polyphemus moth and cocoon. This is a yellowish or brownish moth with a window-like spot in each wing

late in the spring when they can have natural conditions for laying their eggs, and the young caterpillars will be supplied with plenty of food consisting of new and tender leaves.

The Cocoon

Observations — 1. On what tree did you find it? Does it look like a cocoon? Does it not look like a dried leaf still clinging to the tree? Do you think that this disguise keeps the birds from attacking it? Do you know which birds are clever enough to see through this disguise?

2. How is the leaf fastened to the twig? Could you pull it off readily? What fastened the leaf to the twig?

3. Tear off the leaf and study the cocoon. Is there an opening to it? At which end? What is this for?

4. Cut open a cocoon. Is it as thick as that of the cecropia?

5. Study the pupa. Is it as large as that of the cecropia?

6. Can you see where the antennæ of the moth are? Can you see the wing covers? Can the pupa move?

The Moth

1. Are there two kinds of moths that come from the promethea cocoons? Does one of them look something like the cecropia? This is the mother promethea.

2. Are any of the moths almost black in color with wings bordered with gray and

with graceful prolonged tips to the front wings? This is the father moth.

3. Make water-color drawings of promethea moths, male and female.

4. If the promethea mother lays eggs, describe them.

The Caterpillar

1. How do the promethea caterpillars look when they first hatch from the eggs? Do they stay together when they are very young? How do they act? Where do they hide?

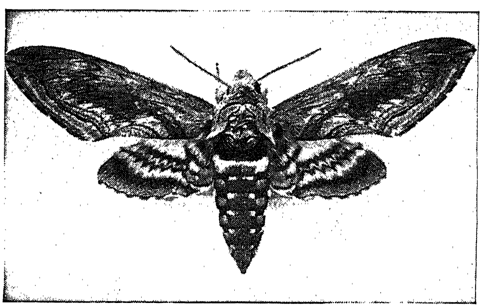
2. How do they change color as they grow older? Do they remain together or scatter? Do they continue to hide on the lower sides of leaves?

3. What preparation does a promethea caterpillar make before changing its skin? Why does it shed its skin? Does the color of the caterpillar change with every change of skin?

4. Describe the caterpillar when it is full grown. What is its ground color? What are the colors of its ornamental tubercles? The color of its head?

5. Describe how a promethea caterpillar makes its cocoon.

THE HUMMINGBIRD OR SPHINX MOTHS



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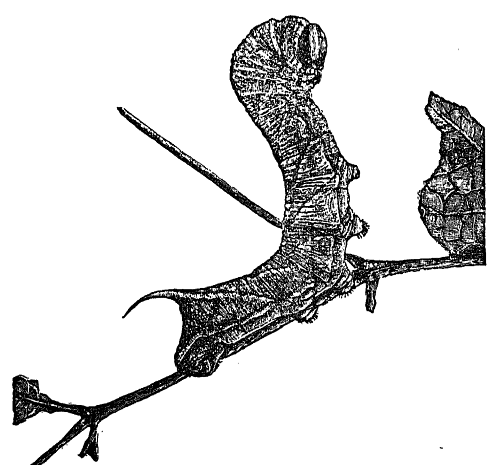
The moth of the sphinx caterpillar which feeds on tomato plants

If during the early evening, when all the swift hummingbirds are abed, we hear the whirr of rapidly moving wings and detect the blur of them in the twilight, as if the creature carried by them hung entranced before some deep-throated flower, and then whizzed away like a bullet, we know that it is a hummingbird or sphinx moth. And when we see a caterpillar with a horn on the wrong end of the body, a caterpillar which, when disturbed, rears threateningly, then we may know it is the sphinx larva. And when we find a strange, brown, segmented shell, with a long jug handle at one side, buried in the earth as we spade up the garden in the spring, then we know we have the sphinx pupa.

The sphinx was a vaudeville person of ancient mythology, who went about boring people by asking them riddles, and, if they could not give the right answers, very promptly ate them up. Although Linnæus gave the name of sphinx to these moths, because he fancied he saw a resemblance in the resting or threatening attitude of the larvæ to the Egyptian Sphinx, there are still other resemblances. These insects present three riddles: The first one is, "Am I a hummingbird?" the second, "Why do I wear a horn or an eyespot on the rear end of my body where horns and eyes are surely useless?" and the third, "Why do I look like a jug with a handle and no spout?"

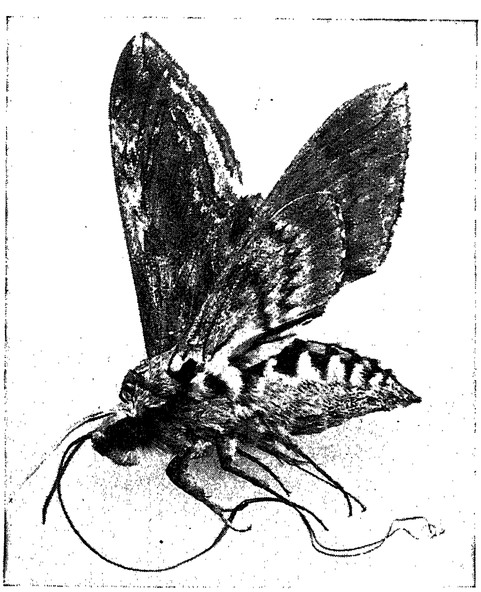
The sphinx moths are beautiful and



Sphinx larva in sphinx attitude

elegant creatures. They have a distinctly tailor-made appearance, their colors are so genteel and "the cut" so perfect. They have long, rather narrow, strong wings which enable them to fly with extraordinary rapidity. The hind wings are shorter, but act as one with the front wings. The body is stout and spindle-shaped. The antennæ are thickened in the middle or toward the tip, and in many species have the tip recurved into a hook. Their colors show most harmonious combinations and most exquisite contrasts; the pattern, although often complex, shows perfect refinement. Olive, tan, brown and ochre, black and yellow, and the whole gamut of grays, with eyespots or bands athwart the hind wings of rose color or crimson, are some of the sphinx color schemes.

Most of the sphinx moths have remarkably long tongues, which are sometimes twice the length of the body. When not in use, the tongue is curled like a watch spring in front of and beneath the head; but of what possible use is such a long tongue? That is a story for certain flowers to tell, the flowers which have the nectar-wells far down at the base of tubular corollas, like the petunia, the morning glory, or the nasturtium. Some of these flowers, like jimson weed and flowering tobacco, open late in the day when these evening visitors are flying about. In some cases, especially among the or-



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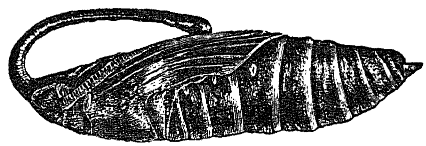
The tobacco sphinx moth with tongue extended



The pupa of the common tomato sphinx caterpillar. Note that the part encasing the long tongue is free and looks like the handle of a jug

chids, there is a special partnership established between one species of flower and one species of sphinx moth. The tobacco sphinx is an instance of such partnership; this moth visits tobacco flowers and helps develop the seeds by carrying pollen from flower to flower; and in turn it lays its eggs upon the leaves of this plant, on which its great caterpillar feeds and waxes fat, and in high dudgeon often disputes the smoker's sole right to the "weed." Tobacco probably receives enough benefit from the ministrations of the moth to compensate for the injury it suffers from the caterpillars; but the owner of the tobacco field, not being a plant, does not look at it in this equitable manner.

The sphinx caterpillars are leaf-eaters, and each species feeds upon a limited number of plants which are usually related; for instance, one feeds upon both the potato and tomato; another upon the Virginia creeper and grapes. In color these caterpillars so resemble the leaves that they are discovered with difficulty. Those on the Virginia creeper, which shades porches, may be located by the black pellets of waste material which fall from them to the ground; but even after this unmistakable hint I have searched a long time to find the caterpillar in the leaves above; its color serves to hide the insect from birds which feed upon it eagerly. In some species, the caterpillars are ornamented with oblique stripes along the sides, and in others the stripes are length-

Dept. of Entomology, Cornell U.
Adults of the Myron sphinx

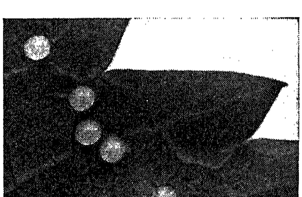
wise. There is often a great variation in color between the caterpillars of the same species; the tomato worm is sometimes green and sometimes black.

In the young larva the horn on the rear end is often of different color from the body; in some species it stands straight up and in some it is curled toward the back. It is an absolutely harmless projection and does not sting nor is it poisonous. However, it looks awe-inspiring and perhaps protects its owner in that way. The *Pandora* sphinx has its horn curled over its back in the young stage but when fully grown the horn is shed; in its place is an eyespot which, if seen between the leaves, is enough to frighten away any cautious bird fearing the evil eye of serpents. The sphinx caterpillars have a habit, when disturbed or when resting, of rearing up the front part of the body, telescoping the head back into the thoracic segments, which in most species are enlarged, and assuming a most threatening and ferocious aspect. If attacked they will swing sidewise, this way and then that, making a fierce crackling sound meanwhile, well calculated to fill the trespasser with terror. When resting they often remain in this lifted attitude for hours, absolutely rigid.

The six true legs are short with sharp little claws. There are four pairs of fleshy prolegs, each foot being armed with hooks for holding on to leaf or twig; and the large, fleshy prop-leg on the rear segment is able to clasp a twig like a vise. All these fleshy legs are used for holding on, while the true legs are used for holding the edges of the leaf where the sidewise working jaws can cut it freely. These caterpillars do clean work, leaving only the harder and more woody ribs of the leaves. The Myron caterpillar seems to go out of its way to cut off the stems of both the grape and Virginia creeper.

There are nine pairs of spiracles, a pair on each segment of the abdomen and on the first thoracic segment. The edges of these air openings are often strikingly colored. Through the spiracles the air is admitted into all the breathing tubes of the body around which the blood flows and is purified; no insect breathes through its mouth. These caterpillars, like all others, grow by shedding the skeleton skin, which splits down the back.

Often one of these caterpillars is seen covered with white objects which the uninformed, who do not know that caterpillars never lay eggs, have called eggs. But the sphinx moths at any stage would have horror of such eggs as these! They are not



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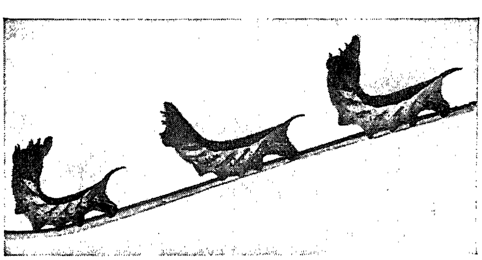
Eggs of the Myron sphinx

eggs but are little silken cocoons spun by the larvæ of a hymenopterous parasite. It is a tiny four-winged " fly " which lays its eggs within the caterpillar. The little grubs which hatch from these eggs feed upon the fleshy portions of the caterpillar until they get their growth, at which time the poor caterpillar is almost exhausted; and then they have the impudence to come out and spin their silken cocoons and fasten them to the back of their victim. Later, they cut a little lid to their silken cells which they lift up as they come out into the world to search for more caterpillars.

As soon as the sphinx larva has obtained its growth, it descends and burrows into the earth. It does not spin any cocoon but packs the soil into a smooth-walled cell in which it changes to a pupa. In the spring the pupa works its way to the surface of the ground and the moth issues. In the case of the tomato and tobacco sphinx pupa, the enormously long tongue has its case separate from the body of the pupa, which makes the "jug handle." The wing cases and the antennæ cases can be distinctly seen. In other species the pupæ have the tongue case fast to the body. The larva of the Myron sphinx does not enter the ground, but draws a few leaves about it on the surface of the ground, fastens them with silk, and there changes to a pupa.

Suggested Reading — *Butterfly and Moth Book*, by Ellen Robertson-Miller; *Caterpillars and Their Moths*, by Ida M. Eliot and Caroline G. Soule; *Holiday Hill*, by Edith M. Patch; *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*; also, readings on page 300.



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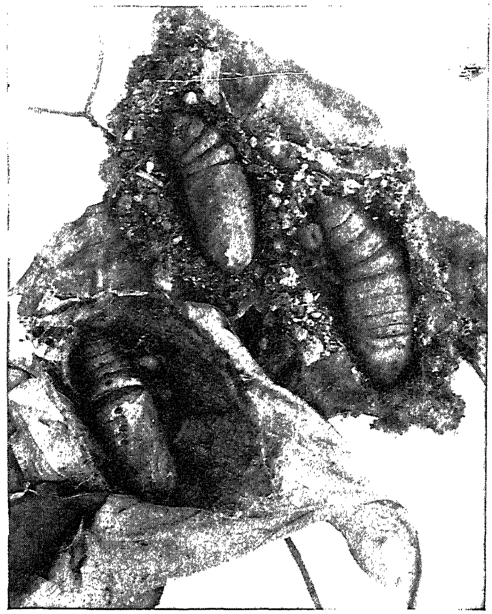
A "cake walk." Caterpillars of the Myron sphinx in an attitude of defense



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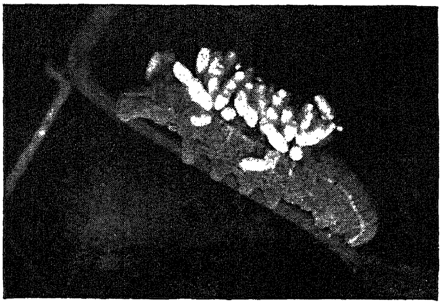
Pupæ of the Myron sphinx within the cocoons

LESSON 75

The Hummingbird or Sphinx Moths

Leading Thought — The sphinx caterpillars have a slender horn or eyespot on the last segment of the body. When disturbed or when resting they rear the front part of the body in a threatening attitude. They spin no cocoons but change to pupæ in the ground. The adults are called hummingbird moths, because of their swift and purring flight. The sphinx moths carry pollen for many flowers.

Method — The sphinx caterpillar found on the potato or tobacco, or one of the species feeding upon the Virginia creeper, is in autumn available in almost any locality for this lesson. The caterpillars should be placed in a breeding cage in the schoolroom. Fresh food should be given them every day and moist earth be placed in the bottom of the cages. It is useless for the amateur to try to rear the adults from the pupæ in breeding cages. The moths may be caught in nets during the evening when they are hovering over the petunia beds. These may be placed on leaves in a tumbler or jar for observation.



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A Myron caterpillar that has been parasitized. The white objects upon it are the cocoons of the little grubs which feed upon the fatty parts of the caterpillar

The Caterpillar

Observations — 1. On what plant is it feeding? What is its general color? Is it striped? What colors in the stripes? Are they oblique or lengthwise stripes? Are all the caterpillars the same color?

2. Can you find the caterpillar easily when feeding? Why is it not conspicuous when on the plant? Of what use is this to the caterpillar?

3. Note the horn on the end of the caterpillar. Is it straight or curled? Is it on the head end? What color is it? Do you think it is of any use to the caterpillar? Do you think it is a sting? If there is no horn, is there an eyespot on the last segment? What color is it? Can you think of any way in which this eyespot protects the caterpillar?

4. Which segments of the caterpillar are the largest? When the creature is disturbed what position does it assume? How does it move? What noise does it make? Do you think this attitude scares away enemies? What position does it assume when resting? Do you think that it resembles the Egyptian Sphinx when resting?

5. How many true legs has this caterpillar? How does it use them when feeding? How many prolegs has it? How are these fleshy legs used? How are they armed to hold fast to the leaf or twig? Describe the hind or prop-leg. How is it used?

6. Do you see the breathing pores or spiracles along the sides of the body? How many are there? How are they colored? How does the caterpillar breathe? Do you think it can breathe through its mouth?

7. How does the sphinx caterpillar grow? Watch your caterpillar and see it shed its skin. Where does the old skin break open? How does the new, soft skin look? Do the young caterpillars resemble the full-grown ones?

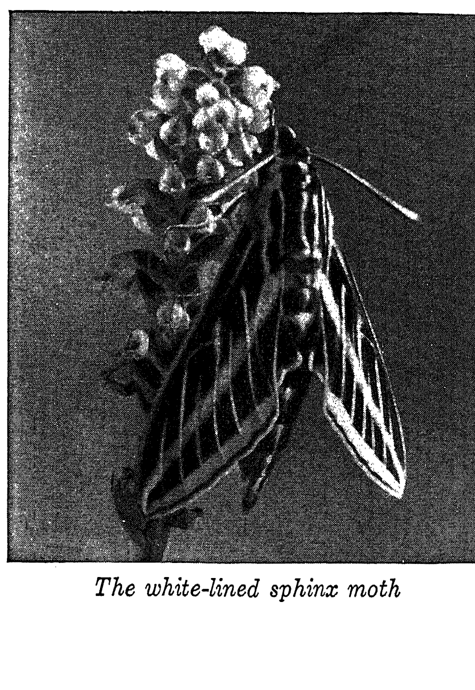
8. Describe how the caterpillar eats. Can you see the jaws move? Does it eat up the plant clean as it goes?

9. Have you ever found the sphinx caterpillar covered with whitish, oval objects? What are these? Does the caterpillar look plump or emaciated? Explain what these objects are and how they came to be there.

10. Where does the caterpillar go to change to a pupa? Does it make cocoons? How does the pupa look? Can you see the long tongue case, the wing cases, the antennæ cases?

The Moth

1. Where did you find this moth? Was it flying by daylight or in the dusk? How did its rapidly moving wings sound? Was it visiting flowers? What flowers? Where is the nectar in these flowers?



The white-lined sphinx moth

2. What is the shape of the moth's body? Is it stout or slender? What colors has it? How is it marked?

3. The wings of which pair are longer? Sketch or describe the form of the front and the hind wings. Are the outer edges scalloped, notched, or even? What colors are on the front wing? On the hind one? Are these colors harmonious and beautiful? Make a sketch of the moth in water color.

4. What is the shape of the antennæ? Describe the eyes. Can you see the coiled tongue? Uncoil it with a pin and note how long it is. Why does this moth need such a long tongue?

5. From what flowers do the sphinx moths get nectar? How does the moth support itself when probing for nectar? Do you know any flowers which are dependent on the sphinx moths for carrying their pollen? How many kinds of sphinx moths do you know?

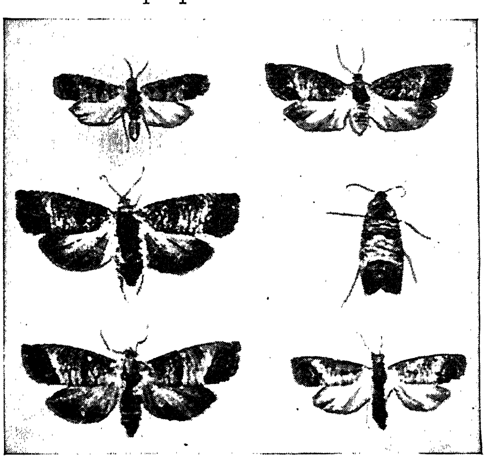
Hurt no living thing:
Ladybird, nor butterfly,
Nor moth with dusty wing,
Nor cricket chirping cheerily,
Nor grasshopper so light of leap,
Nor dancing gnat, nor beetle fat,
Nor harmless worms that creep.

— Christina Rossetti

THE CODLING MOTH

It is difficult to decide which seems the more disturbed, the person who bites into an apple and uncovers a worm, or the worm which is uncovered. From our standpoint, there is nothing attractive about the worm which destroys the beauty and appetizing qualities of our fruit, but from the insect standpoint the codling caterpillar (which is not a worm at all) is not at all bad. When full grown, it is about three-fourths of an inch long, and is likely to be flesh color, or even rose color, with brownish head; as a young larva, it has a number of darker rose spots on each segment and is whitish in color; the shield on the first segment behind the head, and that on the last segment of the body, are black. When full grown, the apple worm is plump and lively; and while it is jerking angrily at being disturbed, we can see its true legs, one pair to each of the three segments of the body behind the head. These true legs have sharp, single claws. Behind these the third, fourth, fifth, and sixth segments of the abdomen are each furnished with a pair of fleshy prolegs and the hind segment has a prop-leg. These fleshy legs are mere makeshifts on the part of the caterpillar for carrying the long body, since the three pairs of front legs are the ones from which develop the legs of the moth. The noticing of the legs of the codling moth is an important observation on the part of the pupils, since, by their presence, this insect may be distinguished from the young of the plum curculio, which is also found in apples but which is legless. The codling moth has twelve segments in the body, back of the head.

The codling larva usually enters the apple at the blossom end and tunnels down by the side of the core until it reaches the middle, before making its way out into the pulp. The larva weaves a web



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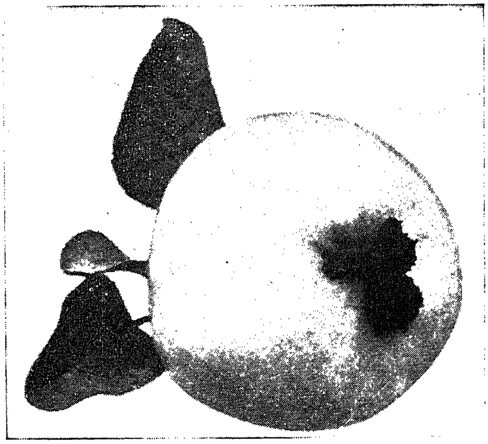
The adult of the codling moth, showing the variations of its markings. The two larger ones are about three times natural size



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A wormy apple

as it goes, but this is probably incidental, since many caterpillars spin silk as they go, "street yarn" our grandmothers might have called it. In this web are entangled the pellets of indigestible matter, making a very unsavory looking mass. The place of exit is usually circular, large enough to accommodate the body of the larva, and it leads out from a tunnel which may be a half inch or more in diameter beneath the rind. Often the larva makes the door some time before it is ready to leave the apple, and plugs it with a mass of debris, fastened together with the silk. As it leaves the apple, the remnants of this plug may be seen streaming out of the opening. Often also, there is a mass of waste pellets pushed out by the young larva from its burrow, as it enters the apple; thus it injures the appearance of the apple at both entrance and exit. If the apple has not received infection by lying next to another rotting apple, it first begins to rot around the burrow of the worm, especially near the place of exit.

The codling caterpillar injures the fruit in the following ways: The apples are likely to be stunted and fall early; the apples rot about the injured places and thus cannot be stored successfully; the apples thus injured look unattractive, and therefore their market value is lessened; wormy apples, packed in barrels with others, rot and contaminate all the neighboring apples. This insect also attacks pears and sometimes peaches.

The larvæ usually leave the apples before winter. If the apples have fallen, they crawl up the tree and there make their cocoons beneath the loose bark; but if they leave the apples while they are on the trees, they spin silk and swing down. If carried into the storeroom or placed in barrels, they seek quarters in protected crevices. In fact, while they particularly like the loose bark of the apple trees, they are likely to build their cocoons on nearby fences or on brush, wherever they can find the needed protection. The cocoon is made of fine but rather rough silk which is spun from a gland opening near the mouth of the caterpillar; the cocoon is not beautiful, although it is smooth inside. It is usually spun between a loose bit of bark and the body of the tree; but after making it, the insect seems in no hurry to change its condition and remains a quite lively caterpillar until spring. It is while the codling larvæ are in their winter quarters that our bird friends of the winter, the nuthatches, woodpeckers, and chickadees, destroy them in great numbers, hunting eagerly for them in every crevice of the trees. It is therefore good policy for us to

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Larva of the codling moth, greatly enlarged coax these birds to our orchards by placing beef fat on the branches and thus entice these little caterpillar hunters to visit the trees every day.

It is an interesting fact that the codling caterpillars, which make cocoons before August first, change immediately to pupæ which soon change to moths, and thus another generation gets in its work before the apples are harvested.

The codling moth is a beautiful little creature with delicate antennæ and a brown, mottled and banded body; its wings are graced by wavy bands of ashy and brown lines, and the tips of the front wings are dark brown with a pattern of gold bronze wrought into them; the hind wings are shiny brown with darker edges and little fringes. The moths which have wintered in cocoons issue in the spring and lay their eggs on the young apples just after the petals fall. The egg looks like a minute drop of dried milk and is laid on the side of the bud; but the little larva, soon after it is hatched, crawls to the blossom and finds entrance there; and it is therefore important that its first lunch should include a bit of arsenic and thus

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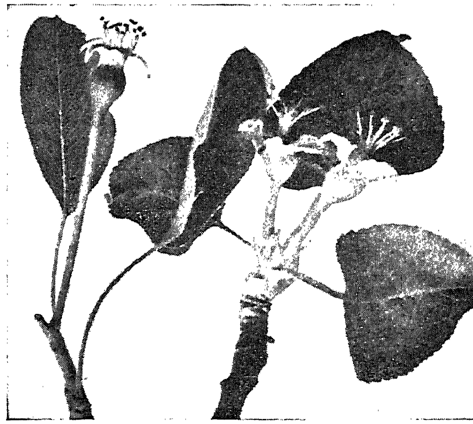
The pupæ and cocoons of codling moths



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Just ready to spray. A pear and two apples with the petals recently fallen and with the calyx lobes widely spread

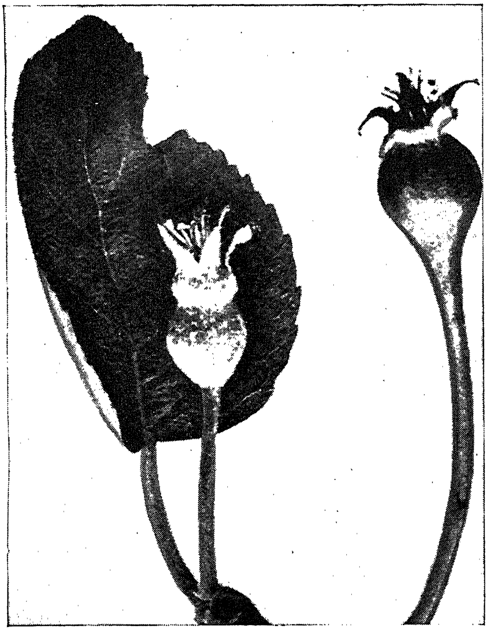
end its career before it fairly begins. The trees should be sprayed with some stomach poison directly after the petals fall, and before the five lobes of the calyx close up around the stamens. If the trees are sprayed while blossoming, the pollen is washed away and the apples do not set; moreover, the bees which help us much in carrying pollen are killed. If the trees are sprayed directly after the calyx closes up around the stamens the poison does not lodge at the base of the stamens and the little rascals get into the apples without getting a dose. (See the lesson on the apple.)

Suggested Reading — *Insect Pests of Farm, Garden and Orchard*, by E. D. Sanderson and L. M. Peairs; *Manual of Injurious Insects*, by Glenn W. Herrick; also, readings on page 300.

LESSON 76

The Codling Moth

Leading Thought — The codling moth is a tiny brown moth with bronze markings, which lays its egg on the apple. The larva hatching from the egg enters the blossom end and feeds upon the pulp of the apple, injuring it greatly. After attaining its growth it leaves the apple and hides beneath the bark of the tree or in some other protected place, and in the spring



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Almost too late to spray. The apple on the left has the calyx lobes nearly drawn together. The pear on the right still has the calyx cavity open

makes the cocoon from which the moth issues in time to lay eggs upon the young apples.

METHOD — The lesson should begin with a study of wormy apples, preferably in the fall when the worms are still within their burrows. After the pupils become familiar with the appearance of the insect and its methods of work, a prize of some sort might be offered for the one who will bring to school the greatest number of hibernating larvæ found in their winter quarters. Place these larvæ in a box with cheesecloth tacked over its open side; place this box out of doors in a protected position. Examine the cocoons to find the pupæ about the last of April; after the pupæ appear, look for the moths in about five days.

It would be a very good idea for the pupils to prepare a Riker mount showing specimens of the moths, of the cocoons showing the cast pupa skin, and of the caterpillar in a homeopathic vial of alcohol; pictures illustrating the work of the insect may be added. The pictures should be drawn by the pupils, showing the wormy apple, both the outside and in section. The pupils can also sketch, from the pictures here given, the young apple when just in the right condition to spray, with a note explaining why.

OBSERVATIONS — 1. Find an apple with a codling moth larva in it. How large is the worm? How does it act when disturbed?

2. What is the color of the caterpillar's body? Its head?

3. How many segments are there in the body? How many of these bear legs? What is the difference in form between the three front pairs of legs and the others?

4. Look at a wormy apple. How can you tell it is wormy from the outside? Can you see where the worm entered the apple? Was the burrow large or small at first? Can you find an apple with a worm in it which has the door for exit made, but closed with waste matter? How is this matter fastened together? If the apple has no worm in it, can you see where it left the apple? Make a sketch or describe the evidence of the caterpillar's progress through the apple. Do you find a web of silk in the wormy part? Why is this? Does the worm eat the seeds as well as the pulp of the apple?

5. Take a dozen rotting apples; how many of them are wormy? Do the parts of the apple injured by the worm begin to rot first? In how many ways does the codling moth injure the apple? Does it injure other fruits than apples?

6. How late in the fall do you find the codling larvæ in the apple? Where do these larvæ go when they leave the apple?

Work to be done in March or early April — Visit an orchard and look under the loose bark on old trees, or along protected sections of fences or brush piles, and bring in all the cocoons you can find. Do not injure the cocoons by tearing them from the places where they are woven, but bring them in on bits of the bark or other material to which they are attached.

1. How does the cocoon look outside and inside? What is in the cocoon? Why was the cocoon made? When was it made?

2. Place the cocoons in a box covered with cheesecloth and place the box out of doors where the contents can be frequently observed and make the following notes:

(a) When does the larva change to the pupa? Describe the pupa. How does the cocoon look after the moth issues from it?

(b) Describe the moth, noting color of head, thorax, body, and front and hind wings.

3. If these moths were free to fly around the orchard, when and where would they lay their eggs?

4. When should the trees be sprayed to kill the young codling moth? With what should they be sprayed? Why should they not be sprayed during the blossoming period? Why not after the calyx closes?

5. How do the nuthatches, downy woodpeckers, and chickadees help us get rid of the codling moth?

6. Write an essay on the life history of the codling moth, the damage done by it, and the best methods of keeping it in check.

LEAF-MINERS

And there's never a leaf nor a blade too mean
To be some happy creature's palace.

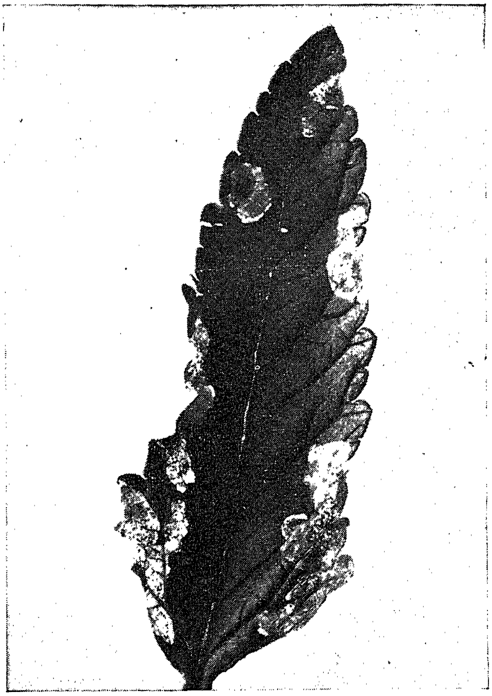
— Lowell

May not Lowell have had in mind, when he wrote these lines, the canny little creatures which find sustenance for their complete growth between the upper and lower surfaces of a leaf which seems to us as thin as a sheet of paper? To most children, it seems quite incredible that there is anything between the upper and lower surfaces of a leaf, and this lesson should hinge on the fact that in every leaf, however thin, there are rows of cells containing the living substance of the leaf, with a wall above and a wall below to protect them. Some of the smaller insects have discovered this hidden treasure, which they mine while safely protected from sight, and thus make strange figures upon the leaves.

Among the most familiar of these are the serpentine mines, so called because the figure formed by the eating out of the green pulp of the leaf curves like a serpent. Some serpentine mines are made by the caterpillars of certain tiny moths, which have long fringes upon the hind wings. The life story of such a moth is as follows: The little moth, whose expanded wings measure scarcely a quarter of an inch across, lays an egg on the leaf; from this, there hatches a tiny caterpillar that soon eats its way into the midst of the leaf. In shape, the caterpillar is somewhat "square built," being rather stocky and wide for its length; it feeds upon the juicy tissues of the leaf and divides, as it goes, the upper from the lower surface of the leaf; and it teaches us, if we choose to look, that these outer walls of the leaf are thin, colorless, and paper-like. We can trace the

Grace H. Griswold

Serpentine mines in a columbine leaf



Grace H. Griswold

A verbena leaf, showing mines that are mere blotches

whole life history and wanderings of the little creature, from the time when, as small as a pinpoint, it began to feed, until it attained its full growth. As it increased in size, its appetite grew larger also, and these two forces working together naturally enlarged its house. When finally the little miner got its growth, it made a rather larger and more commodious room at the end of its mine, which to us looks like the head of the serpent; here it changed to a pupa, perhaps after nibbling a hole with its sharp little jaws, so that when it changed to a soft, fluffy little moth with mouth unfitted for biting, it was able to escape. In some species, the caterpillar comes out of the mine and goes into the ground to change to a pupa. By holding up to the light a leaf thus mined, we can see why this little chap was never obliged to clean house; it mined out a new room every day, and left the sweepings in the abandoned mine behind. Mines of this sort are often seen on the leaves of the nasturtium, the smooth pigweed, the columbine, and many other plants. There are mines of many shapes, each form being made by a different species of insect. Some flare suddenly from a point and are trumpet-shaped, while some are mere blotches. The blotch mines are made through the habits of the insect within them; it feeds around and around, instead of forging ahead as the serpentine miners do. The larvæ of beetles, flies, and moths may mine leaves, each species having its own special food plant. Most of the smaller leaf mines are made by the caterpillars of the moths which are fitly called the Tineina or Tineids. Most of these barely have a wing expanse that will reach a quarter of an inch, and many are smaller; they all have narrow wings, the hind wings being mere threads bordered with beautiful fringes. The specific names of these moths usually end in "ella"; thus, the one that mines in apple is *malifoliella*, the one in grain is *granella*. One of these little moths, *Gelechia pinifoliella*, lives the whole of its growing life in half of a pine needle. The moth lays the egg at

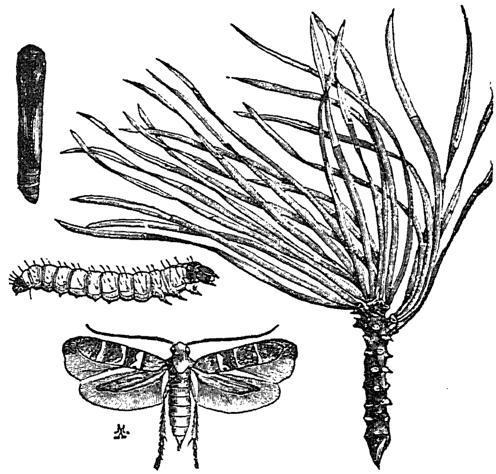
Dept. of Entomology, Cornell U.

Mines of the trumpet leaf-miner

about the middle of the needle, and the little caterpillar that hatches from it gnaws its way directly into the heart of the needle; and there, as snug as snug can be, it lives and feeds until it is almost a quarter of an inch long; think of it! Many a time I have held up to the light a pine needle thus inhabited, and have seen the little miner race up and down its abode as if it knew that something was happening. When it finally attains its growth it makes wider the little door through which it entered; it does this very neatly; the door is an even oval, and looks as if it were made with the use of dividers. After thus opening the door, the caterpillar changes to a little, long pupa, very close to its exit; and later it emerges, an exquisite little moth with silvery bands on its narrow, brown wings, and a luxurious fringe on the edges of its narrow hind wings and also on the outer hind edges of the front wings.

The gross mines in the leaves of dock and beet are not pretty. The leaves are slitted, sometimes for their whole length, and soon turn brown and lie prone on the ground, or dangle pathetically from the stalk. These mines are made by the larvæ of a fly, and a whole family live in the same habitation. If we hold a leaf thus mined up to the light, while it is still green, we can see several of the larvæ working, each making a bag in the life substance of the leaf, and yet all joining together to make a great blister. The flies that do this mischief belong to the family *Anthomyidæ;* and there are several species which have the perturbing habit of mining the leaves of beets and spinach. It behooves those of us who are fond of these "greens," as our New England ancestors called them, to hold every leaf up to the light before we put it into the skillet, lest we get more meat than vegetable in these viands. The flies who thus take our greens ahead of us are perhaps a little larger than houseflies, and are generally gray in color with the front of the head silver white. These insects ought to teach us the value of clean culture in our gardens, since they also mine in the smooth pigweed.

Suggested Reading — *Insect Pests of Farm, Garden and Orchard,* by E. D. Sanderson and L. M. Peairs; *Leaf Mining Insects,* by James G. Needham, Stuart W. Frost and Beatrice W. Tothill; also, readings on page 300.



The pine-needle leaf-miner. Note the mined leaves. The pupa, the caterpillar, and the moth of the leaf-miner are much enlarged

LESSON 77

Leaf-Miners

Leading Thought — The serpent-like markings and the blister-like blotches which we often see on leaves are made by the larvæ of insects which complete their growth by feeding upon the inner living substance of the leaf.

Method — The nasturtium leaf-miner is perhaps the most available for this lesson since it may be found in its mine in early autumn. However, the pupils should bring to the schoolroom all the leaves with mines in them that they can find and study the different forms.

Observations — 1. Sketch the leaf with the mine in it, showing the shape of the mine. What is the name of the plant on which the leaf grew?

2. Hold the leaf up to the light; can you see the insect within the mine? What is it doing? Is there more than one insect in the mine? Open the mine and see how the miner looks.

3. There are three general types of mines: those that are long, curving lines, called serpentine mines; those that begin small and flare out, called trumpet mines; and those that are blister-like, called blotch mines. Which of these is the mine you are studying?

4. Study a serpentine mine. Note that where the little insect began to eat, the mine is small. Why does it widen from this point? What happened in the part which we call the serpent's head?

5. Look closely with a lens and find if there is a break above the mine in the upper surface of the leaf or below the mine in the lower surface of the leaf. If the insect is no longer in the mine can you find where it escaped? Can you find a shed pupa skin in the "serpent's head"?

6. Why does an insect mine in a leaf? What does it find to eat? How is it protected from the birds or insects of prey while it is getting its growth?

7. Look on leaves of nasturtium, columbine, lamb's quarters, dock, and burdock, for serpentine mines. Are the mines on these different plants alike? Do you suppose the mines are made by the same insect?

8. Look on leaves of dock, burdock, beet, and spinach for blotch mines. Is there more than one insect in these mines? If the insects are present, hold the leaf up to the light and watch them eat.

9. Look in the leaves of pitch or other thick-leaved pines (not white pine) for pine needles which are yellow at the tip. Examine these for miners. If the miner is not within, can you find the little circular door by which it escaped? Would you think there was enough substance in half a pine needle to support a little creature while it grew up?

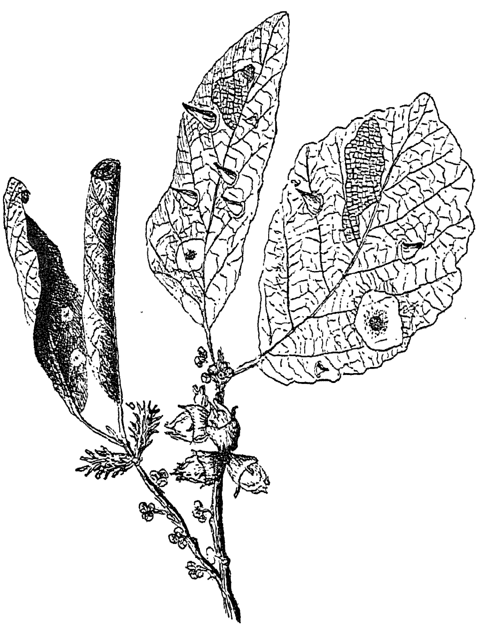
10. If you find leaf-miners at work, do not pluck off the leaves being mined but cover each with a little bag of Swiss muslin tied close about the petiole and thus capture the winged insect.

THE LEAF-ROLLERS

If we look closely at sumac leaves before they are aflame from autumn's torch, we find many of the leaflets rolled into little cornucopias fastened with silk. The silk is not in a web, like that of the spider, but the strands are twisted together, hundreds of threads combined in one strong cable, and these are fastened from roll to leaf, like tent ropes. If we look at the young basswoods, we find perhaps many of their leaves cut across, and the flap made into a roll and likewise fastened with silken ropes. The witch hazel, which is a veritable insect tenement, also shows these rolls. In fact, we may find them upon the leaves of almost any species of tree or shrub, and each of these rolls has its own special maker or indweller. Each species of insect which rolls the leaves is limited to the species of plant on which it is found; and one of these caterpillars would sooner starve than take a mouthful from a leaf of any other plant. Some people think that insects will eat anything that comes in their way; but of all animals, insects are the most fastidious as to their food.

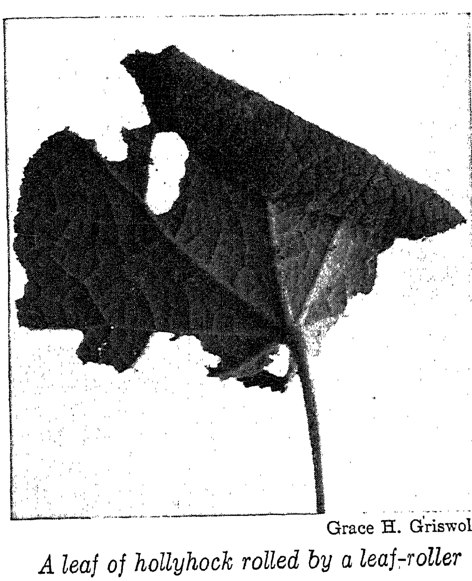
Some species of leaf-rollers unite several leaflets together, while others use a single leaf. The sumac leaf-roller begins in a single leaf; but in its later stages, it fastens together two or three of the terminal leaflets in order to gain more pasturage. The little silken tent ropes which hold the folded leaves are well worth study with a lens. They are made of hundreds of threads of the finest silk, woven from a gland opening near the lower lip of the caterpillar. The rope is always larger where it is attached to the leaf than at the center, because the caterpillar crisscrosses the threads in order to make the attachment to the leaf larger and firmer. Unroll a tent carefully, and you may see the fastenings used in an earlier stage, and may even find the first turned-down edge of the leaf. However, the center of a leaf-roller's habitation is usually very much eaten, for the whole reason for making its little house is that the soft-bodied caterpillar may eat its fill completely hidden from the eyes of birds or other animals. When it first hatches from the egg, it feeds for a short time, usually on the underside of the leaf; but when still so small that we can barely see it with the naked eye, it somehow manages to fold over itself one edge of the leaf and peg it down. The problem of how so small a creature is able to pull over

Leaf-rollers in sumac, showing the fastening of the silk stay-ropes



Witch hazel, showing work of leaf-rollers, leaf-miners, and gall-makers

and fold down or to make in a roll a stiff leaf is hard to solve. I myself believe it is done by making many threads, each a little more taut than the last. I have watched several species working, and the leaf comes slowly together as the caterpillar stretches its head and sways back and forth hundreds of times, fastening the silk first to one side and then to the other. Some observers believe that the caterpillar throws its weight upon the silk, in order to pull the leaf together; but in the case of the sumac leaf-roller, I am sure this is not true, as I have watched the process again and again under a lens, and could detect no signs of this method. Many of the caterpillars which make rolls change to small moths known as Tortricids. This is a very large family, containing a vast number of species, and not all of the members are leaf-rollers. These little moths have the



Grace H. Griswold

A leaf of hollyhock rolled by a leaf-roller front wings rather wide and more or less rectangular in outline. The entomologists have a pleasing fashion of ending the names of all of these moths with "ana"; the one that rolls the currant leaves is *Rosana*, the one on juniper is *Rutilana*, etc. Since many of the caterpillars of this family seek the ground to pupate and do not appear as moths until the following spring, it is somewhat difficult to study

Leaflets fastened together by the skipper caterpillar to make a nest. The adult skipper is shown

their complete life histories, unless one has well-made breeding cages with earth at the bottom; and even then it is difficult to keep them under natural conditions, since in an ordinary living room the insects dry up and do not mature.

SUGGESTED READING — Readings on page 300.

LESSON 78

THE LEAF-ROLLERS

LEADING THOUGHT — Many kinds of insects roll the leaves of trees and plants into tents, in which they dwell and feed during their early stages.

METHOD — This is an excellent lesson for early autumn when the pupils may find many of these rolled leaves, which they may bring to the schoolroom, and which will give material for the lesson. The rolls are found plentifully on sumac, basswood, and witch hazel.

OBSERVATIONS — 1. What is the name of the trees and shrubs from which these rolled leaves that you have collected were taken?

2. Is more than one leaf or leaflet used in making the roll?

3. Is the leaf rolled crosswise or lengthwise? How large is the tube thus made?

4. Is the nest in the shape of a tube, or are several leaves fastened together, making a box-shaped nest?

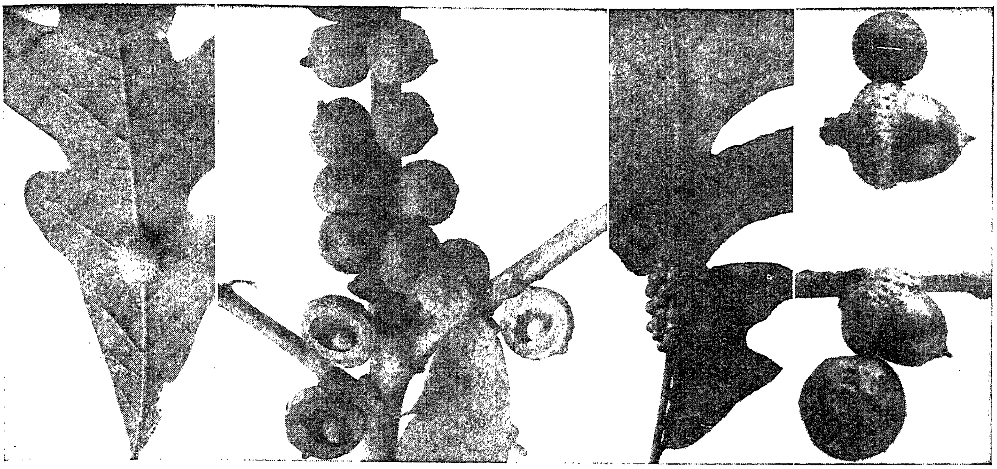
5. How is the roll made fast? Examine the little silken ropes with a lens and describe one of them. Is it wider where it is attached to the leaf than at the middle? Why?

6. How many of these tent ropes are there which make fast the roll? Unroll a leaf carefully and see if you can find signs of the tent ropes that fastened the roll together when it was smaller. Can you find where it began?

7. As you unroll the leaves what do you see at the center? Has the leaf been eaten? Can you discover the reason why the caterpillar made this roll?

8. How do you think a caterpillar manages to roll a leaf so successfully? Where is the spinning gland of a caterpillar? How does the insect act when spinning threads back and forth when rolling the leaf? What sort of insect does the caterpillar which rolls the leaf change into? Do you suppose that the same kind of caterpillars make the rolls on two different species of trees?

9. In July or early August get some of the rolls with the caterpillars in them, unroll a nest, take the caterpillar out and put it on a fresh leaf of the same kind of tree or shrub on which you found it, and watch it make its roll.



L. H. Weld

The spiny oak-gall — *The pointed bullet-gall on oak twigs* — *A cluster of galls on mid-rib of an oak leaf* — *The acorn plum-gall*

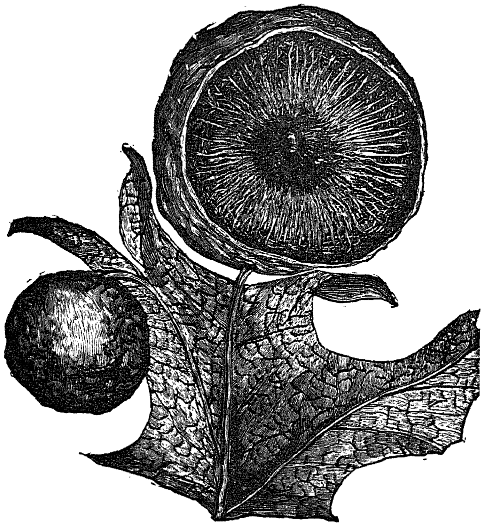
THE GALL DWELLERS

He retired to his chamber, took his lamp, and summoned the genius as usual. " Genius," said he, " build me a palace near the sultan's, fit for the reception of my spouse, the princess; but instead of stone, let the walls be formed of massy gold and silver, laid in alternate rows; and let the interstices be enriched with diamonds and emeralds. The palace must have a delightful garden, planted with aromatic shrubs and plants, bearing the most delicious fruits and beautiful flowers. But, in particular, let there be an immense treasure of gold and silver coin. The palace, moreover, must be well provided with offices, storehouses, and stables full of the finest horses, and attended by equerries, grooms, and hunting equipage." By the dawn of the ensuing morning, the genius presented himself to Aladdin, and said, " Sir, your palace is finished; come and see if it accords with your wishes." — Arabian Nights' Entertainments

Although Aladdin is out of fashion, we still have houses of magic that are even more wonderful than that produced by his resourceful lamp. These houses are built through an occult partnership between insects and plant tissues; we do not understand exactly how they are made, although we are beginning to understand a little concerning the reasons for the growth. These houses are called galls and are thus well named, since they grow because of an irritation to the plant caused by the insect.

There are many forms of these gall dwellings, and they may grow upon the root, branch, leaf, blossom, or fruit. The miraculous thing about them is that each kind of insect builds its magical house on a certain part of a certain species of tree or plant; and the house is always of a certain definite form on the outside and of a certain particular pattern within. Many widely differing species of insects are gall-makers; and he who is skilled in gall lore knows, when he looks at the outside of the house, just what insect dwells within it.

We may take the history of the common oak apple as an example. A little, four-winged, flylike creature, a wasp, lays its eggs, early in the season, on the leaf of the scarlet oak. As soon as the larva hatches, it begins to eat into the substance of one of the leaf veins. As it eats, it discharges through its mouth into the tissues of the leaf a substance which is secreted from glands within its body. Immediately

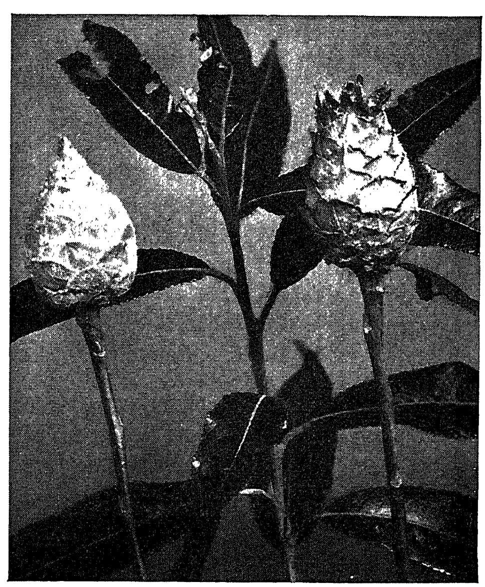


Oak apple, showing the larva of the gall insect

the building of the house commences; out around the little creature grow radiating vegetable fibers, showing by their position plainly that the grub is the center of all of this new growth; meanwhile, a smooth, thin covering completely encloses the globular house; larger and larger grows the house until we have what we are accustomed to call an oak apple, so large is it. The little chap inside is surely content and happy, for it is protected from the sight of all of its enemies, and it finds the walls of its house the best of food. It is comparable to a boy living in the middle of a giant sponge cake, who when hungry would naturally eat out a larger cave in the heart of the cake. After the inmate of the oak apple completes its growth, it changes to a pupa and finally comes out into the world a tiny wasp, scarcely a quarter of an inch in length.

The story of the willow cone-gall is quite different. A little gnat lays her eggs on the tip of the bud of a twig; as soon as the grub hatches and begins to eat, the growth of the twig is arrested, the leaves are stunted until they are mere scales and are obliged to overlap in rows around the little inmate, thus making for it a cone-shaped house which is very thoroughly shingled. The inhabitant of this gall is a hospitable little fellow, and his house shelters and feeds many other insect guests. He does not pay any attention to them, being a recluse in his own cell, but he civilly allows them to take care of themselves in his domain, and to feed upon the walls of his house. He stays in his snug home all winter and comes out in the spring a tiny, two-winged fly.

There are two galls common on the stems of goldenrod. The more numerous is spherical in form and is made by a fat and prosperous looking little grub which later develops into a fly. But although it is a fly that makes the globular gall in the stem of goldenrod, the spindle-shaped gall often seen on the same stem has quite another story. A little brown and gray mottled moth, about three-fourths of an inch long, lays her egg on the stem of the young goldenrod. The caterpillar, when it hatches, lives inside the stem, which accommodatingly enlarges into an oblong room. The caterpillar feeds upon the substance of the stem until it attains its growth, and then it cuts, with sharp jaws,



Verne Morton

Willow cone-galls

a little oval door at the upper end of its house and makes an even bevel by widening the opening toward the outside. It then makes a little plug of debris which completely fills the door; but because of the bevel, no intrusive beetle or ant can push it in. Thus the caterpillar changes to a helpless pupa in entire safety; and when the little moth issues from the pupa skin, all it has to do is to push its head against the door, and out it falls, and the recluse is now a creature of the outside world.

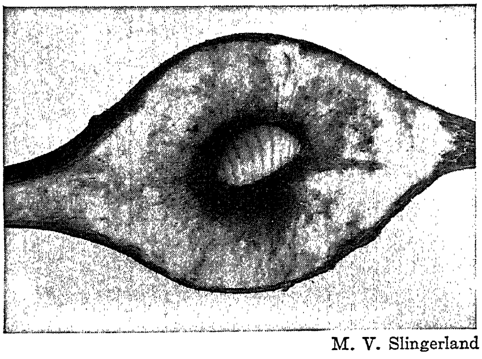
Many galls are compound, that is, they are made up of a community of larvæ, each in its own cell. The mossy rose gall is an instance of this. The galls made by mites and aphids are open either below or above the surface of the leaf; the little conical galls on witch hazel are examples of these. In fact, each gall has its own particular history, which proves a most interesting story if we seek to read it with our own eyes.

Suggested Reading — *Interesting Neighbors*, by Oliver P. Jenkins; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; Scientific Living Series, Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on page 300.

LESSON 79

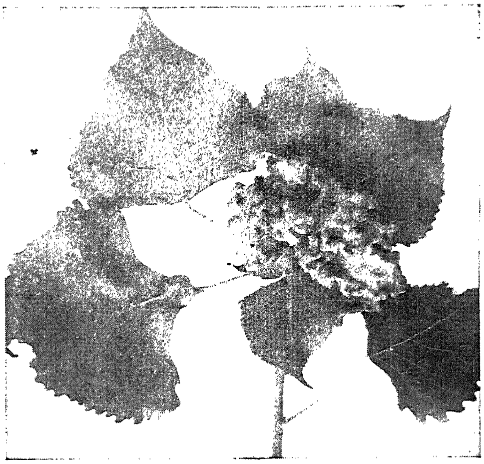
The Gall Dwellers

Leading Thought — The galls are protective habitations for the little insects which dwell within them. Each kind of insect makes its own peculiar gall on a certain species of plant.



M. V. Slingerland

Spherical gall of the goldenrod, opened, showing its prosperous looking owner



Glenn W. Herrick

The vagabond gall of the cottonwood

Method — Ask the pupils to bring in as many of these galls as possible. Note that some have open doors and some are entirely closed. Cut open a gall and see what sorts of insects are found within it. Place each kind of gall in a tumbler or jar covered with cheesecloth and put them where they may be under observation for perhaps several months; note what sort of winged insect comes from each.

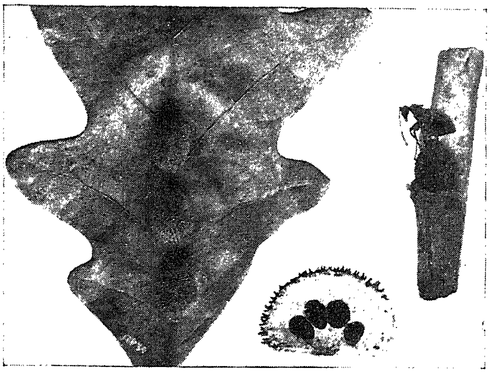
Observations — 1. On what plant or tree did this gall grow? Were there many like it? Did they grow upon the root, stem, leaf, flower, or fruit? If on the leaf, did they grow upon the petiole or the blade?

2. What is the shape of the little house? What is its color? Its size? Is it smooth or wrinkled on the outside? Is it covered with fuzz or with spines?

3. Open the gall; is there an insect within it? If so, where is it and how does it look? What is the appearance of the inside of the gall?

4. Is there a cell for the insect at the very center of the gall, or are there many such cells?

5. Has the house an open door? If so, does the door open above or below? Is there more than one insect in the galls



C. V. Triggerson

Pictured here are porcupine galls on the leaf of a white oak; a section of a porcupine gall showing the cells; and a female gall-fly laying eggs in an oak bud

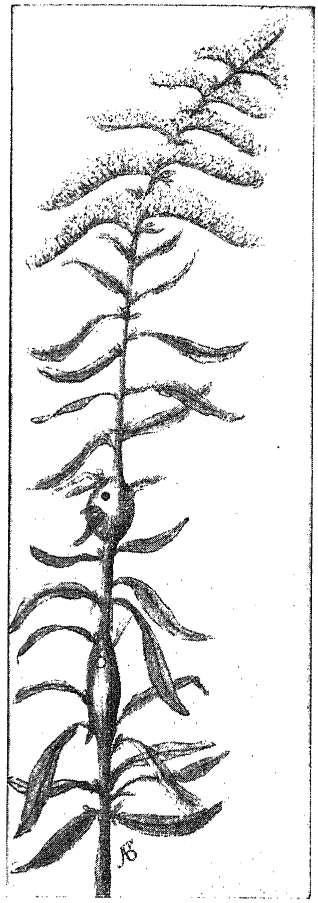
with open doors? What sort of insect makes this kind of house?

6. Do you find any insects besides the original gall-maker within it? If so, what are they doing?

7. Of what use are these houses to their little inmates? How do they protect them from enemies? How do they furnish them with food?

8. Do the gall insects live all their lives within the galls or do they change to winged insects and come out into the world? If so, how do they get out?

9. How many kinds of galls can you find upon oaks? Upon goldenrod? Upon witch hazel? Upon willow?



Stem of goldenrod showing the spherical gall above, made by the larva of a fly; and the spindle-shaped gall below, made by the caterpillar of a moth

A green little world
With me at its heart!
A house grown by magic,
Of a green stem, a part.

My walls give me food
And protect me from foes,
I eat at my leisure,
In safety repose.

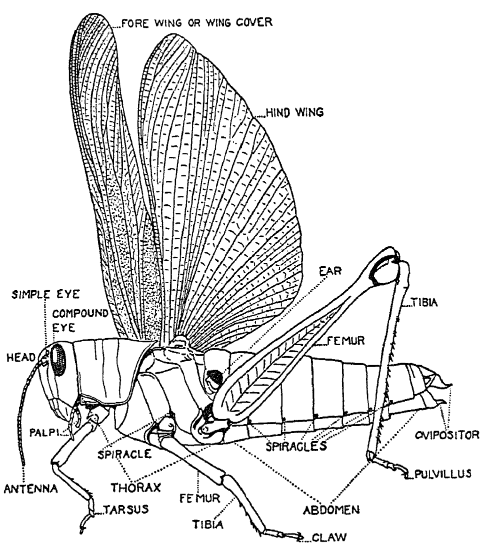
My house hath no window,
'Tis dark as the night!
But I make me a door
And batten it tight.

And when my wings grow
I throw wide my door;
And to my green castle
I return nevermore.

THE GRASSHOPPER

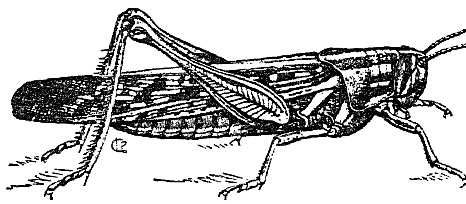
Because the grasshopper affords special facilities for the study of insect structure, it has indeed become a burden to the students in the laboratories of American universities. But in nature-study we must not make anything a burden, least of all the grasshopper, which, being such a famous jumper as well as flier, does not long voluntarily burden any object.

Since we naturally select the most salient characteristic of a creature to present first to young pupils, we naturally begin this lesson with the peculiarity which makes this insect a "grasshopper." When any creature has unusually strong hind legs, we may be sure it is a jumper, and the grasshopper shows this peculiarity at first glance. The front legs are short, the middle legs a trifle longer, but the femur of the hind leg is nearly as long as the entire body, and contains many powerful muscles which have the appearance of being



A grasshopper with parts of the external anatomy named

braided, because of the way they are attached to the skeleton of the leg; the tibia of the hind leg is long and as stiff as if made of steel. When getting ready to jump the grasshopper lowers the great femur below the level of the closed wings and until the tibia is parallel with it and the entire foot is pressed against the ground. The pair of double spines at the end of the tibia, just back of the foot, are pressed against the ground like a spiked heel, and the whole attitude of the insect is tense. Then, like a steel spring, the long legs straighten and the insect is propelled high into the air and far away. This is a remarkable example of insect dynamics. Since so many species of birds feed upon the grasshopper, its leaping power is much

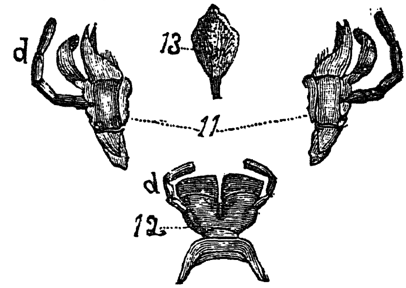


The American bird grasshopper

needed to escape them. However, when the grasshopper makes a journey it uses its wings.

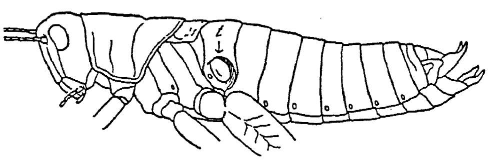
As we watch a grasshopper crawling up the side of a vial or tumbler we can examine its feet with a lens. Between and in front of the claws is an oval pad which clings to the glass, not by air pressure as was once supposed, but by means of microscopic hairs, called tenent hairs, which secrete a sticky fluid. Each foot consists of three segments and a claw; when the insect is quiet, the entire foot rests upon the ground; but when it is climbing on glass, the toe pads are used.

The grasshopper's face has a droll expression; would that some caricaturist could analyze it! It is a long face, and the compound eyes placed high upon it give a look of solemnity. The simple eyes can



The mouth-parts of a grasshopper, enlarged
8, upper lip or *labrum*. 10, upper jaws or *mandibles*. 11, lower jaws or *maxillae*. 12, under lip or *labium*. 13, tongue. *d*, palpi

be made out with a lens. There is one just in front of each big eye, and another, like the naughty little girl's curl, is " right in the middle of the forehead." The antennæ are short but alert. The two pairs or palpi connected with the mouth-parts are easily seen, likewise the two pairs of jaws, the notched mandibles looking like a pair of nippers. We can see these jaws much better when the insect is eating, which act is done methodically. First, it begins at one edge of a leaf, which it seizes between the front feet so as to hold it firm; it eats by reaching up and cutting downwards, making an even-edged, long hole on the leaf margin; it makes the hole deeper by repeating the process. It sometimes makes a hole in the middle of a leaf and bites in any direction, but it prefers to move the jaws downward. While it is feeding, its palpi tap the leaf continually and its whole attitude is one of deep satisfaction. There is an up-rolled expression to the compound eyes which reminds us of the way a child looks over the upper edge of its cup while drinking milk. The grasshopper has a preference for tender herbage, but in time of drought will eat almost any living plant.



A drawing of a grasshopper without the wings to show an ear, labeled t

Back of the head is a sunbonnet-shaped piece, bent down at the sides, forming a cover for the thorax. The grasshopper has excellent wings, as efficient as its legs; the upper pair are merely strong, thick, membranous covers, bending down at the sides so as to protect the under wings; these wing covers are not meant for flying and are held stiff and straight up in the air during flight. The true wings, when the grasshopper is at rest, are folded lengthwise like a fan beneath the wing covers; they are strongly veined and circular in shape, giving much surface for beating the air. The grasshopper's flight is usually swift and short; but in years of famine some kinds of grasshoppers fly high in the air and for long distances, a fact recorded in the Bible regarding the plague of locusts. When they thus appear in vast hordes, they destroy all the vegetation in the region where they settle.

The wings of grasshoppers vary in color, those of the red-legged species being gray, while those of the Carolina locusts are black with yellow edges. The abdomen is segmented, as in all insects, and along the lower side there are two lengthwise sutures or creases which open and shut bellows-like when the grasshopper breathes. The spiracles or breathing pores can be seen on each segment, just above this suture.

The grasshopper has its ears well protected; to find them, we must lift the wings in order to see the two large sounding discs, one on each side of the first segment of the abdomen. These are larger and much more like ears than are the little ears in the elbows of the katydids.

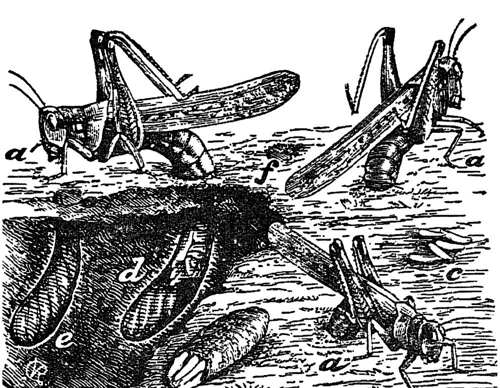
The singing of the short-horned grasshoppers is a varied performance, each species doing it in its own way. One species makes a most seductive little note by placing the femur and tibia of the hind legs together; with the hind feet completely off the ground, the legs are moved up and down with great rapidity, giving off a little purr. The wings in this case do not lift at all. There are other species that make the sound by rubbing the legs against the wing covers.

The grasshopper makes its toilet thus: It cleans first the hind feet by rubbing them together and also by reaching back and scrubbing them with the middle feet; the big hind femur it polishes with the bent elbow of the second pair of legs. It cleans the middle feet by nibbling and licking them, bending the head far beneath the body in order to do it. It polishes its eyes and face with the front feet, stopping to lick them clean between whiles, and it has a most comical manner of cleaning its antennæ; this is accomplished by tipping the head sidewise, and bending it down so that the antenna of one side rests upon the floor; it then plants the front foot of that side firmly upon the antenna and pulls it slowly backward between the foot and floor.

The grasshopper has some means of defense as well as of escape; it can give a painful nip with its mandibles; and when seized, it emits copiously from the mouth a brownish liquid which is acrid and ill smelling. This performance interests children who are wont to seize the insect by its jumping legs and hold it up, commanding it to "chew tobacco."

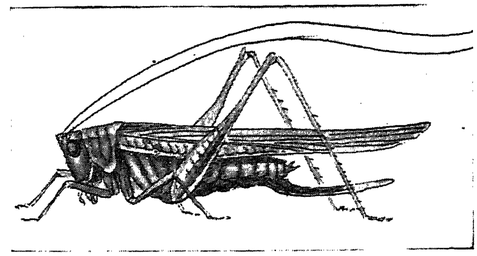
Grasshoppers are insects with incomplete metamorphosis, which merely means that the baby grasshopper, as soon as it emerges from the egg, is similar in form to its parent except that it has a very large head and a funny little body, and that it has no quiet pupal stage during life. When immature, the under wings or true wings have a position outside of the wing covers and look like little fans.

The short-horned grasshoppers lay their eggs in oval masses protected by a tough overcoat. The ovipositor of the mother grasshopper is a very efficient tool, and with it she makes a deep hole in the ground, or sometimes in fence rails or other decaying wood; after placing her eggs in such a cavity, she covers the hiding place with a gummy substance so that no intruders or robbers may work harm



Grasshoppers laying eggs

a, a, a, females, ovipositing; *b,* egg-pod extracted from the ground with the end broken open; *c,* a few eggs lying loose upon the ground; *d, e,* show the earth partially removed to illustrate an egg-mass already in place and one being placed; *f* shows where such a mass has been covered up



Long-horned or meadow grasshopper

to her progeny. Most species of grasshoppers pass the winter in the egg stage; but sometimes we find in early spring the young ones which hatched in the fall, and they seem as spry as if they had not been frozen stiff.

Suggested Reading — *Do You Know?* by Janet Smalley; *Insect Pests of Farm, Garden and Orchard*, by E. D. Sanderson and L. M. Peairs; *Insect People*, by Eleanor King and Wellmer Pessels; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals;* also, readings on page 300.

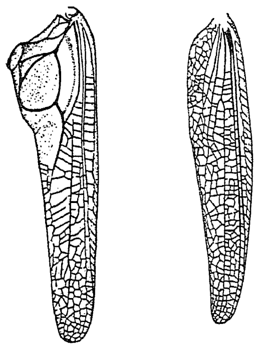
LESSON 80

The Red-legged Grasshopper

Leading Thought — The grasshopper feeds upon grass and other herbage and is especially fitted for living in grassy fields. Its color protects it from being seen by its enemies, the birds. If attacked, it escapes by long jumps and by flight. It can make long journeys on the wing.

Method — The red-legged grasshopper (*M. femur-rubrum*) has been selected for this lesson because it is the most common of all grasshoppers in many parts of our country, though other species may be used as well. The red-legged locust or grasshopper has, as is indicated by its name, the large femur of the hind legs reddish in color. Place the grasshopper under a tumbler and upon a spray of fresh herbage, and allow the pupils to observe it at leisure. It might be well to keep some of the grasshoppers in a cage similar to that described for crickets. When one is studying the feet, or other parts of the insect requiring close scrutiny, the grasshopper should be placed in a vial so that it may be passed around and observed with a lens. Give the questions a few at a time, and encourage the pupils to study these insects in the field.

Observations — 1. Since a grasshopper is such a high jumper, discover if you can



Left, *wing of male; and* right, *wing of female meadow grasshoppers*

how he does this "event." Which pair of legs is the longest? Which the shortest? How long are the femur and tibia of the hind leg compared with the body? What do you think gives the braided appearance to the surface of the hind femur? What is there peculiar about the hind femur? Note the spines at the end of the tibia just behind the foot.

2. Watch the grasshopper prepare to jump and describe the process. How do you think it manages to throw itself so far? If a man were as good a jumper as a grasshopper in comparison to his size, he could jump 300 feet high or 500 feet in distance. Why do you think the grasshopper needs to jump so far?

3. As the grasshopper climbs up the side of a tumbler or vial, look at its feet through a lens and describe them. How many segments are there? Describe the claws. How does it cling to the glass? Describe the little pad between the claws.

4. Look the grasshopper in the face. Where are the compound eyes situated? Can you see the tiny simple eyes like mere dots? How many are there? Where are they? How long are the antennæ? For what are they used?

5. How does a grasshopper eat? Do the jaws move up and down or sidewise? What does the grasshopper eat? How many pairs of palpi can you see connected with the mouth-parts? How are these used when the insect is eating? When there are many grasshoppers, what may happen to the crops?

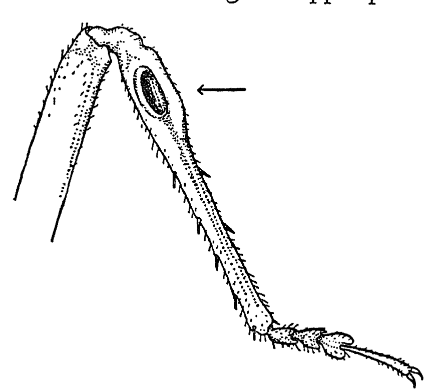
6. What do you see just back of the grasshopper's head, when looked at from above?

7. Can the grasshopper fly as well as jump? How many pairs of wings has it? Does it use the first pair of wings to fly with? How does it hold them when flying? Where is the lower or hind pair of wings when the grasshopper is walking? How do they differ in shape from the front wings?

8. Note the abdomen. It is made of many rings or segments. Are these rings continuous around the entire body? Where do their breaks occur? Describe the movement of the abdomen as the insect breathes. Can you see the spiracles or breathing pores? Lift the wings, and find the ear on the first segment of the abdomen.

9. If you seize the grasshopper how may it show that it is offended?

10. How does the grasshopper perform



Front leg of a katydid showing the ear near the elbow

its toilet? Describe how it cleans its antennæ, face, and legs.

11. What becomes of the grasshoppers in the winter? Where are the eggs laid? How can you tell a young from a full-grown grasshopper?

12. Do all grasshoppers have antennæ shorter than half the length of their bodies? Do some have antennæ longer than their bodies? Where are the long-horned grasshoppers found? Describe how they resemble the katydids in the way they make music and in the position of their ears.

THE KATYDID

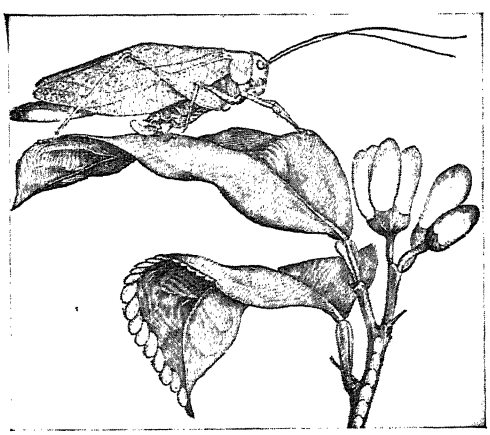
I love to hear thine earnest voice
Wherever thou art hid,
Thou testy little dogmatist,
Thou pretty katydid,

Thou mindest me of gentle folks,
Old gentle folks are they,
Thou say'st an undisputed thing
In such a solemn way.

— HOLMES

Distance, however, lends enchantment to the song of the katydid, for it grates on our nerves as well as on our ears, when at close quarters. The katydid makes his music in a manner similar to that of the cricket but is not, however, so well equipped, since he has only one file and only one scraper for playing. As with the meadow grasshoppers and crickets, only the males make the music, the wings of the females being delicate and normally veined at the base. The ears, too, are in the same position as those of the cricket, and may be seen as a black spot in the front elbow. The song is persistent and may last the night long: "Katy did, she didn't, she did." James Whitcomb Riley says, "The katydid is rasping at the silence," and the word "rasping" well describes the note.

The katydids are beautiful insects, with green, finely veined, leaflike wing covers under which is a pair of well developed wings, folded like fans; they resemble in form the long-horned grasshoppers. The common northern species (*Cyrtophyllus*) is all green above except for the long, delicate fawn-colored antennæ, and the brownish fiddle of the male, which consists of a flat triangle just back of the thorax where the wing covers overlap. Sometimes this region is pale brown and sometimes green, and with the unaided eye we can plainly see the strong cross-vein, bearing the file. The green eyes have darker centers and are not so large as the eyes of the grasshopper. The body is green with white lines below on either side. There is a suture the length of the abdomen in which are placed the spiracles. The insect breathes by sidewise expansion and contraction, and the sutures rhythmically open and shut; when they are open, the spiracles can be seen as black dots.

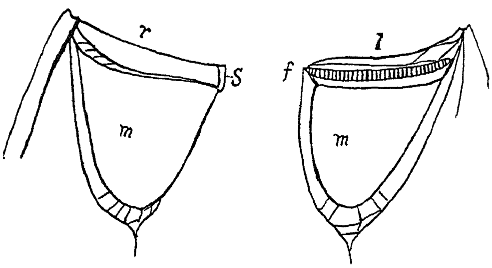


The angular-winged katydid and her eggs

The legs are slender and the hind pair very long. The feet are provided with two little pads, one on each side of the base of the claw. In the grasshopper there is only one pad, which is placed between the two hooks of the claw. The female has a green, sickle-shaped ovipositor at the end of the body. With this she lays her flat, oval eggs, slightly overlapping in a neat row.

The katydids are almost all dwellers in trees and shrubs; although I have often found our common species upon asters and similar high weeds. The leaflike wings of these insects are, in form and color, so similar to the leaves that they are very completely hidden. The katydid is rarely discovered except by accident; although when one is singing, it may be approached and ferreted out with the aid of a lantern.

The katydid, when feeding, often holds the leaf or the flower firmly with the front



The front portions of the wings of a male katydid showing the file, f, *on one wing and the scraper,* s, *on the other*

feet, while biting it off like a grazing cow, and if it is tough, chews it industriously with the sidewise-working jaws. A katydid will often remain quiet a long time with one long antenna directed forward and the other backward, as if on the lookout for news from the front and the rear. But when the katydid "cleans up," it does a thorough job. It nibbles its front feet, paying special attention to the pads, meanwhile holding the foot to its mandibles with the aid of the palpi. But one washing is not enough; I have seen a katydid go over the same foot a dozen times in succession, beginning always with the hind spurs of the tibia and nibbling along the tarsus to the claws. It cleans its face with its front foot, drawing it downward over the eye and then licking it clean. It cleans its antenna with its mandibles by beginning at the base and drawing it up in a loop as fast as finished. After watching the process of these lengthy ablutions, we must conclude that the katydid is among the most fastidious members of the insect "four hundred."

SUGGESTED READING — *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals;* also, readings on page 300.

LESSON 81
THE KATYDID

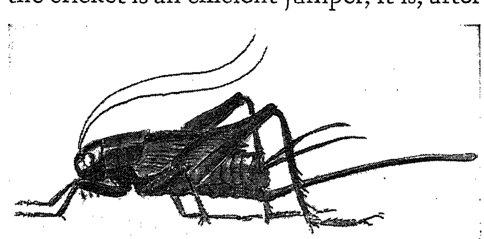
LEADING THOUGHT — The katydids resemble the long-horned grasshoppers and the crickets. They live in trees, and the male sings "katy did" by means of a musical instrument similar to that of the cricket.

METHOD — Place a katydid in a cricket cage in the schoolroom, giving it fresh leaves or flowers each day, and encouraging the pupils to watch it at recess. It may be placed in a vial and passed around for close observation. In studying this insect, use the lesson on the red-legged grasshopper and also that on the cricket. These lessons will serve to call the attention of the pupils to the differences and resemblances between the katydid and these two related insects.

THE BLACK CRICKET

If we wish to become acquainted with these charming little troubadours of the field, we should have a cricket cage with a pair of them within it. They are most companionable, and it is interesting to note how quickly they respond to a musical sound. I had a pair in my room at one time, when I lived very near a cathedral. Almost every time that the bells rang during the night, my cricket would respond with a most vivacious and sympathetic chirping.

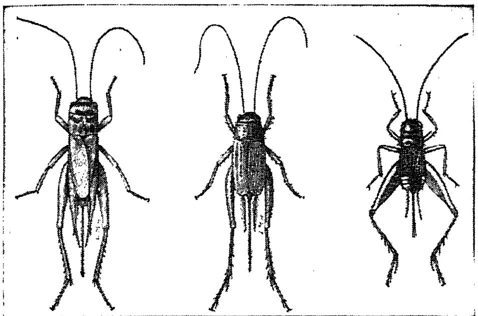
The patent-leather finish to this cricket's clothes is of great use; for, although the cricket is an efficient jumper, it is, after



The field cricket

all, mostly by running between grass blades that it escapes its enemies. If we try to catch one, we realize how slippery it is, and how efficiently it is thus able to slide through the fingers.

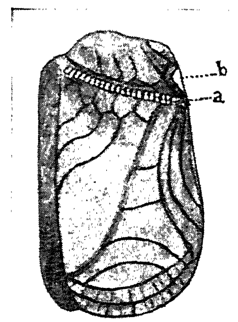
The haunts of the cricket are usually sunny; it digs a little cave beneath a stone or clod in some field, where it can have the whole benefit of all the sunshine when it issues from its door. These crickets cannot fly, since they have no wings under



Left, *a house cricket;* center, *field cricket;* right, *another species of field cricket*

their wing covers, as do the grasshoppers. The hind legs have a strong femur, and a short but strong tibia with downward-slanting spines along the hind edge, which undoubtedly help the insect in scrambling through the grass. At the end of the tibia, next to the foot, is a rosette of five spines, the two longer ones slanting to meet the foot; these spines give the insect a firm hold, when making ready for its spring. When walking, the cricket places the whole hind foot flat on the ground, but rests only upon the claw and the adjoining segment of the front pairs of feet. The claws have no pads like those of the katydid or grasshopper; the segment of the tarsus next the claw has long spines on the hind feet and shorter spines on the middle and front feet, thus showing that the feet are not made for climbing, but for scrambling along the ground. When getting ready to jump, the cricket crouches so that the tibia and femur of the hind legs are shut together and almost on the ground. The dynamics of the cricket's leap are well worth studying.

The cricket's features are not so easily made out, because the head is polished and black; the eyes are not so polished as the head; the simple eyes are present, but are discerned with difficulty. The antennæ

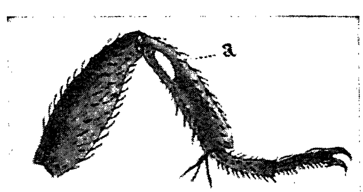


The wing of a male cricket enlarged. a, *file;* b, *scraper*

are longer than the body and very active; there is a globular segment where they join the face. I have not discovered that the crickets are so fastidious about keeping generally clean as are some other in-

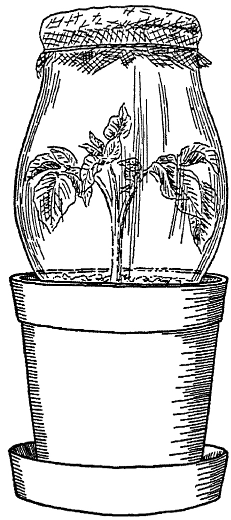
A section of the file enlarged

sects, but they are always cleaning their antennæ. I have seen a cricket play his wing mandolin lustily and at the same time carefully clean his antennæ; he polished these by putting up a foot and bend-



The front leg of a cricket enlarged to show the ear at a

ing the antenna down so that his mouth reached it near the base; he then pulled the antenna through his jaws with great deliberation, nibbling it clean to the very end. The lens reveals to us that the flexibility of the antennæ is due to the fact that they are many jointed. The palpi are easily seen, a large pair above and a smaller pair beneath the "chin." The palpi are used to test food and prove if it be palatable. The crickets are fond of melon or other sweet, juicy fruits, and by putting such food into the cage we can see them bite out pieces with their sidewise-working jaws, chewing the toothsome morsel with gusto. They take hold of the sub-



A cricket cage

stance they are eating with the front feet as if to make sure of it.

The wing covers of the cricket are bent down at the sides at right angles, like a box cover. The wing covers are much shorter than the abdomen and beneath them are vestiges of wings, which are never used. The male has larger wing covers than the female, and they are veined in a peculiar scroll pattern. This veining seems to be a framework for the purpose of making a sounding board of the wing membrane, by stretching it out as a drumhead is stretched. Near the base of the wing cover there is a heavy cross-vein covered with transverse ridges, which is called the file; on the inner edge of the same wing, near the base, is a hardened portion called the scraper. When he makes his cry, the cricket lifts his wing covers at an angle of forty-five degrees and draws the scraper of the under wing against the file of the overlapping one; lest his musical apparatus become worn out, he can change by putting the other wing cover above. The wing covers are excellent sounding boards and they quiver as the note is made, setting the air in vibration, and sending the sound a long distance. The female cricket's wing covers are more normal in venation; and she may always be distinguished from her spouse by the long swordlike ovipositor at the end of her body; this she thrusts into the ground when she lays her eggs, thus placing them where they will remain safely protected during the winter. Both sexes have a pair of "tail feathers," as the children call them, which are known as the cerci (*sing. cercus*) and are fleshy prongs at the end of the abdomen.

There would be no use of the cricket's playing his mandolin if there were not an appreciative ear to listen to his music. This ear is placed most conveniently in the tibia of the front leg, so that the crickets literally hear with their elbows, as do the katydids and the meadow grasshoppers. The ear is easily seen with the naked eye as a little white, disclike spot.

The chirp of the cricket is, in literature, usually associated with the coming of autumn; but the careful listener may hear it in early summer, although the song is not then so insistent as later in the season. He usually commences singing in the afternoon and keeps it up periodically all night. I have always been an admirer of the manly, dignified methods of this little "minnesinger," who does not wander abroad to seek his ladylove but stands sturdily at his own gate, playing his mandolin the best he is able; he has faith that his sable sweetheart is not far away, and that if she likes his song she will come to him of her own free will. The cricket is ever a lover of warmth and his mandolin gets out of tune soon after the evenings become frosty. He is a jealous musician. When he hears the note of a rival he at once "bristles up," lifting his wings at a higher angle and giving off a sharp militant note. If the two rivals come in sight of each other there is a fierce duel. They rush at each other with wide-open jaws, and fight until one is conquered and retreats, often minus an antenna, cercus, or even a leg. The cricket's note has a wide range of expression. When waiting for his ladylove, he keeps up a constant droning; if he hears his rival, the tone is sharp and defiant; but as the object of his affection approaches, the music changes to a seductive whispering, even having in it an uncertain quiver, as if his feelings were too strong for utterance.

SUGGESTED READING — *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals; Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting;* also, readings on page 300.

THE BLACK CRICKETS

Of the insect musicians the cricket is easily the most popular. Long associated with man, as a companion of the hearth and the field, his song touches ever the chords of human experience. Although we, in America, do not have the house-cricket which English poets praise, yet our field-crickets have a liking for warm corners, and will, if encouraged, take up their abode among our hearthstones. The greatest tribute to the music of the cricket is the wide range of human emotion which it expresses. "As merry as a cricket" is a very old saying and is evidence that the cricket's fiddling has ever chimed with the gay moods of dancers and merrymakers. Again, the cricket's song is made an emblem of peace; and again we hear that the cricket's "plaintive cry" is taken as the harbinger of the sere and dying year. From happiness to utter loneliness is the gamut covered by this sympathetic song. Leigh Hunt found him glad and thus addresses him:

And you, little housekeeper who class
With those who think the candles come
too soon,
Loving the fire, and with your tricksome
tune
Nick the glad, silent moments as they
pass.

— "WAYS OF THE SIX-FOOTED," COMSTOCK

LESSON 82

THE BLACK CRICKET

LEADING THOUGHT — The crickets are among the most famous of the insect musicians. They live in the fields under stones and in burrows, and feed upon grass and clover. As with most birds, only the male makes music; he has his wing covers developed into a mandolin or violin, which he plays to attract his mate and also for his own pleasure.

METHOD — Make some cricket cages as follows: Take a small flowerpot and plant in it a root of fresh grass or clover. Place over this and press well into the soil a glass chimney, or a small piece of fine mesh screen rolled into the shape of a cylinder and fastened securely with string or fine wire. Cover the top with mosquito netting. Place the pot in its saucer, so that it may be watered by keeping the saucer filled. Ask the pupils to collect some crickets. In each cage, place a male and one or more females, the latter being readily distinguished by the long ovipositors. Place the cages in a sunny window, where the pupils may observe them, and ask for the following observations. In studying the cricket closely, it may be well to put one in a vial and pass it around. In observing the crickets eat, it is well to give them a piece of sweet apple or melon rind, as they are very fond of pulpy fruits.

OBSERVATIONS — 1. Is the covering of the cricket shining, like black patent leather, or is it dull? What portions are dull? Of what use do you think it is to the cricket to be so smoothly polished?

2. Where did you find the crickets? When you tried to catch them, how did they act? Did they fly like grasshoppers or did they run and leap?

3. Look carefully at the cricket's legs. Which is the largest of the three pairs? Of what use are these strong legs? Look

carefully at the tibia of the hind leg. Can you see the strong spines at the end, just behind the foot or tarsus? Watch the cricket jump and see if you can discover the use of these spines. How many joints in the tarsus? Has the cricket a pad like the grasshopper's between its claws? When the cricket walks or jumps does it walk on all the *tarsi* of each pair of legs?

4. Study the cricket's head. Can you see the eyes? Describe the antennæ — their color, length, and the way they are used. Watch the cricket clean its antennæ and describe the process. Can you see the little feelers, or palpi, connected with the mouth? How many are there? How does it use these feelers in tasting food before it eats? Watch the cricket eat, and see whether you can tell whether its mouth is made for biting or sucking.

5. Study the wings. Are the wings of the mother cricket the same size and shape as those of her mate? How do they differ? Does the cricket have any wings under these front wings, as the grasshopper does? Note the cricket when he is playing his wing mandolin to attract his mate. How does he make the noise? Can you see the wings vibrate? Ask your teacher to show you a picture of the musical wings of the cricket, or to show you the wings themselves under the microscope, so that you may see how the music is made.

6. Why does the mother cricket need such a long ovipositor? Where does she put her eggs in the fall to keep them safe until spring?

7. Look in the tibia, or elbow, of the front leg for a little white spot. What do you suppose this is? Are there any white spots like it on the other legs? Ask your teacher to tell you what this is.

8. Can you find the homes of the crickets in the fields? Do the black crickets chirp in the daytime or after dark? Do they chirp in cold or windy weather, or only when the sun shines?

CRICKET SONG

Welcome with thy clicking, cricket!
Clicking songs of sober mirth;
Autumn, stripping field and thicket,
Brings thee to my hearth,
Where thy clicking shrills and quickens,
While the mist of twilight thickens.

. . . .

No annoy, good-humored cricket,
With thy trills is ever blent;
Spleen of mine, how dost thou trick it
To a calm content?
So, by thicket, hearth, or wicket,
Click thy little lifetime, cricket!

— Bayard Taylor

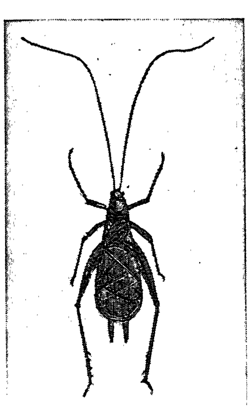
THE SNOWY TREE CRICKET

This is a slim, ghostlike cricket. It is pale green, almost white in color, and about three-fourths of an inch long. Its long, slender hind legs show that it is a good jumper. Its long antennæ, living threads, pale gray in color, join the head with amber globelike segments. The pale eyes have a darker center and the palpi are very long. The male has the wing covers shaped and veined like those of the black cricket, but they are not so broad and are whitish and very delicate. The wings beneath are wide, for these crickets can fly. The female has a long, swordlike ovipositor.

The snowy tree cricket, like its relatives, spends much time at its toilet. It whips the front foot over an antenna and brings the base of the latter to the mandibles with the palpi and then cleans it carefully to the very tip. It washes its face with the front foot, always with a downward movement. If the hind foot becomes entangled in anything it first tries to kick it clean, and then, drawing it beneath the body, bends the head so as to reach it with the mandibles and nibbles it clean. The middle foot it also thrusts beneath the body, bringing it forward between the front legs for cleaning. But when cleaning its front feet, the snowy tree cricket puts on airs; it lifts the elbow high and draws the foot through the mouth with a gesture very like that of a young lady with a seal ring on her little finger, holding the ornate member out from its companions as if it were stiff with a consciousness of its own importance.

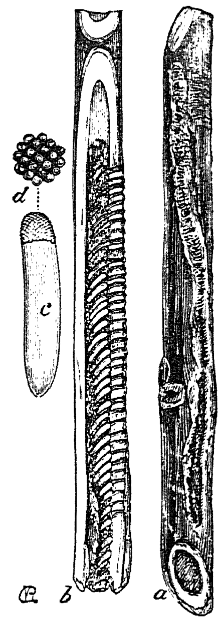
There are two common species of the snowy tree crickets which can hardly be separated except by specialists or by watching their habits. One is called " the whistler " and lives on low shrubs or grass; it gives a clear, soft, prolonged, unbroken note. The other is called " the fiddler " and lives on shrubs and in trees and vines. Its note is a pianissimo performance of the katydid's song; it is delightful, rhythmic, and sleep-inspiring; it begins in the late afternoon and continues all night until the early, cold hours of the approaching dawn. The vivacity of the music depends upon the temperature, as the notes are given much more rapidly during the hot nights.

" So far as we know, this snowy tree cricket is the only one of the insect musicians that seems conscious of the fact that he belongs to an orchestra. If you listen on a September evening, you will hear the first player begin; soon another



The snowy tree cricket

will join, but not in harmony at first. For some time there may be a seesaw of accented and unaccented notes; but after a while the two will be in unison; perhaps not, however, until many more players have joined the concert. When the rhythmical beat is once established, it is in as perfect time as if governed by the baton of



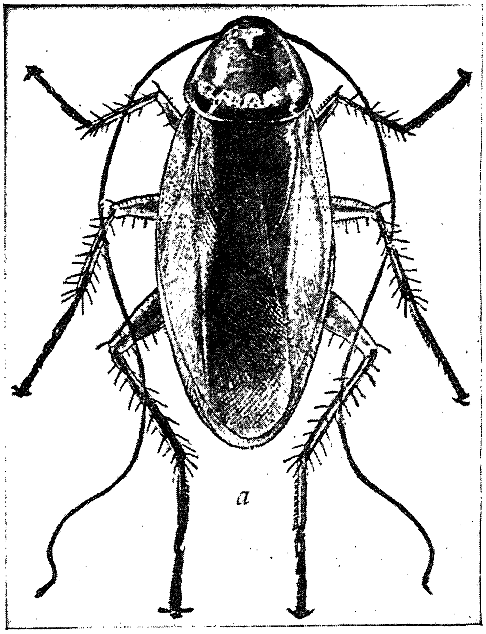
Eggs of the snowy tree cricket, laid in raspberry cane; c *and* d, *egg enlarged*

a Damrosch or a Thomas. The throbbing of the cricket heart of September, it has been fitly named. Sometimes an injudicious player joins the chorus at the wrong beat, but he soon discovers his error and rectifies it. Sometimes, also, late at night, one part of the orchestra in an orchard gets out of time with the majority, and discord may continue for some moments, as if the players were too cold and too sleepy to pay good attention. This delectable concert begins usually in the late afternoons and continues without ceasing until just before dawn the next morning. Many times I have heard the close of the concert; with the 'wee sma' hours the rhythmic beat becomes slower; toward dawn there is a falling off in the number of players; the beat is still slower, and the notes are hoarse, as if the fiddlers were tired and cold; finally, when only two or three are left the music stops abruptly." (*Ways of the Six-footed*, Comstock.)

The lesson on this cricket may be adapted from that on the black cricket.

Suggested Reading — *Insect Pests of Farm, Garden and Orchard*, by E. D. Sanderson and L. M. Peairs; also, readings on page 300.

THE COCKROACH



The American cockroach

Cockroaches in our kitchens are undoubtedly an unmitigated nuisance, and yet, as in many other instances, when we come to consider the individual cockroach, we find him an interesting fellow and exceedingly well adapted for living in our kitchens despite us.

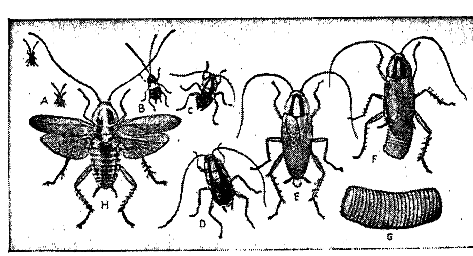
In shape, the cockroach is flat, and is thus well adapted to slide beneath utensils and into crevices and corners. Its covering is smooth and polished like patent leather, and this makes it slippery and enables it to get into food without becoming clogged by the adherence of any sticky substance. The antennæ are very long and flexible and can be bent in any direction. They may be placed far forward to touch things which the insect is approaching, or may be placed over the back in order to be out of the way. They are like graceful, living threads, and the cockroach tests its whole environment with their aid. The mouth has two pairs of palpi or feelers, one of which is very long and noticeable; these are kept in constant motion as if to test the appetizing qualities of food. The mouth-parts are provided with jaws for biting and, like all insect jaws, these work sidewise instead of up and down. The eyes are black but not prominent or large, and seem to be merely a part of the sleek, polished head-covering.

Some species of cockroaches have wings, and some do not. Those which have wings have the upper pair thickened and used for wing covers. The under pair are thinner and are laid in plaits like a fan. The wing covers are as polished as the body and quite as successful in shedding dirt.

The legs are armed with long spines which are very noticeable and might prove to be a disadvantage in accumulating filth; but they are polished also; and too, this insect spends much time at its toilet.

Cockroaches run "like a streak," children say; so speedily, indeed, do they go that they escape our notice, although we may be looking directly at them. This celerity in vanishing, saves many a cockroach from being crushed by an avenging foot.

When making its toilet, the cockroach draws its long antenna through its jaws



The Croton bug

a, b, c, d, successive stages of development; *e*, adult; *f*, adult female laying her case of eggs, *g*, the egg case; *h*, adult with the wings spread as if it were a whiplash, beginning at the base and finishing at the tip. It cleans each leg by beginning near the body and so stroking downward the long spines which seem to shut against the leg. It nibbles its feet clean to the very claws, and scrubs its head vigorously with the front femur.

The cockroach's eggs are laid in a mass enclosed in a pod-shaped covering, which is waterproof and polished and protects its contents from dampness.

Like the grasshopper, the cockroach has an incomplete metamorphosis; that is, the young insect when hatched from the egg resembles the adults in shape and general appearance, but is of course quite small.

When the cockroaches, or the Croton bugs, as the small introduced species of cockroach is called, once become established in a house, one way to get rid of them is to fumigate the kitchen; this is a dangerous performance and should be done only by an expert. In storerooms and dwelling houses sprinkling the runways liberally with sodium fluoride has proved very successful; this can be done by anyone, although great care should be exercised, for sodium fluoride is somewhat poisonous to man.

Suggested Reading — *Insects Injurious to the Household and Annoying to Man*, by Glenn W. Herrick; also, readings on page 300.

LESSON 83

The Cockroach

Leading Thought — The cockroach is adapted for living in crevices, and although its haunts may be anything but clean, the cockroach keeps itself quite clean. The American species live in fields and woods and under stones and sticks and only occasionally venture into dwellings. The species that infest our kitchens and water-pipes are European.

Method — Place a cockroach in a vial with bread, potato, or some other food, cork the vial, and pass it around so that the children may observe the prisoner at their leisure.

Observations — 1. What is the general shape of the cockroach? Why is this an advantage? What is the texture of its covering? Why is this an advantage?

2. Describe the antennæ and the way they are used. Note the two little pairs of feelers at the mouth. If possible, see how they are used when the cockroach is inspecting something to eat. Can you see whether its mouth is fitted for biting, lapping, or sucking its food?

3. Note the eyes. Are they as large and prominent as those of the bees or butterflies?

4. Has this cockroach wings? If so, how many and what are they like? Note two little organs at the end of the body. These are the cerci, like those of the crickets.

5. Describe the general appearance of the cockroach's legs, and tell what you think about its ability as a runner.

6. Note how the cockroach cleans itself and how completely and carefully this act is performed. Have you ever seen a cockroach's eggs? If so, describe them.

7. How can you get rid of cockroaches if they invade your kitchen?

THE APHIDS OR PLANT LICE

I know of no more diverting occupation than watching a colony of aphids through a lens. These insects are the most helpless and amiable little ninnies in the whole insect world; and they look the part, probably because their eyes, so large and wide apart, seem so innocent and wondering. The usual color of aphids is green; but there are many species which are otherwise colored, and some have most bizarre and striking ornamentations. In looking along an infested leafstalk, we see them in all stages and positions. One may have thrust its beak to the hilt in a plant stem, and be so satisfied and absorbed in sucking the juice that its hind feet are lifted high in the air and its antennæ curved backward, making all together a gesture which

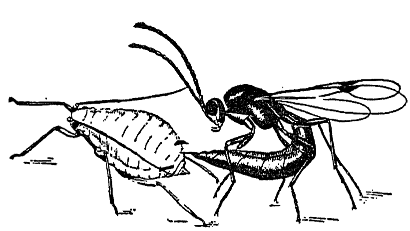
Grace H. Griswold

Aphids on a nasturtium

seems an adequate expression of bliss; another may conclude to seek a new well, and pull up its sucking tube, folding it back underneath the body so it will be out of the way, and walk off slowly on its six rather stiff legs; when thus moving, it thrusts the antennæ forward, patting its pathway to insure safety. Perhaps this pathway may lead over other aphids which are feeding, but this does not deter the traveler or turn it aside; over the backs of the obstructionists it crawls, at which the disturbed ones kick the intruder with both hind legs; it is not a vicious kick but a push rather, which says, "This seat reserved, please!" It is comical to see a row of them sucking a plant stem "for dear life," the heads all in the same direction, and they packed in and around each other as if there were no other plants in the world to give them room, the little ones wedged in between the big ones, until sometimes some of them are obliged to rest their hind legs on the antennæ of the neighbors next behind.

Aphids seem to be born to serve as food for other creatures — they are simply little machines for making sap into honeydew, which they produce from the alimentary canal for the delectation of ants; they are, in fact, merely little animated drops of sap on legs. How helpless they are when attacked by any one of their many enemies! All they do, when they are seized, is to claw the air with their six impotent legs and two antennæ, keeping up this performance as long as there is a leg left, and apparently to the very last never realizing "what is doing." But they are not without means of defense; those two little tubes at the end of the body are not for ornament or for producing honeydew for the ants, but for secreting at their tips a globule of waxy substance which smears the eyes of the attacking insect. I once saw an aphid perform this act, when confronted by a baby spider; a drop of yellow liquid oozed out of one tube, and the aphid almost stood on its head in order to thrust this offensive globule directly into the face of the spider — the whole performance reminding me of a boy who shakes his clenched fist in his opponent's face and says, "Smell of that!" The spider beat a hasty retreat.

A German scientist, Mr. Busgen, discovered that a plant louse smeared the eyes and jaws of its enemy the aphis lion with this wax, which dried as soon as applied. In action it was something like throwing a basin of paste at the head of the attacking party; the aphis lion thus treated was obliged to stop and clean itself before it could go on with its hunt, and the aphid walked off in safety. The aphids surely need this protection because they have two fierce enemies, the larvæ of the aphis lions and the larvæ of the ladybirds. They are also the victims of parasitic insects; a tiny four-winged "fly" lays an egg within an aphid; the larva hatching from it feeds upon the inner portions of the aphid, causing it to swell as if afflicted with dropsy. Later the aphid dies, and the interloper with malicious impertinence cuts a neat circular door in the poor aphid's skeleton skin and issues from it a full-fledged insect.



Bureau of Ent., U. S. D. A.

An aphid parasite laying its eggs within an aphid, enlarged

The aphids are not without their resources to meet the exigencies of their lives in colonies. There are several distinct forms in each species, and they seem to be needed for the general good. During the summer, we find most of the aphids on plants are without wings; these are females which give birth to living young and do not lay eggs. They do this until the plant is overstocked and the food supply seems to be giving out; then another form which has four wings is produced. These fly away to some other plant and start a colony there; but at the approach of cold weather, or if the food plants give out, male and female individuals are developed, the females being always wingless, and it is their office to lay the eggs which shall last during the long winter months, when the living aphids must die for lack of food plants. The next spring each winter egg hatches into a female which we call the "stem mother" since she with her descendants will populate the entire plant.

Plant lice vary in their habits. Some live in the ground on the roots of plants and are very destructive; but the greater number of species live on the foliage of plants and are very fond of the young, tender leaves and thus do great damage. Some aphids have their bodies covered with white powder or with tiny fringes, which give them the appearance of being covered with cotton; these are called "woolly aphids."

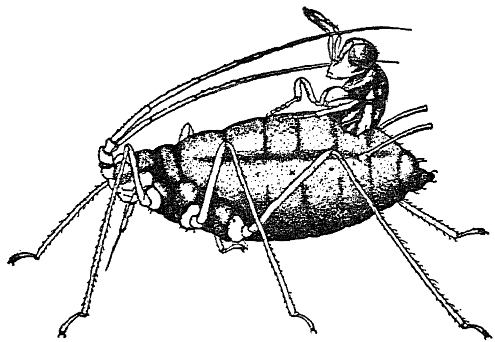
The aphids injuring our flowers and plants may, in general, be killed by spraying them with nicotine sulfate in the proportion of one teaspoonful to one gallon of water in which three or four ounces of soap have been dissolved. The spraying must be done very thoroughly so as to reach all the aphids hidden on the stems and beneath the leaves. A second application may be necessary in three or four days.

Suggested Reading — *Holiday Pond*, by Edith M. Patch; *Insect Pests of Farm, Garden and Orchard*, by E. D. Sanderson and L. M. Peairs; also, readings on page 300.

LESSON 84

The Aphids or Plant Lice

Leading Thought — Aphids have the mouth in the form of a sucking-tube which is thrust into the stems and leaves of plants; through it the plant juices are drawn for nourishment. Aphids are the source of honeydew of which ants are fond.



Grace H. Griswold

A parasite emerging from a geranium aphid, enlarged

Method — Bring into the schoolroom a plant infested with aphids, place the stem in water, and let the pupils examine the insects through the lens.

Observations — 1. How are the aphids settled on the leaf? Are their heads in the same direction? What are they doing?

2. Touch one and make it move along. What does it do in order to leave its place? What does it do with its sucking-tube as it walks off? On what part of the plant was it feeding? Why does not Paris green when applied to the leaves of plants kill aphids?

3. Describe an aphid, including its eyes, antennæ, legs, and tubes upon the back. Does its color protect it from observation?

4. Can you see cast skins of aphids on the plant? Why does an aphid have to shed its skin?

5. Are all the aphids on a plant wingless? When a plant becomes dry, are there, after several days, more winged aphids? Why do the aphids need wings?

6. Do you know what honeydew is? Have you ever seen it upon the leaf? How is honeydew made by the aphids? Does it

come from the tubes on their back? What insects feed upon this honeydew?

7. What insect enemies have the aphids?

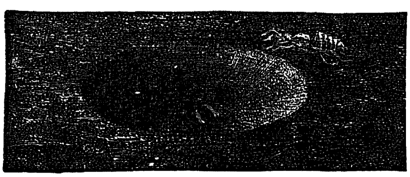
8. What damage do aphids do to plants? How can you clean plants of plant lice?

I saw it [an ant], *at first, pass, without stopping, some aphids which it did not, however, disturb. It shortly after stationed itself near one of the smallest, and appeared to caress it, by touching the extremity of its body, alternately with its antennæ, with an extremely rapid movement. I saw, with much surprise, the fluid proceed from the body of the aphid, and the ant take it in its mouth. Its antennæ were afterwards directed to a much larger aphid than the first, which, on being caressed after the same manner, discharged the nourishing fluid in greater quantity, which the ant immediately swallowed; it then passed to a third which it caressed, like the preceding, by giving it several gentle blows, with the antennæ, on the posterior extremity of the body; and the liquid was ejected at the same moment, and the ant lapped it up.*

— Pierre Huber, 1810

THE ANT LION

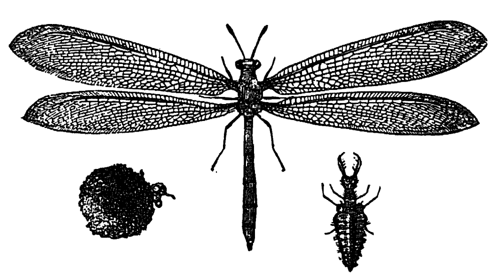
A child is thrilled with fairy stories of ogres in their dens, with the bones of their victims strewn around. The ants have real



Pitfall of an ant lion

ogres, but luckily they do not know about it and so cannot suffer from agonizing fears. The ant ogres seem to have depended upon the fact that the ant is so absorbed in her work that she carries her booty up hill and down dale with small regard for the topography of the country. By instinct they build pits which will someday be entered by ants obsessed by industry and careless of what lies in the path. The pits vary with the size of the ogre at the bottom; there are as many sized pits as there are beds in the story of Golden Locks and the bears; often the pits are not more than an inch across, or even less, while others are two inches in diameter. They are always made in sandy or crumbly soil and in a place protected from wind and rain; they vary in depth in proportion to their width, for the slope is always as steep as the soil will stand without slipping.

All that can be seen of the ogre at the bottom is a pair of long, curved jaws, looking innocent enough at the very center of the pit. If we dig the creature out, we find it a comical looking insect. It is humpbacked, with a big, spindle-shaped abdomen; from its great awkward body projects a flat, sneaking looking head, armed in front with the sickle jaws, which are spiny and bristly near the base, and smooth, sharp, and curved at the tip. The strange thing about these jaws is that they lead directly to the throat, since the ant lion has no mouth. Each jaw is made up of two pieces which are grooved where they join and thus form a tube with a hole in the tip through which the industrious blood of the ants can be sucked; not only do the sharp sickle points hold the victim, but there are three teeth along the side of each jaw to help with this. The two front pairs of legs are small and spiny; the hind



Ant lion with its cocoon and larva

legs are strong and peculiarly twisted, and have a sharp spikelike claw at the end, which is so arranged as to push the insect backward vigorously if occasion requires; in fact, the ant lion in walking about moves more naturally backward than forward because of the peculiar structure of his legs.

Having studied the ogre, we can see better how he manages to trap his victim. As the ant goes scurrying along, she rushes over the edge of the pit and at once begins to slide downward; she is frightened and struggles to get back; just then a jet of sand, aimed well from the bottom of the pit, hits her and knocks her back. She still struggles, and there follows a fusillade of sand jets, each hitting her from above and knocking her down to the fatal center where the sickle jaws await her and are promptly thrust into her; if she is large and still struggles, the big, unwieldy body of the ogre, buried in the sand, anchors him fast and his peculiar, crooked hind legs push his body backward in this strange tug of war; thus, the ant ogre is not dragged out of his den by the struggles of the ant, and soon the loss of blood weakens her and she shrivels up.

The secret of the jets of sand lies in the flat head of the ogre; if we look at it regarding it as a shovel, we can see that it is well fitted for its purpose; for it is a shovel with a strong mechanism working it. In fact, the whole pit is dug with this shovel head. Wonderful stories are told about the way that ant lions dig their pits, marking out the outer margin in a circle, and working inward. However, our common ant lion of the East simply digs down into the sand and flips the sand out until it makes a pit. If an ant lion can be caught and put in a jar of sand it will soon make its pit, and the process may be noted carefully.

There is one quality in the ogre which merits praise, and that is his patience. There he lies in his hole for days or perhaps weeks, with nothing to eat and no ant coming that way; so when we see an absent-minded ant scrambling over into the pit, let us think of the empty stomach of this patient little engineer who has constructed his pit with such accuracy and so much labor. So precarious is the living picked up by the ant lions, that it may require one, two, or three years to bring one to maturity. At that time it makes a perfectly globular cocoon of silk and sand, the size of a large pea, and within it changes to a pupa; and when finally ready to emerge, the pupa pushes itself part way out of the cocoon, and the skin is shed and left at the cocoon door. The adult resembles a small dragonfly; it has large net-veined wings and is a most graceful insect, as different as can be from the hump-backed ogre which it once was — a transformation quite as marvelous as that which occurred in Beauty and the Beast. Throughout the Middle West, the ant lion in its pit is called the "doodlebug."

Suggested Reading — *Interesting Neighbors*, by Oliver P. Jenkins; also, readings on page 300.

LESSON 85

The Ant Lion

Leading Thought — The ant lion or "doodlebug" makes a little pit in the sand with very steep sides, and hidden at the bottom of it, waits for ants to tumble in to be seized by its waiting jaws. Later the ant lion changes to a beautiful insect with gauzy wings, resembling a small dragonfly.

Method — The pupils should see the ant lion pits in their natural situations, but the insects may be studied in the schoolroom. Some of the ant lions may be dug out of their pits and placed in a dish of sand. They will soon make their pits, and may be watched during this interesting process. It is hardly advisable to try to rear these insects, as they may require two or three years for development.

Observations — 1. Where were the ant lion pits out of doors? Were they in a windy place? Were they in a place protected from storms? In what kind of soil were they made?

2. Measure one of the pits. How broad

across was it and how deep? Are all the pits of the same size? Why not?

3. What can you see as you look down into the ant lion's pit? Roll a tiny pebble in and see what happens. Watch until an ant comes hurrying along and slips into the pit. What happens then? As she struggles to get out how is she knocked back in? What happens to her if she falls to the bottom?

4. Take a trowel and dig out the doodlebug. What is the shape of its body? What part of the insect did you see at the bottom of the pit? Do you know that these great sickle-shaped jaws are hollow tubes for sucking blood? Does the ant lion eat anything except the blood of its victim?

5. Can you see that the ant lion moves backward more easily than forward? How are its hind legs formed to help push it backward? How does this help the ant lion in holding its prey? How does the big awkward body of the ant lion help to hold it in place at the bottom of the pit when it seizes an ant in its jaws?

6. What shape is the ant lion's head? How does it use this head in taking its prey? In digging its pit?

7. Take a doodlebug to the schoolroom, place it in a dish of sand covered with glass, and watch it build its pit in the sand.

8. Read in the entomological books about the cocoon of the ant lion and what the adult looks like, and then write an ant lion autobiography.

THE MOTHER LACEWING AND THE APHIS LION

Flitting leisurely through the air on her green gauze wings, the lacewing seems like a filmy leaf, broken loose and drifting on the breeze. But there is purpose in her

Aphis lion. Larva, eggs, cocoon, and the adult lacewing

flight, and through some instinct she is enabled to seek out an aphis-ridden plant or tree, to which she comes as a friend in need. As she alights upon a leaf, she is scarcely discernible because of the pale green of her delicate body and wings; however, her great globular eyes that shine like gold attract the attention of the careful observer. But though she is so fairy-like in appearance, if you pick her up, you will be sorry if your sense of smell is keen, for she exhales a most disagreeable odor when disturbed — a habit which probably protects her from birds or other creatures which might otherwise eat her.

However, if we watch her we shall see that she is a canny creature despite her frivolous appearance; her actions are surely peculiar. A drop of sticky fluid issues from the tip of her body, and she presses it down on the surface of the leaf; then lifting up her slender abdomen like a distaff, she spins the drop into a thread a half inch long or more, which the air soon dries; and this silken thread is stiff enough to sustain an oblong egg, as large as the point of a pin, which she lays at the very tip of it. This done she lays another egg in a like manner, and when she is through, the leaf looks as if it were covered with spore cases of a glittering white mold. This done she flies off and disports herself in the sunshine, care free, knowing that she has done all she can for her family.

After a few days the eggs begin to look dark, and then if we examine them with a lens, we may detect that they contain little doubled-up creatures. The first we see of the egg inmate as it hatches is a pair of jaws thrust through the shell, opening it for a peephole; a little later the owner of the jaws, after resting a while with an eye on the world which he is so soon to enter, pushes out his head and legs and drags out a tiny, long body, very callow looking and clothed in long, soft hairs. At first the little creature crawls about his eggshell, clinging tightly with all his six claws, as if fearful of such a dizzy height above his green floor; then he squirms around a little and thrusts out a head inquiringly while still hanging on "for dear life." Finally he gains courage and prospects around until he discovers his egg stalk, and then begins a rope climbing performance, rather difficult for a little chap not more than ten minutes old. He takes a careful hold with his front claws, the two other pairs of legs carefully balancing for a second, and then desperately seizing the stalk with all his clasping claws, and with many new grips and panics, he finally achieves the bottom in safety. As if dazed by his good luck, he stands still for a time, trying to make up his mind what has happened and what to do next; he settles the matter by trotting off to make his first breakfast of aphids; and now we can see that it is a lucky thing for his brothers and sisters, still unhatched, that they are high above his head and out of reach, for he might not be discriminating in the matter of his breakfast food, never having met any of his family before. He is a queer looking little insect, spindle-shaped and with peculiarly long, sickle-shaped jaws projecting from his head. Each of these jaws is made up of two pieces joined lengthwise so as to make a hollow tube, which has an opening at the tip of the jaw, and another one at the base which leads directly to the little lion's throat. Watch him as he catches an aphid; seizing the stupid little bag of sap in his great pincers, he lifts it high in the air, as if drinking a bumper, and sucks its green blood until it shrivels up, kicking a remonstrating leg to the last. It is my conviction that aphids never realize when they are being eaten; they simply dimly wonder what is happening.

It takes a great many aphids to keep an aphis lion nourished until he gets his growth; he grows like any other insect by shedding his skeleton skin when it becomes too tight. Finally he doubles up and spins around himself a cocoon of glistening white silk, leaving it fastened to the leaf; when it is finished, it looks like a seed pearl, round and polished. I wish some child would watch an aphis lion weave its cocoon and tell us how it is done! After a time, a week or two perhaps, a round little hole is cut in the cocoon, and there issues from it a lively little green pupa, with wing pads on its back; but it very soon sheds its pupa skin and issues as a beautiful lacewing fly with golden eyes and large, filmy, iridescent, pale green wings.

Suggested Reading — *Interesting Neighbors*, by Oliver P. Jenkins; *Insect People*, by Eleanor King and Wellmer Pessels; also, readings on page 300.

LESSON 86

The Mother Lacewing and the Aphis Lion

Leading Thought — The lacewing fly or goldeneyes, as she is called, is the mother of the aphis lion. She lays her eggs on the top of stiff, silken stalks. The young aphis lions when hatched, clamber down upon the leaf and feed upon plant lice, sucking their blood through their tubular jaws.

Method — Through July and until frost, the aphis lions may be found on almost any plant infested with plant lice; and the lacewing's eggs or eggshells on the long stalks are also readily found. All these may be brought to the schoolroom. Place the stem of a plant infested with aphids in a jar of water, and the acts of the aphis lions as well as the habits of the aphids may be observed at convenient times by all the pupils.

Observations — 1. When you see a leaf with some white mold upon it, examine it with a lens; the mold is likely to be the eggs of the lacewing. Is the egg as large as a pinhead? What is its shape? What is its color? How long is the stalk on which it is placed? Of what material do you think the stalk is made? Why do you suppose the lacewing mother lays her eggs on the tips of stalks? Are there any of these eggs near each other on the leaf?

2. If the egg is not empty, observe through a lens how the young aphis lion breaks its eggshell and climbs down.

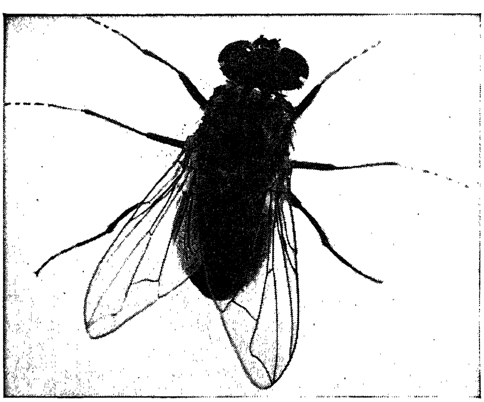
3. Watch an aphis lion among the plant lice. How does it act? Do the aphids seem afraid? Does the aphis lion move rapidly? How does it act when eating an aphid?

4. What is the general shape of the aphis lion? Describe the jaws. Do you think these jaws are used for chewing, or merely as tubes through which the green blood of the aphids is sucked? Do the aphis lions ever attack each other or other insects? How does the aphis lion differ in appearance from the ladybird larva?

5. What happens to the aphis lion after it gets its growth? Describe its cocoon if you can find one.

6. Describe the little lacewing fly that comes from the cocoon. Why is she called goldeneyes? Why lacewing? Does she fly rapidly? Do you suppose that if she should lay her eggs flat on a leaf, the first aphis lion that hatched would run about and eat all its little brothers and sisters which were still in their eggshells? How do the aphis lions benefit our rose bushes and other cultivated plants?

THE HOUSEFLY



Dept. of Entomology, Cornell U.

The housefly

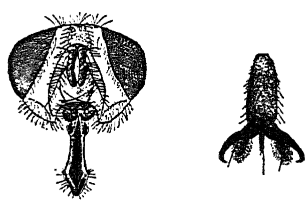
The housefly is one of the most cosmopolitan members of the animal kingdom. It flourishes in every land, plumping itself down in front of us at table, whether we be eating rice in Hong Kong, dhura in Egypt, macaroni in Italy, pie in America, or tamales in Mexico. There it sits, impertinent and imperturbable, taking its toll, letting down its long elephant-trunk tongue, rasping and sucking up such of our meal as fits its needs. As long as we simply knew it as a thief we, during untold ages, merely slapped it and shooed it, which effort on our part apparently gave it exhilarating exercise. But during recent years we have begun trapping and poisoning, trying to match our brains against its agility; although we slay it by thousands, we seem only to make more room for its well-fed progeny of the future, and in the end we seem to have gained nothing. But the most recent discoveries of science have revealed to us that what the housefly takes of our food is of little consequence compared with what it leaves behind. Because of this we have girded up our loins and gone into battle in earnest.

I have always held that nature-study should follow its own peaceful path and not be the slave of economic science. But occasionally it seems necessary, when it is a question of creating public sentiment, and of cultivating public intelligence in combating a great peril, to make nature-study a handmaiden, if not a slave, in this work. If our woods were filled with wolves and bears, as they were in the days of my grandfather, I should give nature-study lessons on these animals which would lead to their subjugation. Bears and wolves trouble us no more; but now we have enemies far more subtle, in the ever present microbes, which we may never hope to conquer but which, with proper precautions, we may render comparatively harmless. Thus, our nature-study with insects which carry disease, like the mosquitoes, flies, and fleas, must be a reconnaissance for a war of extermination; the fighting tactics may be given in lessons on health and hygiene.

Perhaps if a fly were less wonderfully made, it would be a less convenient vehicle for microbes. Its eyes are two great, brown spheres on either side of the head, and are composed of thousands of tiny six-sided eyes that give information of what is coming in any direction; in addition, it has on top of the head, looking straight up, three tiny, shining, simple eyes, which cannot be seen without a lens. Its antennæ are peculiar in shape, and are sense organs; it is attracted from afar by certain odors, and so far as we can discover, its antennæ are all the nose it has. Its mouth-parts are all combined to make a most amazing and efficient organ for getting food; at the tip are two flaps, which can rasp a substance so as to set free the juices, and above this is a tube, through which the juices may be drawn to the stomach. This tube is extensible, being conveniently jointed so that it can be folded under the " chin " when not in use. This is usually called the fly's tongue, but it is really all the mouth-parts combined, as if a boy had his lips, teeth, and tongue, standing out from his face, at the end of a tube a foot long.

The thorax can be easily studied; it is striped black and white above and bears the two wings, and the two little flaps called balancers, which are probably remnants of hind wings with which the remote ancestors of flies flew. The fly's wing is a transparent but strong membrane strengthened by veins, and is prettily iridescent. The thorax bears on its lower side the three pairs of legs. The abdomen consists of five segments and is covered with stiff hairs. The parts of the leg seen when the fly is walking consist of three segments, the last segment or tarsus being more slender; if looked at with a lens the tarsus is seen to be composed of five segments, the last of which bears the claws; it is with these claws that the fly walks, although all of the five segments really form the foot; in other words, it walks on its tiptoes. But it clings to ceilings by means of the two little pads below the claws, which are covered with hairs that excrete at the tips a sticky fluid. Chiefly because of the hairs on its feet, the fly becomes a carrier of microbes and a menace to health.

The greatest grudge I have against this little, persistent companion of our household is the way it has misled us by appearing to be so fastidious in its personal habits. We have all of us seen, with curiosity and admiration, its complex ablutions and brushings. It usually begins, logically, with its front feet, the hands; these it cleans by rubbing them against each other lengthwise. The hairs and spines on



At the left is the head of a housefly showing eyes, antennæ, and mouth parts. At the right is a much enlarged foot of the fly

one leg act as a brush for the other, and then, lest they be not clean, it nibbles them with its rasping disc, which is all the teeth it has. It then cleans its head with these clean hands, rubbing them over its big eyes with a vigor that makes us wink simply to contemplate; then bobbing its head down so as to reach what is literally its back hair, it brushes valiantly. After this is done, it reaches forward first one and then the other foot of the middle pair of legs, and taking each in turn between the front feet, brushes it vigorously, and maybe nibbles it. But as a pair of military brushes, its hind feet are conspicuously efficient; they clean each other by being rubbed together and then they work simultaneously on each side in cleaning the wings, first the under side and then the upper side. Then over they come and comb the top of the thorax; then they brush the sides, top, and under sides of the abdomen, cleaning each other between the acts. Who, after witnessing all this, could believe that the fly could leave any tracks on our food which would lead to our undoing! But the housefly, like many housekeepers with the best intentions in the matter of keeping clean, has not mastered the art of getting rid of the microbes. Although it has so many little eyes, none of them can magnify a germ so as to make it visible; and thus it is that,

Cornell Extension Bulletin

The larva, or maggot, and the pupa of a housefly, much enlarged

when feeding around where there have been cases of typhoid and other diseases, the housefly's little claws become infested with disease germs; and when it stops some day to clean up on our table, it leaves the germs with us. In recent years the fly has been conspicuous in spreading amœbic dysentery. Our only safety lies in the final extermination of this little nuisance.

It is astonishing how few people know about the growth of flies. People of the highest intelligence in other matters, think that a small fly can grow into a large one. A fly when it comes from the pupa stage is as large as it will ever be, the young stages of flies being maggots. The housefly's eggs are little, white, elongated bodies about as large as the point of a pin. These are laid preferably in horse manure. After a few hours, they hatch into slender, pointed, white maggots which feed upon the excrement. After five or six days, the larval skin thickens and turns brown, making the insect look like a small grain of wheat. This is the pupal stage, which lasts about five days, and then the skin bursts open and the full-grown fly appears. Of course, not all the flies multiply according to the example given to the children in the following lesson. The housefly has many enemies and, therefore, probably no one hibernating mother fly is the ancestress of billions by September; however, despite enemies, flies multiply with great rapidity.

I know of no more convincing experiment as an example of the dangerous trail of the fly, than that of letting a housefly walk over a saucer of nutrient gelatin. After three or four days, each track is plainly visible as a little white growth of bacteria.

Much is being done now to eradicate the housefly, and undoubtedly there will be new methods of fighting it devised every year. The teacher should keep in touch with the bulletins on this subject published by the United States Department of Agriculture, and should give the pupils instructions according to the latest ideas. At present the following are the methods of fighting this pest: Keep premises clean and place food and waste materials under cover. All of the windows of the house should be well screened. All the flies which get into the house should be killed by using commercial flypaper, sprays, or swatters.

SUGGESTED READING — *Common Pests,* by Rennie W. Doane; *Insects Injurious to the Household and Annoying to Man,* by Glenn W. Herrick; *Nature — by Seaside and Wayside,* by Mary G. Phillips and Julia M. Wright, Book 2, *Some Animal Neighbors;* also, readings on page 300.

LESSON 87

THE HOUSEFLY

LEADING THOUGHT — The housefly has conquered the world and is found practically everywhere. It breeds in filth and especially in horse manure. It is very prolific; the few flies that manage to pass the winter in this northern climate are the ancestors of the millions which attack us and our food later in the season. These are a menace to health because they carry germs of disease from sputa and excrement to our tables, leaving them upon our food.

METHOD — Give out the questions for

observation and let the pupils answer them either orally or in their notebooks. If possible, every pupil should look at a housefly through a lens or microscope. If this is not possible, pictures should be shown to demonstrate its appearance.

OBSERVATIONS — 1. Look at a fly, using a lens if you have one. Describe its eyes. Do you see that they have a honeycomb arrangement of little eyes? Can you see, on top of the head between the big eyes, a dot? A microscope reveals this dot to be made of three tiny eyes, huddled together. After seeing a fly's eyes, do you wonder that you have so much difficulty in hitting it or catching it?

2. Can you see the fly's antennæ? Do you think that it has a keen sense of smell? Why?

3. How many wings has the fly? How does it differ from the bee in this respect? Can you see two little white objects, one just behind the base of each wing? These are called poisers, or balancers, and all flies have them in some form. What is the color of the wings? Are they transparent? Can you see the veins in them? On what part of the body do the wings grow?

4. Look at the fly from below. How many legs has it? From what part of the body do the legs come? What is that part of the insect's body called to which the legs and wings are attached?

5. How does the fly's abdomen look? What is its color and its covering?

6. Look at the fly's legs. How many segments can you see in a leg? Can you see that the segment on which the fly walks has several joints? Does it walk on all of these segments or on the one at the tip?

7. When the fly eats, can you see its tongue? Can you feel its tongue when it rasps your hand? Where does it keep its tongue usually?

8. Describe how a fly makes its toilet as follows: How does it clean its front feet? Its head? Its middle feet? Its hind feet? Its wings?

9. Do you know how flies carry disease? Did you ever see them making their toilet on your food at the table? Do you know what diseases are carried by flies? What must you do to prevent flies from bringing disease to your family?

10. Do you think that a small fly ever grows to be a large fly? How do the young of all kinds of flies look? Do you know where the housefly lays its eggs? On what do the maggots feed? How long before they change to pupæ? How long does it take them to grow from eggs to flies? How do the houseflies in our northern climate pass the winter?

11. *Lesson in Arithmetic* — It requires perhaps twenty days to span the time from the eggs of one generation of the housefly to the eggs of the next, and thus there might easily be five generations in one summer. Supposing the fly which wintered behind the window curtain in your home last winter, flew out to the stables about May 1 and laid 120 eggs in the sweepings from the horse stable, all of which hatched and matured. Supposing one-half of these were mother flies and each of them, in turn, laid 120 eggs, and so on for five generations, all eggs laid developing into flies, and one-half of the flies of each generation being mother flies. How many flies would the fly that wintered behind your curtain have produced by September?

12. Pour some gelatin, unsweetened, on a clean plate. Let a housefly walk around on the gelatin as soon as it is cool; cover the plate to keep out the dust and leave it for two or three days. Examine it then and see if you can tell where the fly walked. What did it leave in its tracks?

13. Write an essay on the housefly, its dangers and how to combat it, basing the essay on bulletins of the United States Department of Agriculture.

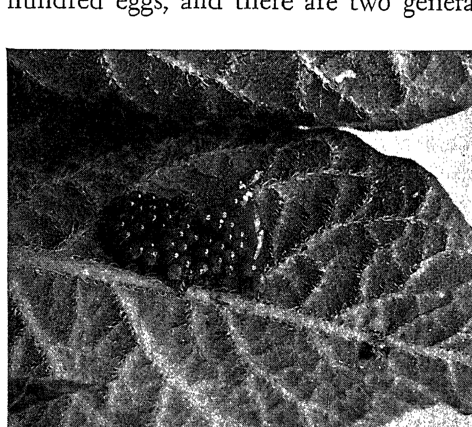
THE COLORADO POTATO BEETLE

The potato beetle is not a very attractive insect, but it has many interesting peculiarities. No other common insect so clearly illustrates the advantage of warning colors. If we take a beetle in the hand, it at first promptly falls upon its back, folds its legs and antennæ down close to its body, and " plays possum " in a very canny manner. But if we squeeze it a little, immediately an orange-red liquid is ejected on the hand, and a very ill-smelling liquid it is. If we press lightly, only a little of the secretion is thrown off; but if we squeeze harder it flows copiously. Thus a bird trying to swallow one of these beetles would surely get a large dose. The liquid is very distasteful to birds, and it is indeed a stupid bird that does not soon learn to let severely alone orange and yellow beetles striped with black. The source of this offensive and defensive juice is at first a mystery, but if we observe closely we can see it issuing along the hind edge of the thorax and the front portion of the wing covers; the glands in these situations secrete the protective juice as it is needed. The larvæ are also equipped with similar glands and, therefore, have the brazen habit of eating the leaves of our precious potatoes without attempting to hide.

M. V. Slingerland

Adult Colorado potato beetles

The life history of the potato beetle is briefly as follows: Some of the adult beetles or pupæ winter beneath the surface of the soil, burrowing down a foot or more to escape freezing. As soon as the potato plants appear above ground the mother beetle comes out and lays her eggs upon the undersides of the leaves. These orange-yellow eggs are usually laid in clusters. In about a week there hatch from the eggs little yellow or orange humpbacked larvæ, which begin at once to feed upon the leaves. These larvæ grow, as do other insects, by shedding their skins. They do this four times, and during the last stages are very conspicuous insects on the green leaves; they are orange or yellow with black dots along the sides, and so humpbacked are they that they seem to be " gathered with a puckering string " along the lower side. It requires from sixteen days to three weeks for a larva to complete its growth. It then descends into the earth and forms a little cell in which it changes to a pupa. It remains in this condition for one or two weeks, according to the temperature, and then the full-fledged beetle appears. The entire life cycle from egg to adult beetle may be passed in about a month, although if the weather is cold, this period will be longer. The beetles are very prolific, a mother beetle having been known to produce five hundred eggs, and there are two genera-



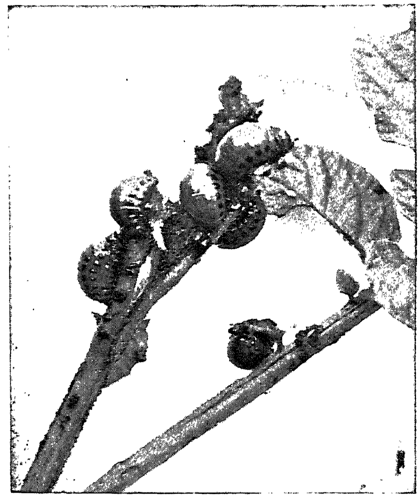
M. V. Slingerland

Eggs of the Colorado potato beetle

tions each year. These beetles damage the potato crop by stopping the growth through destroying the leaves, thus causing the potatoes to be of inferior quality.

The adult beetle is an excellent object lesson in the study of beetle form. Attention should be called to the three regions of the body: a head, which is bright orange; the compound eyes, which are black; and three simple eyes on the top of the head, which are difficult to see without a lens. The antennæ are short, their joints easily noted, and special attention should be paid to their use, for they are constantly moving to feel approaching objects. The two pairs of mouth palpi may be seen, and the beetle will eagerly eat raw potatoes, so that the pupils may see that it has biting mouth-parts. The thoracic shield is orange, ornamented with black. The three pairs of legs are short, which is a proof that these beetles do not migrate on foot. The claws and the pads beneath can be seen with the naked eye. Each wing cover bears five yellow stripes, also five black ones, although the outside black stripe is rather narrow. These beetles are very successful flyers. During flight, the wing covers are raised and held motionless while the gauzy wings beneath are unfolded and do the work. Children are always interested in seeing the way the beetles fold their wings beneath the wing covers.

One of the most remarkable things about the Colorado potato beetle is its history. It is one of the few insect pests which is native to America. It formerly fed upon sandbur, a wild plant allied to the potato, which grows in the region of Colorado, Arizona, and Mexico, and was a well-behaved, harmless insect. With the advance of civilization westward, the potato came also, and proved to be an acceptable plant to this insect; and here we have an example of what an unlimited food supply will do for an insect species. The beetles multiplied so much faster than their parasites, that it seemed at one time as if they would conquer the earth by moving on from potato field to potato field. They started on their march to the Atlantic seaboard in 1859; in 1874 they reached the coast, and judging by the numbers washed ashore, they sought to fly or swim across the Atlantic.



M. V. Slingerland

Larvæ of Colorado potato beetle

Suggested Reading — *Insect Pests of Farm, Garden and Orchard*, by E. D. Sanderson and L. M. Peairs; also, readings on page 300.

LESSON 88

The Colorado Potato Beetle

Leading Thought — The Colorado potato beetle is a very important insect, since it affects to some extent the price of potatoes each year. It is disagreeable as a food for birds, because of an acrid juice which it secretes. We should learn its life history and thus be able to deal with it intelligently in preventing its ravages.

Method — The study of the potato beetle naturally follows and belongs to gardening. The larvæ should be brought into the schoolroom and placed in a breeding cage on leaves of the potato vine. Other plants may be put into the cage to prove that these insects prefer to eat the potato. The children should observe how the larvæ eat and how many leaves a full-grown larva will destroy in a day. Earth should be put in the bottom of the breeding cage so that the children may see the larvæ descend and burrow into it. The adult beetles should be studied carefully, and the children should see the excretion of the acrid juice.

Observations — 1. At what time do you see the potato beetles? Why are they more numerous in the fall than in the spring? Where do those which we find in the spring come from? What will they do if they are allowed to live?

2. What is the shape of the potato beetle? Describe the markings on its head. What color are its eyes? Describe its antennæ. How are they constantly used? Can you see the palpi of the mouth? Give the beetle a bit of potato and note how it eats.

3. What is the color of the shield of the thorax? Describe the legs. Do you think the beetle can run fast? Why not? How many segments has the foot? Describe the claws. Describe how it clings to the sides of a tumbler or bottle.

4. If the beetle cannot walk rapidly, how does it travel? Describe the wing covers. Why is this insect called the ten-lined potato beetle?

5. Describe the wings. How are they folded when at rest? How are the wing covers carried when the beetle is flying?

6. Take a beetle in your hand. What does it do? Of what advantage is it to the insect to pretend that it is dead? If you squeeze the beetle, what happens? How does the fluid which it ejects look and smell? Try to discover where this fluid comes from. Of what use is it to the beetle? Why will birds not eat the potato beetle?

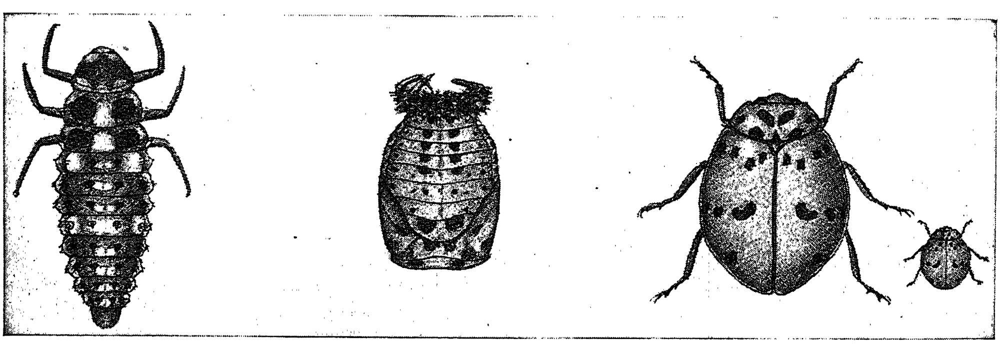
7. Where does the mother beetle lay her eggs? Are they laid singly or in clusters? What color are the eggs? How long is it after they are laid before they hatch?

8. Describe the young larva when it first hatches. What color is it at first? Does it change color later? Describe the colors and markings of a full-grown larva.

9. How does this larva injure the potato vines? Does it remain in sight while it is feeding? Does it act as if it were afraid of birds? Why is it not eaten by birds?

10. Where does the larva go when it is full grown? How many times does it shed its skin during its growth? Does it make a little cell in the ground? How does the pupa look? Can you see in it the eyes, antennæ, legs, and wings of the beetle?

11. Write an English theme giving the history of the Colorado potato beetle, and the reasons for its migration from its native place.



The ladybird. 1, larva. 2, pupa. 3, adult. The small beetle represents actual size

THE LADYBIRD

Ladybird, Ladybird, fly away home!
Your house is on fire, your children will burn.

This incantation we, as children, repeated to this unhearing little beetle, probably because she is, and ever has been, the incarnation of energetic indecision. She runs as fast as her short legs can carry her in one direction, as if her life depended on getting there, then she turns about and goes with quite as much vim in another direction. Thus, it is no wonder the children think that when she hears this news of her domestic disasters, she wheels about and starts for home; but she has not any home now nor did she ever have a home, and she does not carry even a trunk. Perhaps it would be truer to say that she has a home everywhere, whether she is cuddled under a leaf for a night's lodging or industriously climbing out on twigs, only to scramble back again, or perchance to take flight from their tips.

There are many species of ladybirds, but in general they all resemble a tiny pill cut in half, with legs attached to the flat side. Sometimes it may be a round and sometimes an oval pill, but it is always shining, and the colors are always dull dark red, or yellow, or whitish, and black. Sometimes she is black with red or yellow spots, sometimes red or yellow with black spots and the spots are usually on either side of the thorax and one on each snug little wing cover. But if we look at the ladybird carefully we can see the head and the short, clublike antennæ. Behind the head is the thorax with its shield, broadening toward the rear, spotted and ornamented in various ways; the head and thorax together occupy scarcely a fourth of the length of the insect, and the remainder consists of the hemispherical body, encased with polished wing covers. The little black legs, while quite efficient because they can be moved so rapidly, are not the ladybird's only means of locomotion; she is a good flier and has a long pair of dark wings which she folds crosswise under her wing covers. It is comical to see her pull up her wings, as a lady tucks up a long petticoat; and sometimes ladybird is rather slovenly about it and runs around with the tips of her wings hanging out behind, quite untidily.

But any untidiness must be inadvertent, because the ladybird takes very good care of herself and spends much time in "washing up." She begins with her front legs, cleaning them with her mandibles, industriously nibbling off every grain of dust; she then cleans her middle and hind legs by rubbing the two on the same side back and forth against each other, each acting as a whisk broom for the other; she cleans her wings by brushing them between the edges of the wing cover above and the tarsus of her hind leg below.

The ladybird is a clever little creature, even if it does look like a pill, and if you disturb it, it will fold up its legs and drop as if dead, playing possum in a most deceptive manner. It will remain in this attitude of rigid death for at least a minute or two and then will begin to claw the air with all its six legs in its effort to turn right side up.

From our standpoint the ladybird is of great value, for during the larval as well as adult stages, all species except one feed upon those insects which we are glad to be rid of. They are especially fond of aphids and scale insects. One of the greatest achievements of economic entomology was the introduction on the Pacific Coast of a ladybird from Australia which preys upon the cottony cushion scale insect, a species very dangerous to orange and lemon trees. Within a few years the introduced ladybirds had exterminated this pest.

The ladybird's history is as follows: The mother beetle, in the spring, lays her eggs here and there on plants; as soon as the larva hatches, it starts out to hunt for aphids and other insects. It is safe to say that no ladybird would recognize her own children in time to save them, even if the house were burning, for they do not in the least resemble her; they are neither rolypoly nor shiny, but are long and segmented and velvety, with six queer, short legs that look and act as if they were whittled out of wood; they seem only efficient for clinging around a stem. The larvæ are usually black, spotted with orange or yellow; there are six warts on each segment, which make the creature's back look quite rough. The absorbing business of the larva is to crawl around on plants and chew up the foolish aphids or the scale insects. I have seen one use its front foot to push an aphid, which it was eating, closer to its jaws; but when one green leg of its victim still clung to its head, it did not try to rub it off as its mother would have done, but twisted its head over this way and that, wiping off the fragment on a plant stem and then gobbling it up.

After the larva has shed its skeleton skin several times, and destroyed many times its own bulk of insects, it hunts for some quiet corner, hangs itself up by the rear end, and condenses itself into a sub-globular form; it sheds its spiny skin, pushing it up around the point of attachment, and there lets it stay like the lion's skin of Hercules. As a pupa, it is more nearly rectangular than round, and if we look closely we can see the wing cases, the spotted segments of the abdomen, and the eyes, all encased in the pupa skin; the latter bursts open after a few days and the shining little half-globe emerges a full-grown ladybird, ready for hiding through the winter in some cozy spot from which she will emerge in the spring, to stock our trees and vines, next year, with her busy little progeny.

Suggested Reading — *Insect People*, by Eleanor King and Wellmer Pessels; *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 2, *Some Animal Neighbors; Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*; also, readings on page 300.

LESSON 89

The Ladybird

Leading Thought — The ladybird is a beetle. Its young are very different from the adult in appearance, and feed upon plant lice.

Method — These little beetles are very common in autumn and may be brought to the schoolroom and passed around in vials for the children to observe. Their larvæ may be found on almost any plant infested with plant lice. Plant and all may be brought into the schoolroom and the actions of the larvæ noted by the pupils during recess.

Observations — 1. How large is the ladybird? What is its shape? Would two of them make a little globe if they were put flat sides together?

2. What colors do you find on your ladybird?

3. Do you see the ladybird's head and antennæ? What is the broad shield directly back of the head called? How is it marked, and with what colors? What color are the wing covers? Are there any spots upon them? How many? Does the ladybird use its wing covers when it flies? Describe her true wings. Does she fold them beneath the wing covers?

4. Note the legs and feet. Are the legs long? Are they fitted for running? To which part of the body are they attached?

5. If you disturb the ladybird how does she " play possum "? Describe how she makes her toilet.

The Larva

1. Describe the ladybird larva. Does it look like its mother? What is its form? Is it warty and velvety or shiny?

2. Describe its head and jaws as far as you can see. How does it act when eating? Can you see its little stiff legs? Is there a claw at the end of each?

3. Describe the actions of the ladybird larva in attacking and eating the plant lice. Does it shed its skin as it grows?

4. Watch a larva until it changes to a pupa. How does the pupa look? Can you see the shed skin? Where is it? To what is the pupa attached? When the pupa skin breaks open what comes out of it?

5. Why is the ladybird of great use to us? Write a story about the ladybird which saved the orange orchards of California.

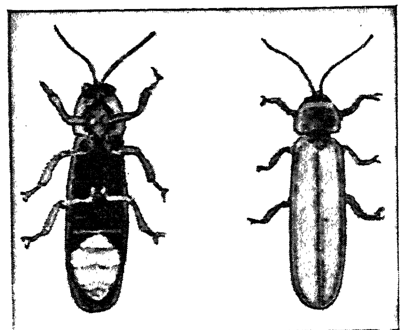
THE FIREFLY

And lavishly to left and right,
The fireflies, like golden seeds,
Are sown upon the night.
— RILEY

The time of the sowing of these seeds is during warm, damp nights in July and August, and even in September, although they are sown less lavishly then. How little most of us know of the harvest, although we see the sowing, which begins in the early twilight against the background of tree shadows, and lasts until the cold atmosphere of the later night dampens the firefly ardor! The flight of various species differs in the height from the ground; some species hover next to the grass, others fly above our heads, but rarely as high as the tree tops in northern latitudes. Some species give a short flash that might be called a refulgent blinking; others give a longer flash so that we get an idea of the direction of their flight; and there is a common species in the Gulf states which gives such long flashes that they mark the night with gleaming curlicues.

It is likely to be an exciting chase before we are able to capture a few of these insects for closer inspection; but when once captured, they do not sulk but will keep on with their flashing and give us a most edifying display. The portion of the firefly which gives the light is in the abdomen, and it glows steadily like phosphorescent wood; then suddenly it gleams with a green light that is strong enough to reveal all its surroundings; and it is so evidently an act of will on the part of the beetle that it is startling to members of our race, who cannot even blush or turn pale voluntarily. The fireflies may be truly said to be socially brilliant, for the flashing of their lights is for the attraction of their mates.

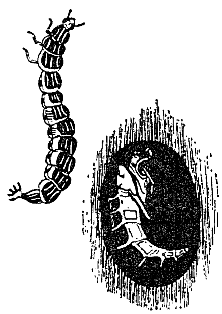
The fireflies are beetles, and there are many species which are luminous. A common one is here figured (*Photinus pyralis*). It is pale gray above and the head is completely hidden by the big shield of the thorax. The legs are short; thus this beetle trusts mostly to its wings as a means of locomotion. The antennæ are rather long and are kept in constant motion, evidently conveying intelligence of surroundings to the insect. Beneath the gray elytra, or wing covers, is a pair of large, dark-veined membranous wings which are folded in a very neat manner crosswise and lengthwise, when not in use. When in use, the wing covers are lifted stiffly and the flying is done wholly with the membranous wings. Looked at from beneath, we can at once see that some of the segments of the abdomen are partly or entirely sulphur yellow, and we recognize them as the lamp. If the specimen is a male, the yellow area covers all of the end of the abdomen up to the fourth or fifth segment; but if it is a female, only the middle portion of the abdomen, especially the fifth segment, is converted into a lamp. These yellow areas, when dissected under the microscope, prove to be filled with fine tracheæ, or air-tubes; and we know very little about the way the light is made.



A common firefly. The view of the underside shows the " lamp "

In some species, the female is wingless and has very short wing covers, and a portion of her body emits a steady, greenish light which tells her lord and master where to find her. These wingless females are called glowworms.

Fireflies during their larval stages are popularly called wireworms, although there are many other beetle larvæ thus called. In many of the species, the firefly eggs, larvæ, and pupæ are all luminescent, but not so brilliant as when adults. The



Larva and pupa of a common firefly

larva of the species here figured was studied by C. V. Riley, who gave us an interesting account of its habits. It lives in the ground and feeds on soft-bodied insects and earthworms. Each segment of this wireworm has a horny, brown plate above, with a straight white line running through the middle and a slightly curved white line on each side; the sides of the larva are soft and rose-colored; the white spiracles show against little, oval, brown patches. Beneath, the larva is cream color with two brown comma-like dots at the center of each segment. The head can be pulled back completely beneath the first segment. The most interesting thing about this larva is the prop-leg at the end of its body, which naturally aids it in locomotion; but this prop-leg also functions as a brush; after the larva has become soiled with too eager delving into the tissues of some earthworm, it curls its body over, and with this fan-shaped hind foot scrubs its head and face very clean. This is a rare instance of a larva paying any attention to its toilet.

When full grown, the larva makes a little oval cell within the earth and changes to a pupa; after about ten days, the pupa skin is shed and the full-fledged beetle comes forth. The larva and pupa of this species give off light, but are not so brilliant as the adult. The pupils should be encouraged to study the early stages of the fireflies, because very little is known concerning them.

In Cuba a large beetle called the cucujo has two great oval spots on its thorax, resembling eyes, which give off light. The Cuban ladies wear cucujos at the opera, in nets in the hair. I once had a pair which I tethered with gold chains to the bodice of my ball gown. The eyespots glowed steadily, but with the movement of dancing, they grew more brilliant until no glittering diamonds could compete with their glow.

Suggested Reading — *Do You Know?* by Janet Smalley; also, readings on page 300.

LESSON 90

The Firefly

Leading Thought — When the firefly wishes to make a light, it can produce one which, if we knew how to make it, would greatly reduce the price of artificial light; for the light made by fireflies and other creatures requires less energy than any other light known.

Method — After the outdoor observations have been made, collect some of these beetles in the evening with a sweep net; place them under a glass jar or tumbler, so that their light can be studied at close range. The next day give the observation lesson on the insects.

Observations — 1. At what time of year do you see fireflies? Do they begin to lighten before it is dark? Do you see them high in the air or near the ground? Is the flash they give short, or long enough to make a streak of light? Do you see them on cold and windy nights or on warm, still, damp evenings? Make a note of the hour when you see the first one flash in an evening.

2. Catch a few fireflies in the night; put them under a glass jar. Can you see the

light when they are not flashing? What color is it? When they make the flash can you see the outline of the "firefly lamp"? Watch closely and see if you think the flashing is a matter of will on the part of the firefly. Do you think the firefly is signaling to his mate when he flashes?

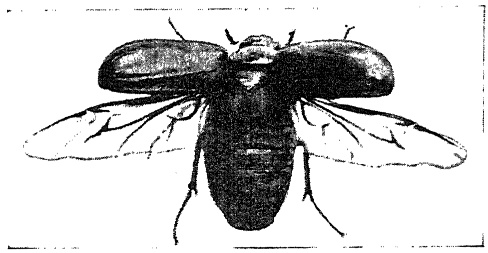
3. Study the firefly in daylight. Is it a fly or is it a beetle? What color is it above? When you look squarely down upon it, can you see its head and eyes?

4. Are the firefly's legs long or short? When a beetle has short legs is it a sign that it usually walks or runs, or flies?

5. Describe the antennæ. Are they in constant motion? What service do you think the firefly's antennæ perform for it?

6. Lift one of the wing covers carefully. What do you find beneath it? Does the beetle use its wing covers to beat the air and help it during flight? How does the beetle hold its wing covers when flying?

7. Turn the beetle on its back. Can you see the part of the body that flashes? What color is it?



M. V. Slingerland

A maybeetle flying, showing that the beetles hold the wing covers rigid and still in flight, the hind wings doing the work

8. Do you know the life history of the firefly? What is it like in its earlier stages? Where does it live? Does it have the power of making light when it is in the larval stage?

There, in warm August gloaming,
With quick, silent brightenings,
From meadow-lands roaming,
The firefly twinkles
His fitful heat-lightnings.

— Lowell

THE WAYS OF THE ANT

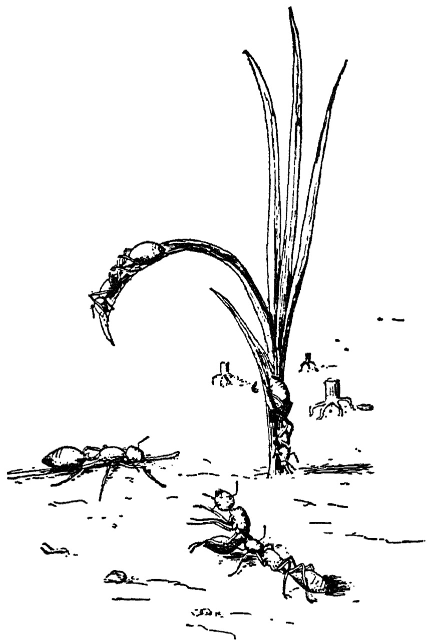
My child, behold the cheerful ant,
How hard she works, each day;
She works as hard as adamant
Which is very hard, they say.

— Oliver Herford

Very many performances on the part of the ant seem to us without reason; undoubtedly many of our performances seem likewise to her. But the more understandingly we study her and her ways, the more we are inclined to believe that she knows what she is about; I am sure that none of us can sit down by an ant-nest and watch its citizens come and go, without discovering things to make us marvel.

By far the greater number of species of ants find exit from their underground burrows beneath stones in fields. They like the stone for more reasons than one: it becomes hot under the noon sun and remains warm during the night, thus giving them a cozy nursery in the evening for their young. Some species make mounds, and often several neighboring mounds belong to the same colony, and are connected by underground galleries. There are usually several openings into these mounds. In the case of some of the western species which make galleries beneath the ground there is but one opening to the nest, and Dr. McCook says that this gate is closed at night; at every gate in any ants' nest, there are likely to be sentinels stationed, to give warning of intruders.

As soon as a nest is disturbed, the scared little citizens run helter-skelter to get out of the way; but if there are any larvæ or pupæ about, they take them up and make off with them; when too hard pressed, however, they will in most cases drop the precious burden, although I have several



Agricultural ants. Note that one ant is carrying a sister

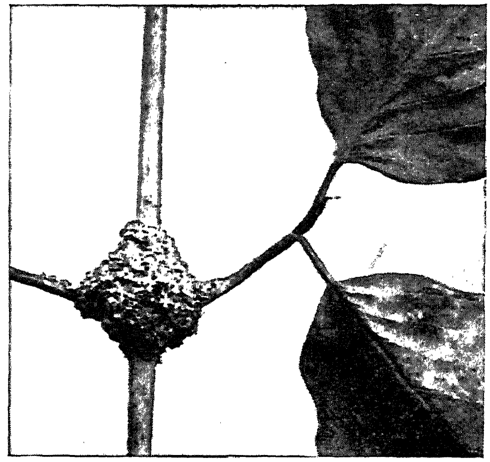
times seen an ant, when she dropped a pupa, stand guard over it and refuse to budge without it. The ant's eggs are very small objects, being oblong and about the size of a pinpoint. The larvæ are translucent creatures, like rice grains with one end pointed. The pupæ are yellowish, covered with a parchment-like sac, and resemble grains of wheat. When we lift stones in a field, we usually find, directly beneath, the young of a certain size.

There are often, in the same species of ants, two sizes; the large ones are called majors and the smaller minors; sometimes there is a smaller size yet, called minims. The smaller sizes are probably the result of lack of nutrition. But whatever their size, they all work together in bringing food for the young and in caring for the nest. We often see an ant carrying a dead insect or some other object larger than herself. If she cannot lift it or shove it, she turns around, and going backwards pulls it along. It is rarely that we see two carrying the same load, although we have observed this several times. In one or two cases, the two seemed not to be in perfect accord as to which path to take. If the ants find some large supply of food, many of them will form a procession to bring it into the nest bit by bit; such processions go back by making a little detour so as not to meet and interfere with those coming. During most of the year, an ant colony consists only of workers and laying queens, but in early summer the nest may be found swarming with winged forms, which are the kings and queens. Some warm day these will issue from the nest and take their marriage flight, the only time in their lives when they use their wings; for ants, like seeds, seem to be provided with wings simply for the sake of scattering wide the species. It is a strange fact that often on the same day swarms will issue from all the nests of one species in the whole region; by what mysterious messenger word is sent that brings about this unanimous exodus is still a mystery to us. This seems to be a provision for crossbreeding; and as bearing upon this, Miss Fielde discovered that an alien king is not only made welcome in a nest, but is sometimes seized by workers and pulled into a nest; this is most significant, since no worker of any other colony of the same species is permitted to live in any but its own nest.

After the marriage flight, the ants fall to the ground and undoubtedly a large number perish; however, just here our knowledge is lamentably lacking, and observations on the part of pupils as to what happens to these winged forms will be valuable. In the case of most species, we know that a queen finds refuge in some shelter and there lays eggs. Mr. Comstock once studied a queen of the big, black carpenter ant which lives under the bark of trees. This queen, without taking any food herself, was able to lay her eggs and rear her first brood to maturity; she regurgitated food for this first brood, and then they went out foraging for the colony. However, Miss Fielde found that in the species she studied the queen could not do this; a question most interesting to solve is whether any of the young queens, after the marriage flight, are adopted into other colonies of the same species. As soon as a queen begins laying eggs, she sheds her then useless wings, laying them aside as a bride does her veil.

When we are looking for ants' nests beneath stones, we often stumble upon a colony consisting of citizens differing in color. One has the head and thorax rust-red with the abdomen and legs brown; associated with this brown ant is a black or ash-colored species. These black ants are the slaves of the brown species; but slavery in the ant world has its ameliorations. When the slave-makers attack the slave nest, they do not fight the inmates unless they are obliged to. They simply loot the nest of the larvæ or pupæ, which they carry off to their own nests; and there they are fed and reared, as carefully as are their own young. The slaves seem to be perfectly contented, and conduct the household affairs of their masters with apparent cheerfulness. They do all the tasks involved in taking care of the nest and feeding the young, but they are never permitted to go out with war parties; thus they never fight, unless their colony is attacked by marauders.

If one chances upon an ant battle, one must needs compare it to a battle of men before the invention of gunpowder; for in those days fighting was more gory and dreadful than now, since man fought man until one of the two was slain. There is a great variation in military skill as well as in courage shown by different species of ants; the species most skilled in warfare march to battle in a solid column and when they meet the enemy the battle resolves itself into duels, although there is no code of ant honor which declares that one must fight the enemy singlehanded. Although some ants are provided with venomous stings, our common species use their jaws for weapons; they also eject upon each other a very acid liquid which we know as formic acid. Two enemies approach each other, rear on their hind legs,



M. V. Slingerland

An aphid stable on a dogwood twig, built by ants to protect their herds

throw this ant vitriol at each other, then close in deadly combat, each trying to cut the other in two. Woe to the one on which the jaws of her enemy are once set! For the ant has bulldog qualities, and if she once gets hold, she never lets go even though she be rent in pieces herself. At night the ant armies retreat to their citadels, but in the morning fare forth again to battle; and thus the war may be waged for days, and the battlefield be strewn with the remains of the dead and dying. So far as we are able to observe, there are two chief causes for ant wars; one is when two colonies desire the same ground, and the other is for the purpose of making slaves.

Perhaps the most interesting as well as most easily observed of all ant practices are those that have to do with plant lice, or aphids. If we find an ant climbing a plant of any sort, it is very likely that we shall find she is doing it for the purpose of tending her aphid herds. The aphid is a stupid little creature which lives by thrusting its bill or sucking tube into a stem or leaf of a plant, and thus settles down for life, nourished by the sap which it sucks up; it has a peculiar habit of exuding from its alimentary canal drops of honeydew when it feels the caress of the ant's antennæ upon its back. I had one year under observation a nest of elegant little ants with shining triangular abdomens which they waved in the air like pennants when excited. These ants were most devoted attendants on the plant lice infesting an evening primrose; if I jarred the primrose stem, the ants had a panic, and often one would seize an aphid in her jaws and dash about madly, as if to rescue it at all hazards. When the ant wishes honeydew, she approaches the aphid, stroking it or patting it gently with her antennæ, and if a drop of the sweet fluid is not at once forthcoming, it is probably because other ants have previously exhausted its individual supply; if the ant gets no response, she hurries on to some other aphid not yet milked dry.

This devotion of ants to aphids has been known for a hundred years, but only recently has it been discovered to be of economic importance. Professor Forbes, in studying the corn root-louse, discovered that the ants care for the eggs of this aphid in their own nests during the winter, and take the young aphids out early in the spring, placing them on the roots of smartweed; later, after the corn is planted, the ants move their charges to the roots of the corn. Ants have been seen to give battle to the enemies of the aphid. The aphids of one species living on dogwood are protected while feeding by stables, which a certain species of ant builds around them, from a mortar made of earth and vegetable matter.

Suggested Reading — *Ant-Hills and Soap-Bubbles*, by Mary G. Phillips; *Backyard Exploration*, by Paul G. Howes; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *Insect People*, by Eleanor King and Wellmer Pessels; *Insects Injurious to the Household and Annoying to Man*, by Glenn W. Herrick; *Little Black Ant*, by Alice C. Gall and Fleming H. Crew; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 2, *Some Animal Neighbors; Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*; *Our Insect Friends and Foes and Spiders*, published by the National Geographic Society; *The Wonder World of Ants*, by Wilfrid S. Bronson; also, readings on page 300.

LESSON 91

Field Observations on Ants

Leading Thought — However aimless to us may seem the course of the ant as we see her running about, undoubtedly if we understood her well enough, we should find that there is rational ant sense in her performances. Therefore, whenever we are walking and have time, let us make careful observations as to the actions of the ants which we may see.

Method — The following questions should be written on the blackboard and copied by the pupils in their notebooks. This should be done in May or June, and the answers to the questions worked out by observations made during the summer vacation.

Observations — 1. Where do you find ants' nests? Describe all the different kinds you have found. In what sort of soil do they make their nests? Describe the entrance to the nest. If the nest is a mound, is there more than one entrance? Are there many mounds near each other? If so, do you think they all belong to the same colony?

2. When the nest is disturbed, how do the ants act? Do they usually try to save themselves alone? Do they seek to save their young at the risk of their own lives? If an ant carrying a young one is hard pressed, will she drop it?

3. Make notes on the difference in appearance of eggs, larvæ, and pupæ in any ants' nest.

4. In nests under stones, can you find larvæ and pupæ assorted according to sizes?

5. How many sizes of ants do you find living in the same nest?

6. What objects do you find ants carrying to their nests? Are these for food? How does an ant manage to carry an object larger than herself? Do you ever see two ants working together carrying the same load?

7. If you find a procession of ants car-

rying food to their nest, note if they follow the same path coming and going.

8. If you find winged ants in a nest, catch a few in a vial with a few of the workers, and compare the two. The winged ants are kings and queens, the kings being much smaller than the queens.

9. If you chance to encounter a swarm of winged ants taking flight, make observations as to the size of swarm, the height above the ground, and whether any are falling to the earth.

10. Look under the loose bark of trees for nests of the big black carpenter ant. You may find in such situations a queen ant starting a colony, which will prove most desirable for stocking an artificial ants' nest.

11. If you find ants climbing shrubs, trees, or other plants, look upon the leaves for aphids and note the following points:

(a) How does an ant act as she approaches an aphid?

(b) If the aphids are crowded on the leaf, does she step on them?

(c) Watch carefully to see how the ant touches the aphid when she wishes the honeydew.

(d) Watch how the aphid excretes the honeydew, and note if the ant eats it.

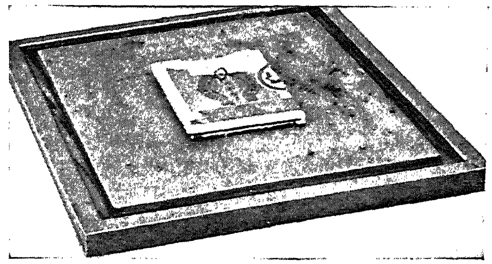
(e) If you disturb aphids which have ants tending them, note whether the ants attempt to defend or rescue their herds.

(f) If there are aphis lions or ladybird larvæ eating the aphids, note if the ants attack them.

12. If you find a colony of ants under stones where there are brown and black ants living together, the black members are the slaves of the brown. Observe as carefully as possible the actions of both the black and the brown inhabitants of the nest.

13. If you chance to see ants fighting, note how they make the attack. With what weapons do they fight? How do they try to get at the adversary?

14. Write a story covering the following points: How ants take their slaves; the attitude of masters and slaves toward each other; the work which the slaves do; the story of the ant battle; and how ants care for and use their herds.



A Lubbock ant-nest

LESSON 92

How to Make the Lubbock Ant-Nest

Material — Two pieces of window glass, 10 inches square; a sheet of tin, 11 inches square; a piece of plank, 1¼ inches thick, 20 inches long, and at least 16 inches wide; a sheet of tin or a thin, flat board, 10 inches square.

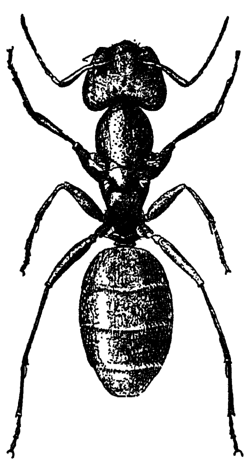
To Make the Nest — Take the plank and on the upper side, a short distance from the edge, cut a deep furrow. This furrow is to be filled with water, as a moat, to keep the ants imprisoned. It is necessary, therefore, that the plank should have no knotholes, and that it be painted thoroughly to keep it from checking. Take the sheet of tin 11 inches square, and make it into a tray by turning up the edges three-eighths of an inch. Place this tray in the middle of the plank. Place within the tray one pane of glass. Lay around the edges of this glass four strips of wood about half an inch wide and a little thicker than the height of the ants which are to live in the nest. Cover the glass with a thin layer of fine earth. Take the remaining pane of glass and cut a triangular piece from one corner, then place the pane on top of the other, resting upon the pieces of wood around the sides. The cover of the nest may be a piece of tin, with a handle soldered to the center, or a board with a screw eye in the center with which to lift it. There should be a piece of blotter or of very thin sponge introduced into the nest between the two panes of glass, in a position where it may be reached with a pipette, without removing the upper glass, for it must be kept always damp.

To establish a colony in this nest proceed as follows: Take a two-quart glass fruit jar and a garden trowel. Armed with these, visit some pasture or meadow near by, and find under some stone a small colony of ants which have plenty of eggs and larvæ. Scoop up carefully eggs, ants, dirt, and all, and place them in the jar, being as careful as possible not to injure the specimens. While digging, search carefully for the queen, which is a larger ant and is sometimes found. But if you have plenty of eggs, larvæ, and pupæ, the ants will become very contented in their new nest while taking care of them. After you have taken all the ants desirable, place the cover on the jar, carry them to the Lubbock nest and carefully empty the contents of the fruit jar on top of the board which covers the nest. Of course the furrow around the plank has been filled with water, so the stragglers cannot escape. The ants will soon find the way into the nest through the cut corner of the upper pane of glass, and will transfer their larvæ to it because it is dark. After they are in the nest, which should be within two or three hours, remove the dirt on the cover, and the nest is ready for observation. But, since light disturbs the little prisoners, the cover should be removed only for short periods.

The Fielde nest is better adapted for a serious study of ants, but it is not so well adapted for the schoolroom as is the Lubbock nest.

THE ANT-NEST AND WHAT MAY BE SEEN WITHIN IT

Ant anatomy becomes a very interesting study when we note the vigorous way the ant uses it — even to the least part. The slender waist characterizes the ant as well



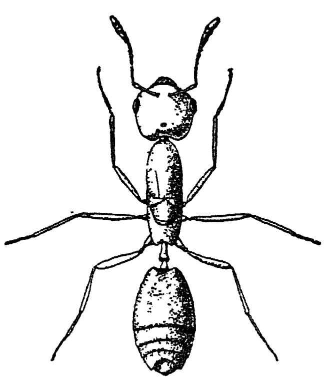
The black carpenter ant, much enlarged

as the wasp; the three regions of the body are easily seen, the head with its ever moving antennæ, the slender thorax with its three pairs of most efficient legs, and the long abdomen. The ant's legs are fairly long as compared with the size of the body and the ant can run with a rapidity that, comparatively, would soon outdistance any Marathon runner, however famed. I timed an ant one day when she was taking a constitutional on my foot rule. She was in no hurry, and yet she made time that if translated into human terms would mean sixteen yards per second. In addition to running, many ants when frightened will make leaps with incredible swiftness.

The ant does not show her cleverness in her physiognomy, probably because her eyes seem small and dull and she has a decidedly "retreating forehead"; but the brain behind this unpromising appearance is far more active and efficient than that behind the gorgeous great eyes of the dragonfly or behind the "high brow" of the grasshopper. The ant's jaws are very large compared with her head; they work sidewise like a pair of shears and are armed with triangular teeth along the biting edges; these are not teeth in a vertebrate sense, but are like the teeth of a saw. These jaws are the ant's chief utensils and weapons; with them she seizes the burdens of food which she carries home;

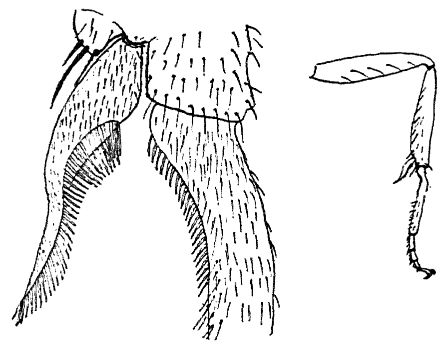
with them she gently lifts her infant charges; with them she crushes and breaks up hard food; with them she carries out soil from her tunnel, and with them she fights her enemies. She also has a pair of long palpi, or feelers.

Although her eyes are so small and furnished with coarse facets, as compared with other insects, this fact need not count against her, for she has little need of eyes. Her home life is passed in dark burrows where her antennæ give her information of her surroundings. Note how these antennæ are always moving, seeming to be atremble in eagerness to receive sensations. But aside from their powers of telling things by the touch, wherein they are more delicate than the fingers of the blind, they have other sense organs which are comparable to our sense of smell. Miss Fielde has shown that each of the five end segments of the antennæ has its own powers in detecting odor. The end segment detects the odor of the ant's own nest and enables her to distinguish this from other nests. The next, or eleventh segment, detects the odor of any descendant of the same queen; by this, she recognizes her sisters wherever she finds them. Through the next, or tenth segment, she



The red ant, much enlarged

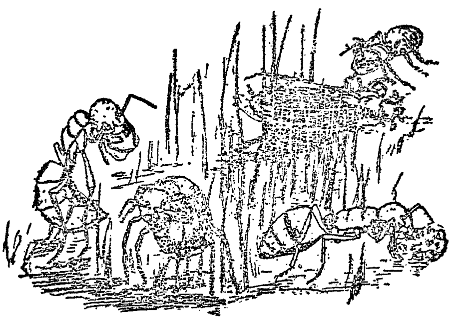
recognizes the odor of her own feet on the trail, and thus can retrace her own steps. The eighth and ninth segments convey to her the intelligence and means of caring for the young. If an ant is deprived of these five end-joints of the antennæ, she loses all power as a social ant and becomes completely disfranchised. Miss Fielde gives her most interesting experiments in detail in the Proceedings of the



The antenna-comb on the front leg of an ant

Academy of Natural Sciences of Philadelphia, July and October, 1901.

It is natural enough that the ant, depending so much on her antennæ for impressions and stimuli, should be very particular to keep them clean and in good order. She is well equipped to do this, for she has a most efficient antennæ brush on her wrist; it is practically a circular comb, which just fits over the antenna; and to see the ants using these brushes is one of the most common sights in the ant-nest and one of the most amusing. The ant usually commences by lifting her leg over one antenna and deftly passing it through the brush, and then licks the brush clean by passing it through her mouth, as a cat washes her face; then she cleans the other in a similar manner and possibly finishes by doing both alternately, winding up with a flourish, like a European gentleman curling his mustaches. Her antennæ cleaned, she starts promptly to do something, for she is a little six-footed Martha, always weighed down or buoyed up by many duties and cares. Keeping her antennæ on the qui vive, she assures herself, by touch, of the nature of any obstacle in her path. If she meets another ant, their antennæ cross and pat each other, and thus they learn whether they are sisters or aliens; if they are sisters, they may stand for some time with their antennæ fluttering. One who has watched ants carefully, is compelled to believe that they thus convey intelligence of some sort, one to the other. The ant is a good sister " according to her lights "; if her sister is hungry, she will give to her, even from her own par-



Ants making their toilets

tially digested food; the two will often stand mouth to mouth for some minutes during this process; if she feels inclined, she will also help a sister at her toilet, and lick her with her tongue as one cow licks another. The tongue of the ant is very useful in several ways; with it she takes up liquids, and also uses it with much vigor as a washcloth. Sometimes an ant will spend a half hour or more at her own toilet, licking every part of her own body that her tongue can reach, meanwhile going through all sorts of contortions to accomplish it; she uses her feet to scrub portions of her body not to be reached by her tongue.

But it is as infant nurse that the ant is a shining example. No mother instinct is hers, for she has yielded the power of motherhood to the exigencies of business life, since all workers are females but are undeveloped sexually. She shows far more sense in the care of her infant sisters than the mother instinct often supplies to human mothers. The ant nurse takes the eggs as soon as laid, and whether her care retards or hastens hatching we know not; but we do know that although the queen ant may not lay more than two eggs a day, a goodly number of these seem to hatch at the same time. The eggs are massed in bundles and are sticky on the outside; so they are held together in a bundle. Miss Fielde says that as the eggs are hatching, one ant will hold up the bundle, while another feeds those which have broken the shell. The larvæ, when young, also hang together by means of tiny hooks on their bodies. This habit of the eggs and young larvæ is a convenient one, since an ant is thus able to carry many at a time.

The larvæ are odd looking little creatures, shaped like crookneck squashes, the small end being the head and neck and the latter being very extensible. The ant nurses, by feeding some more than others, are able to keep a brood at the same stage of development; and in a well-ordered ant-nest, we find those of the same size in one nursery. I have often thought of a graded school as I have noted in ant-nests the youngsters assorted according to size.

The ants seem to realize the cost and care of rearing their young; and when a nest is attacked, the oldest, which are usually in the pupa stage, are saved first. When the larvæ are young, they are fed on regurgitated food; but as they grow older, the food is brought to them, or they to the food, and they do their own eating. In one of my nests, I placed part of the yolk of an egg hard boiled, and the ant nurses dumped the larvæ down around the edges of it; there they munched industriously, until through their transparent bodies I could see the yellow of the egg the whole length of the alimentary canal. The ant nurses are very particular about temperatures for their young, and Miss Fielde says they are even more careful about draughts. Thus they are obliged to move them about in the ground nests, carrying them down to the lower nurseries in the heat of the day, and bringing them up, nearer to the warm stones, during the evenings. This moving is always done carefully, and though the ant's jaws are such formidable nippers, she carries her baby sisters with gentleness; and if they be pupæ, she holds them by the loose pupal skin, like carrying a baby by its clothes. The pupæ look like plump little grain bags, tied at one end with a black string. They are the size of small grains of wheat, and are often called ants' eggs, which is absurd, since they are almost as large as the ant. Ants' eggs are not larger than pinpoints.

The ant nurses keep the larvæ and pupæ very clean by licking them; and when a youngster issues from the pupa skin, it is a matter of much interest to the nurses. I have often seen two or three of them help straighten out the cramped legs and antennæ of the young one, and hasten to feed her with regurgitated food. When ants first issue from the pupa skin they are pale in color, their eyes being very black in contrast; they are usually helpless and stupid, although they often try to clean their antennæ and make a toilet; but they do not know enough to follow their elders from one room to another, and they are a source of much care to the nurses. In case of moving, a nurse will lock jaws with a " callow," as a freshly hatched adult ant is called, and drag her along, the legs of the callow sprawling helplessly meanwhile. If in haste, the nurse takes hold anywhere, by the neck or the leg, and hustles her charge along; if she takes her by the waist the callow curls up like a kitten, and is thus more easily moved. After the nurses have moved them from one chamber to the next, I have noticed that the callows are herded together, their attendants ranged in a circle about them. Often we see one ant carrying another which is not a callow, and this means that a certain number of the colony have made up their minds to move, while the others are not awake to this necessity. In such a case, one of these energetic sisters will seize another by the waist, and carry her off with an air that says plainly, " Come along, you stupid! "

Ants are very cleanly in their nests, and we find the refuse piled in a heap at one corner, or as far as possible from the brood.

If we are fortunate enough to find a queen for the nest, then we may observe the attention she gets; she is always kept in a special compartment, and is surrounded by ladies in waiting, who feed her and lick her clean and show solicitude for her welfare; although I have never observed in an ant-nest that devotion to royalty which we see in a beehive.

Not the least interesting scene in an ant-nest is when all, or some, are asleep and are as motionless as if dead.

LESSON 93

Observations of Ants in an Artificial Nest

Leading Thought — The ants are very devoted to their young and perhaps the care of them is the most interesting feature in the study of the artificial nest.

Method — Have in the schoolroom a Lubbock's nest with a colony of ants within it, with their larvæ in all stages, and if possible, their queen. For observing the form of the ant, pass one or two around in a vial.

Observations — 1. What is there peculiar about the shape of the ant's body? Can you see which section bears the legs? Are the ant's legs long compared with her body? Can she run rapidly?

2. Look at the ant's head through a lens, and describe the antennæ, the jaws, and the eyes.

3. Note how the ant keeps her antennæ in motion. Note how she gropes with them as a blind person with his hands. Note how she uses them in conversing with her companions.

4. How does the ant clean her antennæ? Does she clean them more often than any other part of her body? How does she make her toilet?

5. See how an ant eats syrup. How do ants feed each other?

6. How does the ant carry an object? How does she carry a larva or a pupa? Have you ever seen one ant carry another? If so, describe it.

7. Note the way the ants feed their young. How do they keep them clean? Does an ant carry one egg or one small larva at a time or a bundle of them? How do you suppose the bundle is fastened together?

8. Describe an egg, a larva, and a pupa of the ant and tell how they differ. Do you know which ant is the mother of the larvæ in the nest?

9. Do you find larvæ of different sizes

all together in your nest? Do you find larvæ and pupæ in the same group? Do the ants move the young often from one nest to another? Why do you suppose they do this?

10. Note how the ant nurses take care of the callow ant when it is coming out from the pupa skin. How do they assist her and care for her? How do they lead her around? How do ants look when resting?

11. Note where the ants throw the refuse from the nest. Do they ever change the position of this dump heap?

THE MUD-DAUBER

This little cement worker is a nervous and fidgety creature, jerking her wings constantly as she walks around in the sunshine; but perhaps this is not nervousness,

Nest of a mud-dauber on the back of a picture frame

but rather to show off the rainbow iridescence of her black wings. Her waist is a mere pedicel and the abdomen is only a knob at the end of it. The latter, seen from the outside, would seem of little use as an abdomen; but if we watch the insect flying, we can see plainly that the abdomen is an aid to steering.

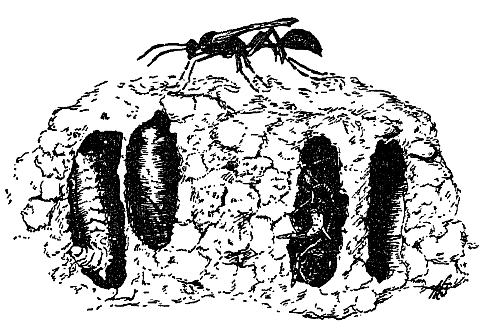
In early summer, we find this black wasp at her trade as a mason. She seeks the edges of pools or puddles where she works industriously, leaving many little holes whence she takes mud to mix with the saliva which she secretes from her mouth to make firm her cement. This cement she plasters on the underside of some roof or rafter or other protected place, going back and forth until she has built a suitable foundation. She works methodically, making a tube about an inch long, smooth inside but rough outside, the walls about one-eighth of an inch thick. She does all the plastering with her jaws, which she uses as a trowel. When the tube is completed except that the end is left open, she starts off in quest of spiders, and very earnestly does she seek them. I have seen her hunt every nook and corner of a porch for this prey. When she finds a spider, she pounces upon it and stings it until it is helpless, and carries it to her cement tube, which is indeed a spider sarcophagus, and thrusts it within. She brings more spiders until her tube is nearly full; she then lays an egg within it and makes more cement and neatly closes the door of the tube. She places another tube by the side of this, which she provisions and closes in the same way; she may make another and another tube, often a half dozen, under one adobe roof.

The wasp in some mysterious way knows how to thrust her sting into the spider's nervous system in a peculiar way which renders her victim unable to move, although it yet lives. The wasp is no vegetarian like the bee, and she must supply her young with wasp-meat instead of beebread. Since it is during the summer and hot weather when the young wasps are hatched and begin their growth, their meat must be kept fresh for a period of two or three weeks.

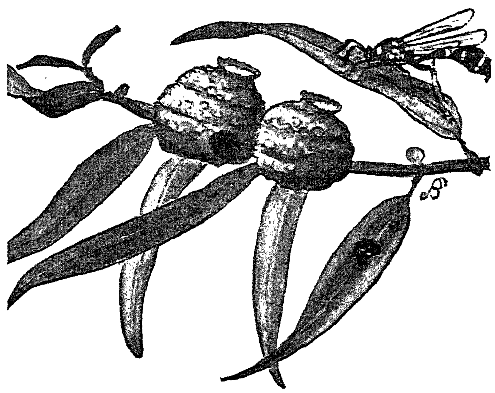
So these paralyzed spiders do not die, although they are helpless. It is certainly a practical joke with justice in it, that these ferocious creatures lie helpless while being eaten by a fat little grub which they would gladly devour, if they could move.

The wasp larva is a whitish, plump grub and it eats industriously until the spider meat is exhausted. It then weaves a cocoon of silk about itself which just covers the walls of its home tube, like a silken tapestry; within this cocoon the grub changes to a pupa. When it finally emerges, it is a full-grown wasp with jaws which are able to cut a door in the end of its tube, through which it comes out into the world, a free and accepted mason. The females, which issue late in the season, hide in warm or protected places during the winter; they particularly like the folds of lace window curtains for hibernating quarters. There they remain until spring comes, when they go off to build their plaster houses.

There are about seventy species of mud wasps in our country. Some provision their nests with caterpillars instead of spiders. This is true of the jug-builder, which makes her nest jug-shaped and places two or three of them side by side upon a twig. She uses hair in her mortar, which makes it stronger. This is necessary, since the jug is saddled upon twigs and is more exposed to the rain than is the nest of the most common mud-dauber. The jug-builder is brown in color and has yellow markings on the abdomen; but she does not resemble the yellow jackets, because she has a threadlike waist. There are other species of mud wasps which use any small cavity



A mud-dauber and her nests, with cells cut open to show from left to right, larva full grown, cocoon, young larva feeding on its spider-meat, and an empty cell



The jug-builder and her nests

they can find for the nest, plastering up the opening after the nest has been provisioned and the egg laid. We often find keyholes, knotholes, and even the cavity in the telephone transmitter plastered up by these small opportunists.

The mud-dauber, which is the most common and most likely to be selected for this lesson, is a slender creature and looks as if she were made of black tinsel; her body gives off glints of steel and blue; her abdomen constantly vibrates with the movement of breathing. Her eyes are large and like black beads; her black antennæ curve gracefully outward, and her wings, corrugated with veins, shimmer with a smoky blue, green, and purple. She stands on her black tiptoes when she walks, and she has a way of turning around constantly as if she expected an attack from the rear. Her wings, like those of other mud wasps, are not folded fanwise like those of the yellow jacket, but are folded beside each other over her back.

Suggested Reading — *Backyard Exploration*, by Paul G. Howes; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes*; also, readings on page 300.

LESSON 94

The Mud-Dauber

Leading Thought — There are certain wasps which gather mud and mix it into mortar with which to build nests for their young. Within these nests, the mother wasp places spiders or insects which are disabled by her sting, to serve as the food of the young wasps.

Method — Have the pupils bring the homes of the mud wasps to school for observation. The wasps themselves are very common in spring and also in autumn, and they may be studied at school and may be passed around in vials for closer observation; they do not sting severely when handled, the sting being a mere prick. The purpose of the lesson should be to stimulate the pupils to watch the mud-daubers while building their nests and capturing their prey.

Observations — 1. Where did you find the mud-dauber's nest? How was it protected from the rain? Was it easily removed? Could you remove it all, or did some of it remain stuck fast?

2. What is the shape of the nest? How does it look inside? Of how many tubes does it consist? How long is each tube? Were the tubes laid side by side?

3. Of what material was the nest made? Is it not much harder than mud? How did the wasp change the mud to cement? Where did she get the mud? How did she carry it? With what tools did she plaster it?

4. For what purpose was the nest made? Is the inside of the tubes smooth as compared with the outside of the nest?

5. Write a little story about all that happens in one of these tubes, including the following points: What did the mother wasp place in the tube? How and why did she close it? What hatched from the egg she placed within it? How does the young wasp look? On what does it feed? What sort of cocoon does it spin? How does it get out of the nest when full grown?

6. Describe the mud-dauber wasp. How large is she? What is the color of her body? Of her wings? How many wings has she? How are her wings folded differently from those of the yellow jacket? Describe her eyes; her antennæ; her legs; her waist; her abdomen.

7. Where did you find the wasp? How did she act? Do you think that she can sting? How does this wasp pass the winter?

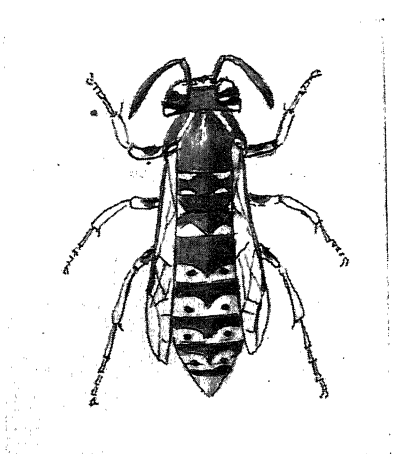
8. Do you know the mud wasps which build the little jug-shaped nests for their young? Do you know the mud wasps which utilize crevices and keyholes for their nests and plaster up the opening?

9. Do you know about the digger wasps which pack away grasshoppers or caterpillars in a hole in the ground, in which they lay their egg and then cover it?

THE YELLOW JACKET

Many wasps are not so waspish after all when we understand one important fact about them; i.e., although they are very nervous themselves, they detest that quality in others. For years the yellow jackets have shared with us our meals at our summer camp on the lake shore. They make inquisitive tours of inspection over the food on the table, often seeming to include ourselves, and coming so near that they fan our faces with their wings. They usually end by selecting the sweetened fruits, but they also carry off bits of roast beef, pouncing down upon the meat platter and seizing a tidbit as a hawk does a chicken. We always remain calm during these visitations, for we know that unless we inadvertently pinch one, we shall not be harmed; and it is great fun to watch one of these graceful creatures poising daintily on the side of the dish lapping up the fruit juice as a cat does milk, the slender, yellow-banded abdomen palpitating as she breathes. Occasionally, two desire the same place, and a wrestling match ensues which is fierce while it lasts, but the participants always come back to the dish unharmed. They are extra polite in their manners, for after one has delved eagerly into the fruit syrup, she proceeds to clean her front feet by passing them through her jaws, which is a wasp's way of using a finger bowl.

Both yellow jackets and the white-faced black hornets build in trees, and their nests are much alike, although the paper made by the yellow jackets is finer in texture. However, some species of yellow jackets build their nests in the ground, but of similar form. The nest is of paper made of bits of wood which the wasps pull off with their jaws from weather-worn fences or boards. This wood is reduced to a pulp by saliva which is secreted from the wasp's mouth, and is laid on in little layers which can be easily seen by examining the outside of the nest. These layers may be of different colors. A wasp will come with her load of paper pulp, and using her jaws and front feet for tools she will join a strip to the edge of the paper and pat it into shape. The paper tears more readily along the lines of the joining than across. The cover of the nest is made of many layers of shell-like pieces fastened together, and the outer layers are waterproof; the opening of a nest is at the bottom. Mr. Lubbock has shown that certain wasps are stationed at the door, as

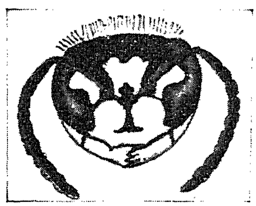


A yellow jacket

A wasps' nest with the side walls removed

sentinels, to give warning on the approach of an enemy. The number of stories of combs in a nest depends upon the age and size of the colony. They are fastened together firmly near the center by a central core or axis of very strong, firm paper, which at the top is attached to a branch or whatever supports the nest. The cells all open downward, in this respect differing from those of the honeybee, which are usually placed horizontally. The wasp comb differs from the honeycomb in that it is made of paper instead of wax, and that the rows of cells are single instead of double. The cells in the wasp comb are not for storing honey, but are simply the cradles for the young wasps. (See figure above.)

Sometimes a wasp family disaster makes it possible for us to examine one of these nests with its inmates. Here we find, in some of the cells, the long white eggs fastened to the very bottom of the cell, in an inner angle, as if a larva when hatched needed to have a cozy corner. These wasp larvæ are the chubbiest little grubs imaginable and are very soft bodied. It was once a mystery to me how they were able to hang in the cells, head down, without getting " black in the face " or falling out; but this was made plain by studying the little disc at the rear end of the larva's body, which is decidedly sticky; after a larva is

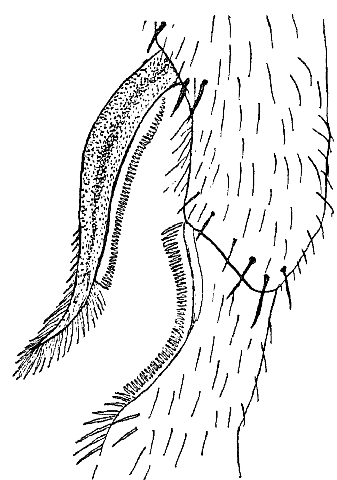


Looking a wasp in the face

dead, its heavy body can be lifted by pressing a match against this disc; thus it evidently suffices to keep the baby wasp stuck fast to its cradle. The larva's body is mostly covered with a white, papery, soft " skeleton skin "; the head is yellowish and highly polished, looking like a drop of honey. At one side may be seen a pair of toothed jaws, showing that it is able to take and chew the food brought by the nurses. They seem to be well-trained youngsters, for they all face toward the center of the nest, so that a nurse, when feeding them, can move from one to another without having to pass to the other side of the cell. It is a funny sight to behold a combful of well-grown larvæ, each fitting in its cell like meal in a bag and with head and several segments projecting out as if the bag were overflowing. It behooves the wasp larva to get its head as far out of the cell as possible, so that it will not be overlooked by the nurses; the little ones do this by holding themselves at the angle of the cell; this they accomplish by wedging the back into the corner. These young larvæ do not face inwards like the older ones, but rest in an inner angle of the cell.

After a larva has reached the limit of its cell room, it spins a veil around itself and fastens it at the sides, so that it forms a lining to the upper part of the cell and makes a bag over the " head and shoulders " of the insect. This cocoon is very tough, and beneath its loose dome the larva skin is shed; the pupa takes on a decidedly waspish form, except that the color is all black; the legs and the wings are folded piously down the breast and the antennæ lie meekly each side of the face, with the " hands " folded outside of them; the strong toothed jaws are ready, so that when the pupa skin is molted, the insect can cut its silken curtain and come out into its little nest world as a full-fledged yellow jacket.

What a harlequin the wasp is, in her costume of yellow and black! Often in the invertebrate world these colors mean " sit up and take notice," and the wasp's costume is no exception. Whoever has had any experience in meddling with yellow jackets avoids acquaintance with all yellow and black insects. Yet we must confess that the lady wasp has good taste in dress. The yellow crossbands on her black skirt are scalloped, and, in fact, all her yellow is put on in a most *chic* manner; she, being slender, can well afford to dress in roundwise stripes; and she folds her wings prettily like a fan, not over her back like the mud wasp, which would cover her decorations. There is a sensation coming to the one who, armed with a lens, looks a wasp in the face; she always does her hair pompadour, and the yellow is here put on with a most bizarre effect, in points and arabesques. Even her jaws are yellow with black borders and black notches. Her antennæ are velvety black,



The antenna-comb or cleaner on the foreleg of a wasp her legs are yellow, and her antennæ comb, on her wrist, is a real comb and quite ornate.

In the nest which we studied in late August, the queen cells were just being developed. They were placed in a story all by themselves, and they were a third larger than the cells of the workers. The queen of this nest was a most majestic wasp, fully twice as large as any of her subjects; her face was entirely black, and the yellow bands on her long abdomen were of quite a different pattern from those on the workers; her sting was not so long in proportion, but I must confess it looked efficient. In fact, a yellow jacket's sting is a formidable looking spear when seen through a microscope, since it has on one side some backward projecting barbs, meant to hold it firm when driving home the thrust.

While wasps are fond of honey and other sweets, they are also fond of animal food and eat a great many insects, benefiting us greatly by destroying mosquitoes and flies. As no food is stored for their winter use, all wasps excepting the queens die of the cold. The queens crawl away to protected places and seem to be able to withstand the rigors of winter; each queen, in the spring, makes a little comb of a few cells, covering it with a thin layer of paper. She then lays eggs in these cells and gathers food for the young; but when these first members of the family, which are always workers, come to maturity, they take upon themselves the work of enlarging the nest and caring for the young. After that, the queen devotes her energies to laying eggs.

Wasps enlarge their houses by cutting away the paper from the inside of the covering, to give more room for building the combs wider; to compensate for this, they build additional layers on the outside of the nest. Thus it is that every wasp's nest, however large, began as a little comb of a few cells and was enlarged to meet the needs of the rapidly growing family. Ordinarily the nest made one year is not used again.

SUGGESTED READING—*Fields and Fence-rows*, by Walter P. Porter and Einar A. Hansen; *First Lessons in Nature Study*, by Edith M. Patch; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes*; also, readings on page 300.

LESSON 95

THE YELLOW JACKET

LEADING THOUGHT — The wasps were the original paper makers, using wood pulp for the purpose. Some species construct their houses of paper in the trees or bushes while others build in the ground.

METHOD — Take a deserted wasp-nest, the larger the better, and with sharp scissors remove one side of the covering of the nest, leaving the combs exposed and follow with the questions and suggestions indicated. From this study of the nest encourage the children to observe more closely the wasps and their habits, which they can do in safety if they learn to move quietly while observing. (See Fig. p. 381.)

OBSERVATIONS — 1. Which kind of wasp do you think made this nest? Of what is the nest made? Where did the wasp get the material? How do the wasps make wood into paper?

2. What is the general shape of the nest? Is the nest well covered to protect it from rain? Where is the door where the wasps went in and out? Is the covering of the nest all of the same color? Do these differences in color give you any idea of how the wasps build the paper into the nest? Does the paper tear more easily one way than another? Is the covering of the nest solid or in layers?

3. How many combs or stories are there in the wasp house? How are they fastened together and how suspended?

4. Compare the combs of the wasp-nest with those of the honeybee. How do they resemble each other and how differ? Do the cells open upward or downward? For what purpose are the combs in the wasp-nest used? Are all the cells of the same size? Do you know the reason for this difference in size?

5. How do the young wasp grubs manage to cling to the cells head downward? Are the cells lined with a different color and does this lining extend out over the opening in some cases? Is this lining of the cells made of paper also? Do you know how a young wasp looks and how the white lining of the cells is made?

6. Do you believe that some wasps of the colony are always posted as sentinels at the door to give warning if the colony is attacked?

7. Do wasps store food to sustain them during the winter? What happens to them during the winter? Is the same nest used year after year?

8. Can you describe the beginning of this wasp-nest? When was it made? Tell the story of the wasp that made it. How large was the nest at first? How was the nest enlarged?

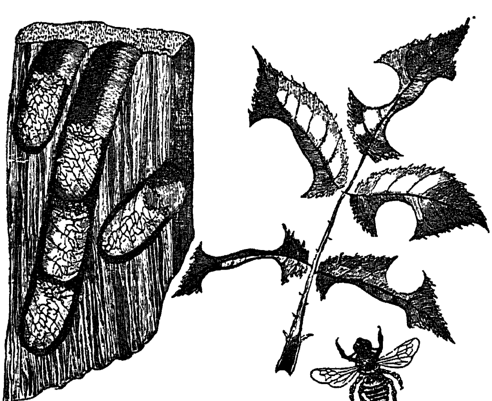
9. What is the food of wasps? How do these insects benefit us?

10. Write a story giving the life history of a wasp.

11. In the summer watch a yellow jacket eat from a dish of sweetened fruit which you may place out of doors to coax her to come where you can carefully observe her. What are the colors of the yellow jacket? Where is the yellow? How are the yellow bands made ornamental? How does she fold her wings? How many wings has she? What is the color of her legs? Describe her antennæ and eyes. How does she eat the fruit juice? Can you observe the motion of her body when she breathes?

THE LEAF-CUTTER BEE

One beautiful day in late June when I was picking some roses, I saw a bee, almost as large as a honeybee but different in shape and darker in color, alight on a leaf

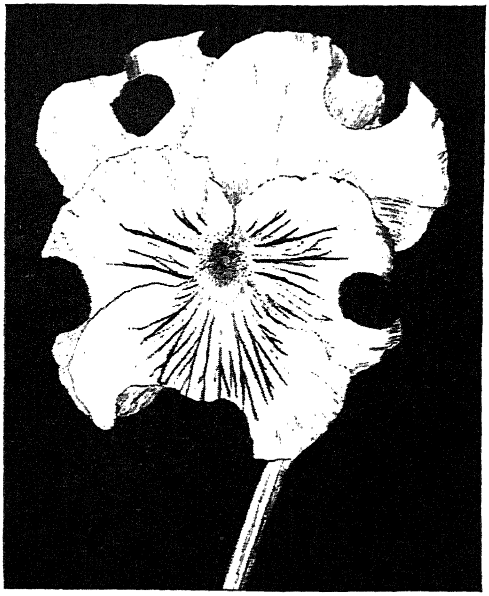


A leaf-cutter bee, its nest, and rose leaves cut by the bee

and, moving with nervous rapidity, cut a circle out of a leaf with her jaws " quicker'n a wink "; then, taking the piece between her forefeet and perhaps holding it also with her jaws, she flew away, the green disc looking as large in proportion to her size as a big bass drum hung to the neck of a small drummer. I waited long for her to come back, but she came not; meanwhile I examined the leaves of the rose bush and found many circlets, and also many oblong holes with the ends deeply rounded, cut from the leaflets.

I knew the story of the little bee and was glad I had seen her cut a leaflet with her jaw shears, which work sidewise like real shears. I knew that somewhere she had found a cavity big enough for her needs; perhaps she had tunneled it herself in the dead wood of some post or stump, using her jaws to cut away the chips; maybe she had found a crevice beneath the shingles of a roof or beneath a stone in the field, or she may have rolled a leaf; anyway, her little cave was several inches long, circular in outline and large enough to admit her body. She first cut a long piece from the rose leaf and folded it at the end of the tunnel; and then she brought another and another long piece and bent and shaped them into a little thimble-like cup, fastening them together with some saliva glue from her mouth. After the cup was made to her liking, she went in search of food, which she found in the pollen of some flowers. This pollen was carried not as the honeybees do, because she has no pollen baskets on her legs; but it was dusted into the fur on the lower side of her body; as she scraped the pollen off, she mixed it with some nectar which she had also found in the flowers, and made it into a pasty mass and heaped it at the bottom of the cup; she probably made many visits to flowers before she had a sufficient amount of this bee pastry, and then she laid an egg upon it; after this, she immediately flew back to the rose bush to cut a lid for her cup. She is a nice mathematician and she cuts the lid just a little larger than the rim of the cup, so that it may be pushed down in, making it fit very closely around the edges; she then cuts another and perhaps another of the same size and puts them over and fastened to the first cover. When finished, it is surely the prettiest baby basket ever made by a mother, all safely enclosed to keep out enemies. But her work is then only begun. She has other baby baskets to make and she perhaps makes ten or more, placing one cup just ahead of another in the little tunnel.

But what is happening meanwhile to the bee babies in the baskets? The egg hatches into a little white bee grub which falls to and eats the pollen and nectar paste with great eagerness. As it eats, it grows and sheds its skeleton skin as often as it becomes too tight, and then eats and grows some more. How many mothers would know just how much food it would require to develop a child from infancy until it grows up! This bee mother knows well this amount, and when the food is all gone, the little bee grub is old enough to change to a pupa; it looks very different now, and although it is mummy-shaped, we can see its folded wings and antennæ. After remaining a motionless pupa for a few days, it sheds its pupa skin and now it is a bee just like its mother; but as the oldest bee is at the bottom of the tunnel, even after it gets its wings and gnaws its way out of its basket, it very likely cannot escape and find its way out into the sunshiny world, until its younger brothers and sisters have gone out before it.



Anna C. Stryke

A pansy cut by a leaf-cutter bee

There are many species of these leaf-cutter bees and each species makes its own kind of nest, always cutting the same size of circlets and usually choosing its own special kind of leaf to make this cradle. Some are daintier in their tastes and use rolled petals instead of leaves; and we have found some tiny cups made of gorgeous peony petals, and some of pansy petals, a most exquisite material.

At Chautauqua, New York, we found a species which rolled maple leaves into a tube that held three or four cups, and we also found there a bee stowing her cups in the open end of a tubular rod used to hold up an awning. There are other species which make short tunnels in the ground for their nests; perhaps the most common of all wedge their cups between or beneath the shingles on the roofs of summer cottages. But, however or wherever the leaf-cutter works, she is a master mechanic and does her work with niceness and daintiness.

Suggested Reading — *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes; Nature and*

Science Readers, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*; also, readings on page 300.

LESSON 96

The Leaf-cutter Bee

Leading Thought — When we see the edges of rose leaves with holes of regular pattern in them, some of the holes being oblong and some circular, we know the leaf-cutter bee has cut them to make her cradle cups.

Method — It is very easy to find in June or autumn the leaves from which the leaf-cutter bee has cut the bedding for her young. Encourage the pupils to look for the nest during the summer and to bring some of the cups to school when they return, so that they may be studied in detail; meanwhile the teacher may tell the story of the nest. This is rather difficult for the pupils to work out.

Observations — 1. Do you find rose leaves with round holes cut in their edges? Do you find on the same bush some leaflets with oblong holes in them? Sketch or describe the rose leaf thus cut, noting exactly the shape of the holes. Are the circular holes of the same size? Are the long holes about equal in size and shape? Do you find any other plants with holes like these cut in them? Do you find any petals of flowers thus cut?

2. What do you think made these holes? If an insect were taking a leaf for food would the holes be as regular? Watch the rose bush carefully and see if you can discover the insect which cuts the leaf.

3. Have you ever seen the little black bee carrying pieces of rose leaves between her front feet? With what instrument do you suppose she cut the leaves? Where do you think she was going?

4. Have you ever found the nest of the leaf-cutter bee? Was it in a tunnel made in dead wood or in some crack or cranny? How many of the little rose-leaf cups are there in it? How are the cups placed? Are the little bees still in the cups or can you see the holes through which they crawled out?

5. Take one cup and study it carefully. How are the pieces of leaves folded to make the cups? How is the lid put on? Soak the cup in water until it comes apart easily. Describe how many of the long pieces were used and how they were bent to make a cup. Of how many thicknesses is the cover made? Are the covers just the same size as the top of the cup or a little larger? How does the cover fit so tightly?

6. If you find the nest in July or early August, examine one of the cups carefully and see what there is in it. Take off the cover without injuring it. What is at the bottom of the nest? Is there an insect within it? How does it look? What is it doing? Of what do you think its food was made? How and by whom was the food placed in the cup? Place the nest in a box or jar with mosquito netting over the top, and put it out of doors in a safe and shaded place. Look at it often and see what this insect changes into.

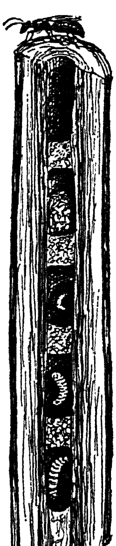
7. If the mother bee made each little nest cup and put in the beebread and honey for her young, which cup contains the oldest of the family? Which the youngest? How do you think the full-grown bees get out of the cup?

8. Do you think that the same species of bee always cuts the same sized holes in a leaf? Is it the same species which cuts the rose leaves and the pansy petals?

THE LITTLE CARPENTER BEE

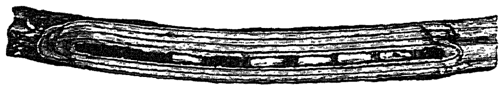
Take a dozen dead twigs from almost any sumac or elder, split them lengthwise, and you will find in at least one or two of them a little tunnel down the center where there was once pith. In the month of June or July, this narrow tunnel is made into an insect apartment house, one little creature in each apartment, partitioned off from the one above and the one below. The nature of this partition reveals to us whether the occupants are bees or wasps; if it is made of tiny chips, like fine sawdust glued together, a bee made it and there are little bees in the cells; if it is made of bits of sand or mud glued together, a wasp was the architect and young wasps are the inhabitants. Also, if the food in the cells is pollen paste, it was placed there by a bee; if paralyzed insects or spiders are in the cells, a wasp made the nest.

The little carpenter bee (*Ceratina dupla*) is a beautiful creature, scarcely one quarter of an inch in length, with metallic blue body and rainbow tinted wings. In spring, she selects some twig of sumac, elder, or raspberry which has been broken, and thus gives her access to the pith; this she at once begins to dig out, mouthful by mouthful, until she has made a smooth tunnel several inches long; she gathers pollen and packs beebread in the bottom of the cell to the depth of a quarter-inch, and then lays upon it a tiny white egg. She brings back some of her chips of pith and glues them together, making a partition about one-tenth of an inch thick, which she fastens firmly to the sides of the tunnel; this is the roof for the first cell and the floor of the next one; she then gathers more pollen, lays another egg, and builds another partition.



The little carpenter bee; her nest, cut open to show the eldest larva at the bottom and the youngest nearest the entrance

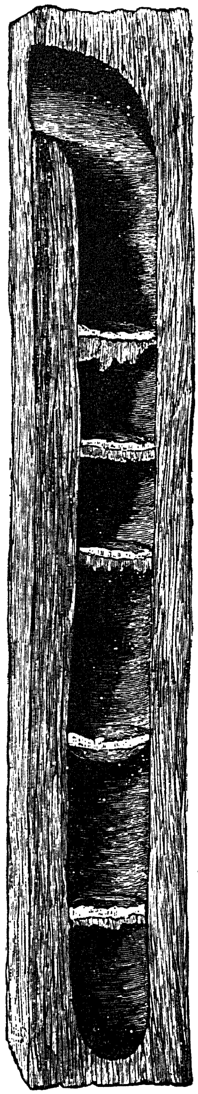
Thus she fills the tunnel, almost to the opening, with cells, sometimes as many as fourteen; but she always leaves a space for a vestibule near the door, and in this she makes her home while her family below her are growing up.



Nest of the carpenter wasp

The egg in the lowest cell of course hatches first; a little bee grub issues from it and eats the beebread industriously. This grub grows by shedding its skin when it becomes too tight, then changes to a pupa, and later to a bee resembling its mother. But, though fully grown, it cannot get out into the sunshine, for all its younger brothers and sisters are blocking the tunnel ahead of it; so it simply tears down the partition above it and kicks away the little pieces. The little grub bides its time until the next youngest brother or sister tears down the partition above its head and pushes the fragments into the very face of the elder, which, in turn, pushes them away. Thus, while the young bees are waiting, they are kept more or less busy pushing behind them the broken bits of all the partitions above them. Finally, the youngest gets its growth, and there they all are in the tunnel, the broken partitions behind the hindmost at the bottom of the nest, and the young bees packed closely together in a row with heads toward the door. When we find the nest at this period, we know the mother because her head is toward her young ones and her back to the door. A little later, on some bright morning, they all come out into the sunshine and flit about on gauzy, rainbow wings, a very happy family, out of prison.

But if the brood is a late one, the home must be cleaned out and used as a winter nest, and still the loyal little mother bee stays true to her post; she is the last one to enter the nest; and not until they are all housed within, does she enter. It is easy to distinguish her, for her wings are torn and frayed with her long labor of building the nest, until they scarcely serve to carry her afield; but she remains on guard over her brood.



Nest of the large carpenter wasp

The story of the little carpenter wasps is similar to that of the bee, except that we have reason to believe they often use her abandoned tunnels instead of making new ones. They make their little partitions out of mud; their pupæ are always in long, slender, silken cocoons, and we have no evidence that the mother remains in attendance.

Suggested Reading — *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes*; also, readings on page 300.

LESSON 97

The Little Carpenter Bee

Leading Thought — Not all bees live in colonies like the honeybees and bumblebees. One tiny bee rears her brood within a tunnel which she makes in the pith of sumac, elder, or raspberry.

Method — This lesson may be given in early summer or in autumn. In spring or early summer, the whole family of bees in their apartments may be observed; in autumn, the empty tenement with the fragments of the partitions still clinging may be readily found and examined; and sometimes a whole family may be found, stowed away in the home tunnel, for the winter.

Observations — 1. Collect dead twigs of sumac or elder and cut them in half, lengthwise. Do you find any with the pith tunneled out?

2. How long is the tunnel? Are its sides smooth? Can you see the partitions which divide the long narrow tunnel into cells? Look at the partitions with a lens, if necessary, to determine whether they are made of tiny bits of wood or of mud. If made of mud, what insect made them? If of little chips, how and by what were they constructed?

3. Are there any insects in the cells? If so, describe them. Is there beebread in the cells?

4. For what was the tunnel made? With what tools was it made? How are the partitions fastened together? How does a young bee look?

5. Write the story of the oldest of the bee family which lived in this tunnel. Why did it hatch first? On what did it feed? When it became a full-fledged bee, what did it do? How did it finally get out?

6. Take a glass tube, the hollow at the center being about one-eighth of an inch across, a tube which you can get in any drug store. Break this tube into sections six or seven inches long, wrap around each a black paper or cloth made fast with rubber bands, and suspend them in a hedge or among thick bushes in May. Examine these tubes each week to see if the wasps or bees are using them.

THE BUMBLEBEE

Thou, in sunny solitudes,
Rover of the underwoods,
The green silence dost replace
With thy mellow, breezy bass.

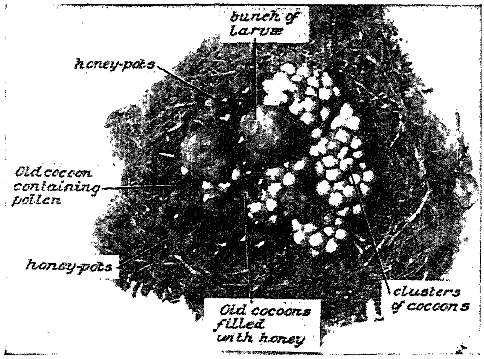
— EMERSON

There seems to have been a hereditary war between the farm boy and the bumblebee, the hostilities usually initiated by the boy. Like many wars, it is very foolish and wicked, and has resulted in great harm to both parties. Luckily, the boys of today are more enlightened; and it is to be hoped that they will learn to endure a bee sting or two for the sake of protecting these diminishing hosts, upon which so many flowers depend for carrying their pollen; for of all the insects of the field, the bumblebees are the best and most needed friends of flowers.

The bumblebees are not so thrifty and forehanded as are the honeybees, and do not provide enough honey to sustain the whole colony during the winter. Only the mother bees, or queens as they are called, survive the cold season. Just how they do it we do not know, but probably they are better nourished and therefore have more endurance than the workers. In early May, one of the most delightful of spring visitants is one of these great buzzing queens, flying low over the freshening meadows, trying to find a suitable place for her nest; and the farmer or fruit grower who knows his business is as anxious as she that she find suitable quarters, knowing well that she and her children will render him most efficient aid in growing his fruit and seed. She finally selects some cosy place, very likely a deserted nest of the field mouse, and there begins to build her home. She toils early and late, gathering pollen and nectar from the blossoms of the orchard and other flowers which she mixes into a loaf as large as a bean upon which she lays a few tiny eggs and then covers them with wax. She then makes a honey-pot of wax

A bumblebee

as large as a small thimble and fills it with honey; thus provided with food she broods over her eggs, keeping them warm until they hatch. Each little bee grub then burrows into the beebread, making for itself a cave while satisfying its hunger. When fully grown, it spins about itself a cocoon, changes to a pupa, and then comes out a true bumblebee but smaller than her queen mother. These workers are daughters and are happy in caring for the growing family; they gather pollen and nectar and add to the mass of beebread for the young to burrow in; meanwhile the queen remains at home and devotes her energies



A bumblebee nest in midsummer

to laying eggs. The workers not only care for the young, but later they strengthen the silken pupa cradles with wax, and thus make them into cells for storing honey. When we understand that the cells in the bumblebee's nest are simply made by the young bees burrowing in any direction, we can understand why the bumblebee comb is so disorderly in the arrangement of its cells. Perhaps the boy of the farm would find the rank bumblebee honey less like the ambrosia of the gods if he knew that it was stored in the deserted cradles and swaddling clothes of the bumblebee grubs.

All of the eggs in the bumblebee nest in the spring and early summer develop into workers which do incidentally the vast labor of carrying pollen for thousands of flowers; to these only is granted the privilege of carrying the pollen for the red clover, since the tongues of the other bees are not sufficiently long to reach the nectar. The red clover does not produce seed in sufficient quantity to be a profitable crop unless there are bumblebees to pollinate its blossoms. Late in the summer, queens and drones are developed in the bumblebee nest, the drones, as with the honeybees, being mates for the queens. But of all the numerous population of the bumblebee nest, only the queens survive the rigors of winter, and on them and their success depends the future of the bumblebee species.

There are many species of bumblebees, some much smaller than others, but they all have the thorax covered with plush above and the abdomen hairy, and their fur is usually marked in various patterns of pale yellow and black. The bumblebee, of whatever species, has short but very active antennæ and a mouth fitted for biting as well as for sucking. Between the large compound eyes are three simple eyes. The wings are four in number and strong; the front legs are very short; all the legs have hairs over them and end in a three-jointed foot, tipped by a claw. On the hind leg, the tibia and the first tarsal joint are enlarged, making the pollen baskets on which the pollen is heaped in golden masses. One of the most interesting observations possible to make is to note how the bumblebee brushes the pollen from her fur and packs it into her pollen baskets.

Suggested Reading — *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *First Lessons in Nature Study*, by Edith M. Patch; *Interesting Neighbors*, by Oliver P. Jenkins; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes*; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*, Book 3, *Surprises*; also, readings on page 300.

LESSON 98
The Bumblebee

Leading Thought — The bumblebees are the chief pollen carriers for most of our wild flowers as well as for the clovers and other farm plants. They should, therefore, be kindly treated everywhere; and we should be careful not to hurt the big queen bumblebee, which we see often in May.

Method — Ask the questions and encourage the pupils to answer them as they have opportunity to observe the bumblebees working in the flowers. A bumblebee may be imprisoned in a tumbler for a short period for observation, and then allowed to go unharmed. It is not advisable to study the nest, which is not only a dangerous proceeding for the pupil, but also means the destruction of a colony of these very useful insects. However, if the location of a nest is discovered, it may be dug up and studied after the first heavy frost. Special stress should be laid upon the observations of the actions of the bees when visiting flowers.

Observations — 1. In how many flowers do you find the bumblebee? Watch her closely and see how she gets the nectar. Notice how she " bumbles around " in a flower and becomes dusted with pollen. Watch her and note how she gets the pollen off her fur and packs it in her pollen baskets. On which legs are her pollen baskets? How does the pollen look when packed in them? What does she do with pollen and nectar?

2. Catch a bumblebee in a jelly glass and look at her closely. Can you see three little eyes between the big compound eyes? Describe her antennæ. Are they active? How many pairs of wings has she? Do you think they are strong? Which pair of legs is the shortest? How many segments are there in the leg? Do you see the claws on the foot?

3. What is the bumblebee's covering? What is the color of her plush? Is she furry above and below?

4. Can you see that she can bite as well as suck with her mouth-parts? Will a bumblebee sting a person unless she is first attacked?

5. Have you seen the very large queen bumblebee in the spring, flying near the ground hunting for a place to build a nest? Why must you be very careful not to hurt her? How does she pass the winter? What does she do first, in starting the nest?

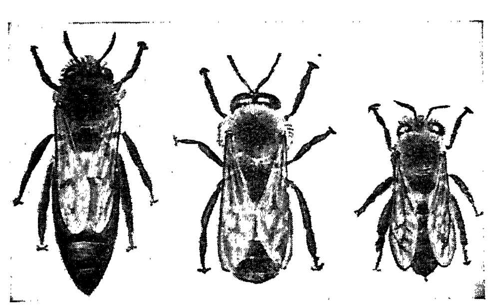
6. In how many ways does the bumblebee benefit us?

THE HONEYBEE

During many years naturalists have been studying the habits and adaptations of the honeybees, and, as yet, the story of their wonderful ways is not half told. Although we know fairly well what the bees do, yet we have no inkling of the processes which lead to a perfect government and management of the bee community; and even the beginner may discover things never known before about these fascinating little workers. In beginning this work it might be well to ask the pupils if they have ever heard of a republic that has many kings and only one queen; and where the citizens do all the governing without voting, and where the kings are powerless and the queen works as hard as and longer than any of her subjects; and then tell them that the pages of history contain no account of a republic so wonderful as this; yet the nearest beehive is the home of just this sort of government.

In addition to the interest of the bee colony from a nature-study standpoint, it is well to get the children interested in beekeeping as a commercial enterprise. A small apiary well managed may bring in an acceptable income; and it should be the source of a regular revenue to the boys and girls of the farm, for one hive should net the young beekeeper from three to five dollars a year and prove a business education to him in the meantime.

Bees are perfect socialists. They have noncompetitive labor, united capital, communal habitations, and unity of interests. The bee commune is composed of castes as immutable as those of the Brahmins, but these castes exist for the benefit of the whole society instead of for the individuals belonging to them. These castes we have named queens, drones, and workers, and perhaps we should first of all



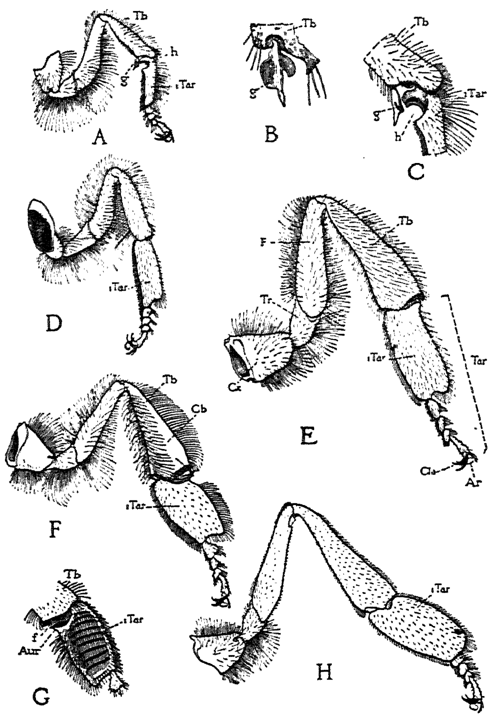
1 2 3

1, *queen bee*. 2, *drone*. 3, *worker*

study the physical adaptations of the members of these castes for their special work in the community.

The Worker

There are three divisions to the body of the bee, as in all insects — head, thorax,



From *Anatomy and Physiology of the Honeybee* by Snodgrass. McGraw-Hill Book Company, Inc.

Legs of the honeybee

A, front leg of worker showing antenna cleaner (g, h); B, spine of antenna cleaner; C, antenna cleaner enlarged; D, middle leg of worker, anterior surface; E, left hind leg of queen, outer surface; F, left hind leg of worker, outer surface, showing pollen basket (Cb); G, first tarsal joint (Tar.), inner surface, of leg of worker, showing pollen comb (transverse rows of spines); H, left hind leg of drone, outer surface

and abdomen. The head bears the eyes, antennæ, and mouth-parts (p. 393, W). There are two large compound eyes on either side of the head and three simple eyes between them. The antennæ arise from the face, each consisting of two parts, one straight segment at the base, and the end portion which is curved and made up of many segments. There is also a short, beadlike segment where the antenna joins the face. A lens is needed to see the jaws of the bee, folded across, much like a pair of hooks, and below them the tongue, which is a sucking tube; the length of the tongue is very important, for upon this depends the ability of the bee to get nectar from the flowers.

The thorax bears three pairs of legs below and two pairs of wings above. Each leg consists of six segments, and the foot or tarsus has four segments and a pair of claws. The front leg has an antenna comb between the tibia and tarsus, A(g,h) and C; the hind leg has a pollen basket, which is a long cavity bordered by hairs wherein the pollen is packed and carried, F(Cb).

On the other side of the large joint beyond the pollen basket are rows of spines which serve to collect pollen grains from other parts of the body, G, and between these two large segments is a cleft through which pollen is forced in loading the baskets. This loading must occur while the bee is on the wing, so that the legs may be free for the peculiar actions by which the loading is brought about.

The front pair of wings is larger than the hind pair. The wings of the old bees that have done much work are always frayed at the edges.

There are six segments or rings to the abdomen, plainly visible from above. If the three to five segments next the thorax are marked above with yellow bands on their front edges, the bee is an Italian. On the lower side of the abdomen, four of the segments are composed of a central part with an overlapping plate on each side. These flaps cover the eight areas through which wax is secreted; but without dissection this cannot be seen, except when the wax plates are abnormally large, in which event they may protrude and be visible. The flecks of wax there formed are used by the bees to build their combs.

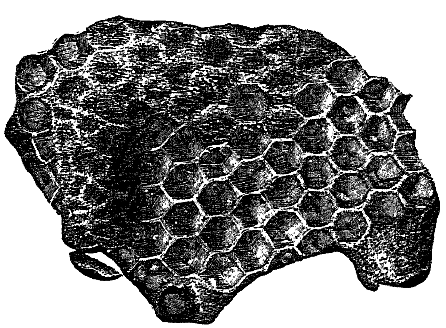
The Queen

The queen bee is a truly royal insect. She is much larger than the worker, her body being long and pointed, and extending far beyond the tips of her closed wings, giving her a graceful form. She has no pollen baskets or pollen comb upon her legs, because it is not a part of her work to gather pollen or honey. The queen bee starts life as an ordinary worker egg, which is selected for special development. The workers tear down the partitions of the cells around the chosen egg and build a projection over the top, making an apartment. The little white bee grub, as soon as it hatches, is fed for five days on the same food that is given to the worker grubs in the earliest part of their feeding period; it is a special substance, secreted by the worker bees, called royal jelly. This food is very nourishing, and after being reared upon it, the princess larva weaves around herself a silken cocoon and changes to a pupa. Meanwhile the workers have sealed her cell with wax.

When the princess pupa changes to the full-grown queen she cuts a circular door in the cover of the cell and pushes through it into the world. Her first real work is to hunt for other queen cells, and if she finds one she will, if not hindered, make a hole in its side and destroy the poor princess within. If she finds another full-grown queen, the two fight until one succumbs. The queen rarely uses her sting upon anything or anyone except a rival queen.

After a few days she takes her marriage flight in the air, where she mates with some drone, and then returns to her hive and begins her great work as mother of the colony. She runs about on the comb, pokes her head into a cell to see if it is ready, then turning about thrusts her abdomen in and neatly glues an egg fast to the bottom.

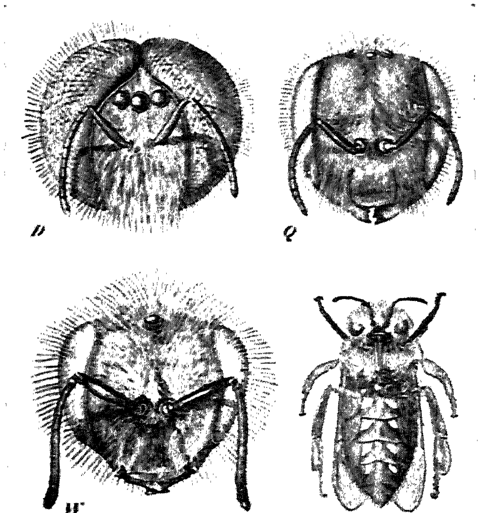
When the honey season is at its height she works with great rapidity, sometimes laying at the rate of six eggs a minute, often producing two thousand eggs during a day, which would equal in weight her own body. If the workers do not allow her to destroy the other developing queens, she departs from the hive with a major portion of the worker bees in what is known as a swarm, seeking a home elsewhere.



Comb of the honeybee. The beginnings of two queen cells are represented on the lower edge of the comb, and a completed queen cell extends over the face of the comb near the left side. From the lower end of it hangs a lid which was cut away by the workers to allow the queen to emerge

The Drone

The drone differs much from the queen and the worker. He is broad and blunt, being very different in shape from the queen, and larger than the worker (p. 391, Fig. 2). He has no pollen baskets on his legs and has no sting. His eyes are very much larger than those of the queen or the worker and unite at the top of the head (D, below). His wings are larger and stronger than those of the worker or



A. J. Hammar

D, head of drone. Q, head of queen bee. W, head of worker. X, worker bee seen from underneath, showing plates of wax secreted from the wax pockets queen. It is not his business to go out and gather honey or to help in the work of the hive. His tongue is not long enough to get honey from the flowers; he has no pollen basket in which to carry pollen; he has no sting to fight enemies and no pockets for secreting wax; he is fed by his sister workers until the latter part of the season when the honey supply runs low, and then he is driven from the hive to die of starvation. The drone should be called a prince or king, since his particular office in the hive is to mate with the queen.

Suggested Reading — *The Bee People*, by Margaret W. Morley; *The Busy Little Honeybee*, by Josephine M. True; *The Children's Life of the Bee*, by Maurice Maeterlinck; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *Honeybees and Fairy Dust*, by Mary G. Phillips; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes; Our Insect Friends and Foes and Spiders*, published by the National Geographic Society; also, readings on page 300.

LESSON 99

The Honeybee

Leading Thought — In a colony of honeybees there are three different forms of bees, the queens, the drones, and the workers. All of these have their own special work to do for the community.

Method — In almost every country or village community there is an apiary, or at least someone who keeps a few colonies of bees; to such the teacher may turn for material for this lesson. If this is not practical the teacher may purchase specimens from any bee dealer; she may, for instance, get an untested queen with attendant workers in a queen cage sent by mail for a small sum. These could be kept alive for some time by feeding them with honey, during which time the pupils can study the forms of the two castes. Any apiary during September will give enough dead drones for a class to observe. Although ordinarily we do not advocate the study of dead specimens, yet common sense surely has its place in nature-study; and in the case of the honeybee, a closer study of the form of the insect than the living bee might see fit to permit is desirable. There are no more wonderful instances of adaptation of form to life than is found in the anatomy of the workers, queens, and drones; moreover, it is highly desirable, if the pupils are ever to become beekeepers, that they know these adaptations.

A lens is almost necessary for these lessons and a compound microscope used with a low power would be a very desirable adjunct. This lesson should not be given below the fifth grade; and it is better adapted to eighth-grade work.

The Worker

Observations — 1. How many divisions of the body are there?

2. What organs are borne on the head?

3. Are there small, simple eyes between the large compound ones?

4. What is the difference between the large eyes and the small?

5. Describe the antennæ.

6. What can you see of the mouth? Describe it.

7. Look at the tongue under the microscope and see how it is fitted for getting nectar from flowers.

8. What organs are borne on the thorax?

9. Study the front or middle leg. How many joints has it?

10. With a lens find the antennæ-cleaner on the front leg. Describe it.

11. Describe the feet and claws.

12. Compare the third segment of the hind leg with that of the front leg.

13. Note that this segment of the hind leg is much wider. Note its form and describe how it forms the pollen basket.

14. Note the cleft through which the pollen is forced in loading the pollen baskets and the pollen combs just below it.

15. Compare the front and hind wing as to shape and size.

16. How many rings are there on the abdomen and how are the rings colored above?

17. Study the lower side of the body: do you know where the wax comes from?

18. Write an account of the development of the larva of the worker bee; the duties of a worker bee from the time it issues from its cocoon until it dies working for the colony.

The Queen Bee

1. How does the queen differ in size and shape from the worker?

2. Has she pollen baskets or pollen combs on her hind legs?

3. How does the shape of the abdomen differ from that of the worker?

4. Write a story of the life of a queen bee. This should cover the following points: The kind of cell in which the queen is developed; the kind of food on which she is reared; the fact that she rarely stings people, but reserves her sting for other queens; why she does not go out to gather honey; how and by whom and on what she is fed; she would not use pollen baskets if she had them; the work she does for the colony; the length of her life compared with that of a worker; the time of year when new queens are developed, and what becomes of the old queen when a new one takes her place; why she is called a queen.

The Drone

1. How does the drone differ in size and form of body from the worker?

2. How does he differ in these respects from the queen?

3. Has he pollen baskets on his legs?

4. Has he a sting?

5. Compare his eyes with those of the queen and the worker.

6. Compare the size of his wings with those of the queen and the worker.

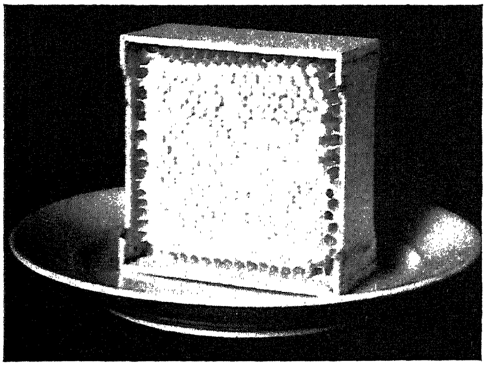
7. Write a composition on the drone. This should cover the following points: In what sort of cell the drone is developed; whether he goes out to gather honey or help in the work of the hive; how he is fed; how he is unfitted for work for the colony in the following particulars: tongue, lack of pollen baskets, lack of sting, and of wax pockets; why the drone should be called a prince or king; the death of the drones; when and by what means it occurs.

HONEYCOMB

The structure of honeycomb has been for ages admired by mathematicians, who have measured the angles of the cells and demonstrated the accurate manner in which the rhomb-shaped cell changes at its base to a three-faced pyramid; and have proved that, considering the material of construction, honeycomb exemplifies the strongest and most economic structure possible for the storing of liquid contents. While recent instruments of greater precision in measuring angles show less perfection in honeycomb than the ancients believed, yet the fact still stands that the general plan of it is mathematically excellent.

Some have tried to detract from bee skill, by stating that the six-sided cell is simply the result of crowding cells together. Perhaps this was the remote origin of the hexagonal cell; but if we watch a bee build her comb, we find that she begins with a base laid out in triangular pyramids, on either side of which she builds out six-sided cells. A cell just begun, is as distinctly six-sided as when completed.

The cell of a honeycomb is six-sided in cross section. The bottom is a three-sided pyramid and its sides help form pyramids at the bottom of the cells opposite, thus economizing every particle of space. In the hive, the cells usually lie horizontal, although sometimes the combs are twisted. The honey is retained in the cell by a cap of wax which is made in a very cunning fashion; it consists of a circular disc at the middle supported from the six angles of the cell by six tiny girders. The comb is made fast to the section of the hive by being plastered upon it. The comb foundation sold to apiarists is quite thick, so that the edges of the cell may be drawn out and almost complete the sides of the cell. This comb foundation is beautifully constructed in imitation of the base of the normal cells, and sometimes has some surplus wax in it which can be used to draw out the first part of the sides of the cell. In order to make a fine section of comb honey, the apiarist uses a full sheet of this material, which guides the bees in the direction of their comb and gives uniform cells throughout. The cells of honeycomb are used also for the storing of beebread and also as cradles for the young bees.



A section of honey. Each cell is capped and supported by six girders

LESSON 100

The Honeycomb

Leading Thought — The cells of honeycomb are six-sided and in double rows and are very perfectly arranged for the storing of honey, so as to save room.

Materials — A section filled with honey and also a bit of empty comb and a bit of commercial comb foundation which may be obtained in any apiary.

Observations — 1. Look at a bit of empty honeycomb; what is the shape of the cell as you look down into it?

2. What is the shape of the bottom of the cell?

3. How does the bottom of the cell join the bottom of the cell opposite? Explain how honeycomb economizes space as storage for honey, and why an economy of space is of use to bees in the wild state.

4. In the hive is the honeycomb placed so that the length of the cells is horizontal or up and down?

5. Observe honeycomb containing honey; how is the honey retained in the cells?

6. Carefully take off a cap from the honey cell and see if you can find the six girders that extend inward from the angles of the cell to support the circular portion in the center.

7. By what means is the honeycomb made fast to the sides of the section or the hive?

8. Study a bit of comb foundation and note where the bees will pull out the wax to form the cell.

9. Why and how is comb foundation used by the bee-keeper?

10. For what purpose besides storing honey are the cells of honeycomb used by the bees?

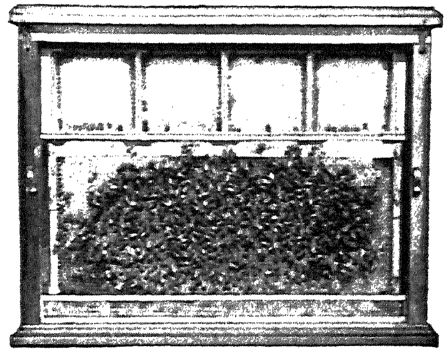
INDUSTRIES OF THE HIVE AND THE OBSERVATION HIVE

Beehives are the houses which man furnishes for the bee colonies, the wild bees ordinarily living in hollow trees or in caves. The usual hive consists of a box which is the lower story and of one or more upper stories, called "supers." In the lower story are placed frames for the brood and for storing the honey for the winter use of the bees. In the supers are placed either large frames containing comb for the storage of honey which is to be thrown out and sold as liquid honey by means of a honey extractor, or smaller sections which contain about one pound of honey and which are sold as made by the bees. It is the habit of the bees to place their brood in the lower part of their nests and store honey in the upper portions. The bee-keepers have taken advantage of this habit of the bees and remove the supers with their filled combs and replace them with others to be filled, and thus get a large crop of honey. The number of bees in a colony varies; there should be at least forty thousand in a healthy colony. Of these a large proportion are workers; there may be a few hundred drones the latter part of the season, but only one queen.

Honeycomb is built of wax and is hung from the frame so that the cells are horizontal; its purpose is to cradle the young and for the storage of pollen and honey. The wax used for building the comb is a secretion of the bees; when comb is needed, a number of self-elected bee citizens gorge themselves with honey and hang themselves up in a curtain, each bee reaching up with her fore feet and taking hold of the hind feet of the one above her. After remaining thus for some time the wax appears in little plates, one on each side of the second, third, fourth, and fifth segments of the abdomen. This wax is chewed by the bees and made into comb.

Honey is made from the nectar of flowers which the bee takes into her honey stomach. This, by the way, is not the true stomach of the bee and has nothing to do with digestion. It is simply a receptacle for storing the nectar, which is mixed with some secretion from the glands of the bee that brings about chemical changes, the chief of which is changing the cane sugar of the nectar into the more easily digested grape sugar and fruit sugar of the honey. After the honey is emptied from the honey stomach into the cell, it remains exposed to the air for some time before the cell is capped, and thus ripens. It is an interesting fact that up to the seventeenth century honey was the only means people had for sweetening their food, as sugar was unknown.

Beebread is made from the pollen of flowers which is mixed with nectar or honey so as to hold it together; it is carried from the field on the pollen baskets of the hind legs of the workers; it is packed into the cell by the bees and is used for food for the developing brood. Propolis is bee glue; it is used as a cement and varnish; it is gathered by the bees from the leaf



A. I. Root Co.

An observation hive

buds of certain trees and plants, although when they can get it, the bees will take fresh varnish. It is used as a filler to make smooth the rough places of the hive; it often helps hold the combs in place; it calks every crack; it is applied as a varnish to the cells of the honeycomb if they remain unused for a time, and if the door of the observation hive be left open, the bees will cover the inside of the glass with this glue, and thus make the interior of the hive dark.

The young bees are footless, white grubs. Each one lives in its own little cell and is fed by the nurse bees, which give it food already largely digested; this food the nurse bees secrete from glands in their heads.

The removal of honey from the supers does not do any harm to the bee colony if there is enough honey left in the brood chambers to support the bees during the winter. There should be forty pounds of honey left in the brood chamber for winter use. In winter, the hives should be protected from the cold by being placed in special houses or by being encased in larger boxes, an opening being left so that the bees may come out in good weather. The chaff hive is best for both winter and summer, as it surrounds the hive with a space which is filled with chaff, and keeps the hive warm in winter and cool in summer. Many beekeepers put their bees in cellars during the winter, but this method is not as safe as the packed hive. Care should be taken in summer to place the hives so that they are shaded at least part of the day. The grass should be mown around the hives so that the bees will not become entangled in it as they return from the fields laden with honey.

What may be seen in the observation hive — First of all, it is very interesting to watch the bees build their comb. When more comb is needed, certain members of the colony gorge themselves with honey and remain suspended while it oozes out of the wax pockets on the lower side of the abdomen. This wax is collected and chewed to make it less brittle and then is carried to the place where the comb is being built and is molded into shape by the jaws of the workers. However, the bee that puts the wax in place is not always the one that molds it into comb.

A bee comes into the hive with her honey stomach filled with nectar and disgorges this into a cell. When a bee comes in loaded with pollen, she first brushes it from the pollen baskets on her hind legs into the cell; later another worker comes along and packs the pollen grains into the cell.

The bee nurses run about on the comb feeding the young bee grubs partially digested honey and pollen. Whenever the queen moves about the comb she is followed by a retinue of devoted attendants which feed her on the rich and perfectly digested royal jelly and also take care of her royal person and give her every attention possible. The queen, when laying, thrusts her abdomen into the cell and glues a little white egg to the bottom. The specially interesting thing about this is that the queen always lays an egg which will produce a female or worker in the smaller cells, and will always lay an egg to produce a drone or male in the larger cells.

If there is any foreign substance in the observation hive, it is interesting to see the bees go to work at once to remove it. They dump all of the debris out in front of the hive. They close all crevices in the hive; and they will always curtain the glass, if the door is kept open too much, with propolis or bee glue, the sticky substance which they get from leaf buds and other vegetable sources. When bees fan to set up a current of air in the hive, they glide back and forth, moving the wings so rapidly that we can only see a blur about their bodies.

If drones are developed in the hive, it is interesting to see how tenderly they are fed by their sister workers, although they do not hesitate to help themselves to the honey stored in the cells; and if the observation hive is working during September, undoubtedly the pupils may be able to see the murder of the drones by their sisters. But the children should understand that this killing of the drones is necessary for the preservation of the colony, as the workers could not store enough honey to keep the colony alive during the winter if the drones were allowed to go on feeding.

If you see the worker bees fighting, it means that robbers are attempting to get at the stores of the observation hive. The entrance to the hive should at once be contracted by placing a block of wood in front, so that there is room for only one bee at a time to pass in and out.

LESSON 101

The Industries of the Hive

Leading Thought — In the hive are carried on the industries of wax-making, building of honeycomb, storing of honey and beebread, caring for the young, keeping the hive clean and ventilated, and calking all crevices with bee glue.

Method — This lesson should be in the nature of a demonstration. If there is an apiary in the neighborhood, it is quite possible that the teacher may show the pupils a hive ready for occupancy by the bees; in any case she will have no difficulty in borrowing a frame of brood comb, and this with a section of honey, which can be bought at the grocery, is sufficient if there is no observation hive. This lesson may be an informal talk between teacher and pupils.

An observation hive in the schoolroom is an object of greatest interest to the pupils, as through its glass sides they may be able to verify for themselves the wonderful tales concerning the lives and doings of the bees which have been told us by naturalists. Moreover, the study thus made of the habits of the bees is an excellent preparation for the practical apiarist, and we sincerely believe that bee-keeping is one of the ways by which the boys and girls of the farm may obtain money for their own use.

The observation hive is very simply constructed and can be made by anyone who knows how to use ordinary carpenter tools. It is simply a small, ordinary hive with a pane of glass on each side which is covered by a hinged door. A hive thus made is placed so that the front end rests upon a window-sill; the sash is lifted an inch or so, a strip of wood or a piece of wire netting being inserted underneath the sash except in front of the entrance of the hive, to hinder the bees from coming back into the room. A covered passageway should extend from the entrance of the hive to the outside of the window-sill. This window should be one which opens away from the playground so that the bees coming and going will not come into collision with the pupils. The observation window should be kept carefully shut, except when the pupils are using it, since the bees object to light in their homes.

Listed in the Source of Materials at the back of this book is an observation hive which we have used by stocking it afresh each season, it being too small for a self-sustaining colony. But it has the advantage of smallness which enables us to see all that is going on within it, which would be impossible in a larger hive. This hive comes in several sizes, and will be shipped from the makers stocked with bees.

Observations — *Industries and Care of the Hive* — 1. What is the hive, and what do wild bees use instead of the hive? Describe as follows:

2. A brood chamber and a super and the uses of each.

3. How many and what bees live in a hive.

Verne Morton

A hornets' nest. The entrance, near the bottom, may be seen

4. How the honeycomb is made and placed and the purpose of it.

5. How the wax is produced and built into the comb.

6. How honey is made.

7. What beebread is and its uses.

8. What propolis is and what it is used for.

9. How young bees look and how they are cradled and fed.

10. Does the removal of the honey from the supers in the fall do any harm to the bee colony?

11. How much honey should a good-sized colony have in the fall to winter well?

12. How should the hives be protected in the winter and summer?

What may be seen in the observation hive — 13. Describe how a bee works when building honeycomb.

14. How does the bee act when storing honey in a cell?

15. How does a bee place pollen in a cell and pack it into beebread?

16. Describe how the nurse bees feed

the young, and how the young look when eating.

17. Describe how the "ladies in waiting" feed and care for the queen.

18. Try to observe the queen when she is laying eggs and describe her actions.

19. How do the bee workers keep their house clean?

20. How do they stop all crevices in the hive? If you keep the hive uncovered too long, how will they curtain the window?

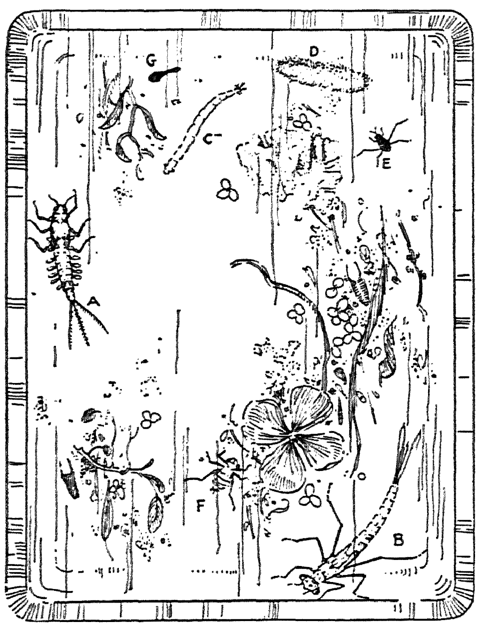
21. Describe the actions of the bees when they are ventilating the hive.

22. If there are any drones in the hive, describe how they are fed.

23. How can you tell queens, drones, and workers apart?

INSECTS OF THE BROOK AND POND

The insects considered on pages 400 to 415 spend a part or all of their lives in brooks and ponds. These insects may be easily studied in the schoolroom, if an aquarium is available. The aquarium may be quite simple, or it may be a more elaborate one. See Fig. page 5.



From *Elementary Lessons on Insects*, Needham

A tray of water with floating algae, weeds, etc., dipped from a pond

A, a may-fly nymph. B, a damsel-fly nymph. C, a midge larva. D, the flocculent dwelling tube of a smaller midge larva. E, a water strider. F, a small dragonfly nymph. G, a tadpole

SUGGESTED READING—*Along the Brook*, by Raymond T. Fuller; *Field Book of Ponds and Streams*, by Ann H. Morgan; *Life of Inland Waters*, by James G. Needham and J. T. Lloyd; *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 300.

LESSON 102

How to Make an Aquarium

The schoolroom aquarium may be a very simple affair and still be effective. Almost any glass receptacle will do, glass being chosen because of its transparency, so that the life within may be observed. Tumblers, jelly tumblers, fruit jars, butter jars, candy jars, and battery jars are all available for aquaria. The tumblers are especially recommended for observing the habits of aquatic insects.

To Make an Aquarium: 1. Place in the jar a layer of sand an inch or more in depth.

2. In this sand plant the water plants which you find growing under water in a pond or stream; the plants most available are waterweed, bladderwort, water starwort, water cress, stoneworts, frog spittle, or water silk.

3. Place on top a layer of small stones or gravel; this is to hold the plants in place.

4. Tip the jar a little and pour in very gently at one side water taken from a pond or stream. Fill the jar to within two or three inches of the top; if it be a jelly tumbler, fill to within an inch of the top.

5. Let it settle.

6. Place it in a window which does not get too direct sunlight. A north window is the best place; if there is no north window in the schoolroom, place it far enough at one side of some other window so that it will not receive too much sunlight.

7. To get living creatures for the aquarium use a dip net, which is made like a shallow insect net.

8. Dip deep into the edges of the pond and be sure to bring up some of the leaves and mud, for it is in these that the little water animals live.

9. As fast as dipped up, these should be placed in a pail of water, so that they may be carried to the schoolroom.

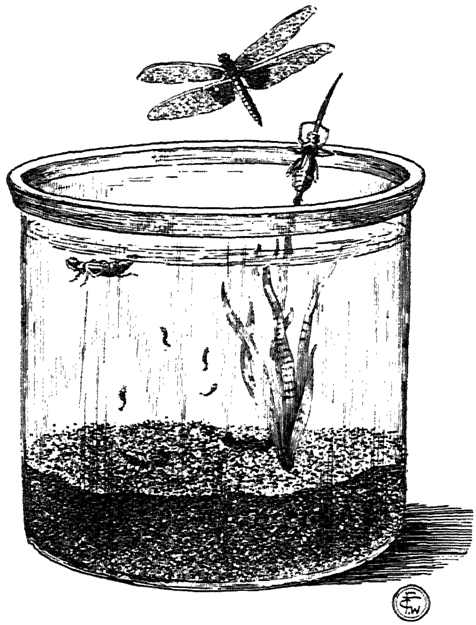
10. After the material has been brought into the schoolroom, it should be poured out into a shallow pan so that it can be sorted into other containers for further study. A little experience will soon show what kinds of creatures are likely to eat others in an aquarium. By putting similar ones together in one container, it will be quite possible to distribute them in such a manner that there will not be many fatalities. It is well to put only a few creatures in each container.

The Care of the Aquarium — Care should be taken to preserve the plant life in the aquarium, as the plants are necessary to the life of the animals. They not only supply the food, but they give off the oxygen which the animals need for breathing, and they also take up from the water the poisonous carbonic acid gas given off from the bodies of the animals.

1. The aquarium should be kept where there is a free circulation of air.

2. If necessary to cover the aquarium to prevent the insects, like the water boatmen and water beetles, from escaping, tie over it a bit of mosquito netting, or lay upon the top a little square of the wire netting used for window screens.

3. The temperature should be kept rather cool; it is better that the water of the aquarium should not be warmer than 50 degrees Fahrenheit, but this is not always possible in the schoolroom.



An inexpensive and durable aquarium

4. If any insects or animals die in the aquarium, they should be removed at once, as the decomposing bodies render the water foul.

5. To feed the animals that live upon other animals, take a bit of raw beef, tie a string to it and drop it in, leaving the free end of the string outside of the jar. After it has been in one day, pull it out; for if it remains longer it will make the water foul.

6. As the water evaporates it should be replaced with water from the pond.

Suggested Reading — *An Aquarium Book for Boys and Girls*, by Alfred P. Morgan; *The Complete Aquarium Book*, by William T. Innes.

THE DRAGONFLIES AND DAMSEL FLIES

A pond without dragonflies darting above it, or without the exquisitely iridescent damsel flies clinging to the leaves of its border would be a lonely place indeed. As one watches these beautiful insects, one wonders at the absurd errors which have crept into popular credence about them. Who could be so silly as to believe that they could sew up ears or that they could bring dead snakes to life! The queer names of these insects illustrate the prejudices of the ignorant — devil's-darning-needles, snake doctors, snake feeders, etc. Despite all this slander, the dragonflies re-

AQUATIC INSECTS

1. Stone Fly, Plecoptera. *Left, adult; right, nymph. The adults are most commonly seen in numbers about street lights. The nymphs swim or crawl; they are found on the underside of rocks in swiftly-flowing permanent streams.*

2. May Fly, Ephemerida. *Left, nymph; right, adult. At most, the adults live only one or two days. The nymphs live in all sorts of aquatic situations.*

3. Back Swimmer, Notonecta. *The back of this insect is shaped like the bottom of a boat, so that by using the hind legs for oars it swims on its back with great ease.*

4. Water Boatman, Corixa. *Although this insect swims, it spends much of the time anchored on the bottom of the stream or pond. Even during the winter months the water boatman is active beneath the ice.*

5. Water Walking Stick, Ranatra. *A long breathing-tube is to be found at the end of this insect's abdomen; by means of this tube, the insect can rest at the bottom of a very shallow pond and still breathe by projecting the tube to the surface of the water.*

6. Water Scorpion, Nepa. *This insect looks quite lifeless as it waits quietly in the trash of a shallow pond for its prey. With its sharp sucking beak and its strong front legs it attacks many aquatic animals which are larger than itself.*

7. Water Bug, Belostoma. *After the female has glued her numerous eggs to the back of the male, he very obligingly stays near the surface of the water and elevates the eggs into the air where they hatch.*

8. Giant Water Bug or Electric-Light Bug, Benacus. *The striped eggs of this insect are large and are laid in clusters on some piece of vegetation which projects from water.*

9. Water Strider, Gerris. *These predacious insects move at a rapid but somewhat uncertain rate over the surface of more quiet waters.*

10. Dobson, Corydalis. *Larva at left; female adult in center; head of male at right. The larvæ, known as hellgrammites, are found under stones in the beds of swiftly-flowing streams.*

11. Predacious Diving Beetle, Dytiscus. *Larva at left; adult at right. The larvæ seize aquatic creatures much larger than themselves and suck the softer portions from their bodies. The brownish-black adults are seen in quiet water.*

12. Diving Beetle, Acilius. *Larva at left; adult at right. It is a common sight to see the slender larvæ hanging head down with their air-breathing "tails" projecting into the air through the upper surface of the water.*

13. Water Scavenger Beetle, Hydrophilus. *Larva at left; adult at right. In quiet pools, these black beetles may be found swimming through the water or hanging head up at the surface.*

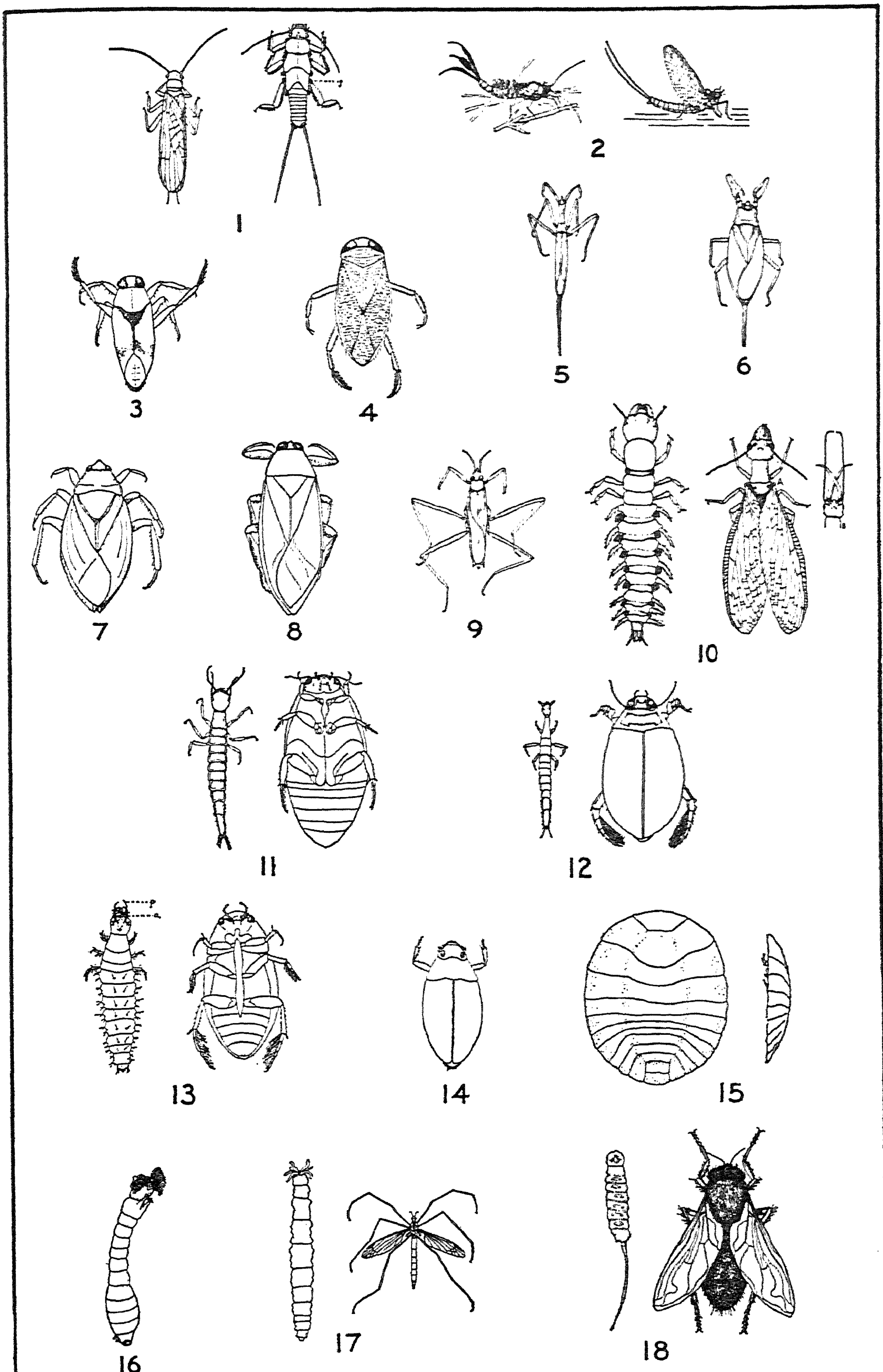
14. Whirligig Beetle, Gyrinus. *One may see companies of these bluish-black, flattened beetles whirling about over the surface of brooks or ponds. Their eyes are divided in such a manner as to appear as four eyes — two looking into the water and two looking into the air.*

15. Water Penny or Riffle Beetle, Psephenus. *Larva, left, shows back view; right shows side view. During any season these larvæ can be found clinging tightly to the lower surface of stones in rapid streams. In general appearance they resemble a crustacean more than an insect.*

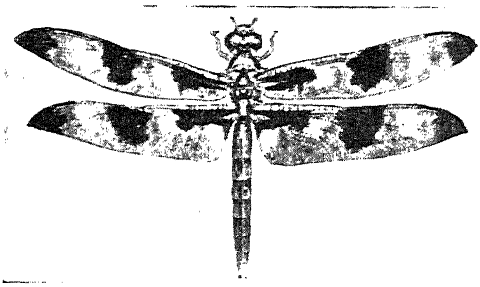
16. Black Fly, Simulium. *The larvæ are aquatic and are able to maintain their position in rapid water by means of a sucking disk at the tail end of the body. Great numbers of these larvæ form the so-called "black moss" which is so evident in some streams in early summer.*

17. Crane Fly, Tipula. *Larva at left; adult at right. Great variations as to habits and habitats exist among the larvæ of the various kinds of crane flies; some are aquatic, some live on plants, and still others live in soil.*

18. Drone Fly, Eristalis. *Left, larva, often called the rat-tailed maggot; right, adult. The drone fly resembles so closely a male honey bee that as it hovers about flowers it is often mistaken for a drone bee. The larva, or rat-tailed maggot, lives about decaying plant and animal material in foul water. The tail-like appendage at the rear end of the body is a breathing-tube.*



From *Common Water Insects*, by Ann Morgan



From *Outdoor Studies*, Needham

The ten-spot, a common dragonfly

main not only entirely harmless to man, but in reality his friends and allies in waging war against flies and mosquitoes; they are especially valuable in battling mosquitoes since the nymphs, or young, of the dragonfly take the wrigglers in the water, and the adults, on swiftest wings, take the mosquitoes that are hovering over ponds laying their eggs.

The poets have been lavish in their attention to these interesting insects and have paid them delightful tributes. Riley says:

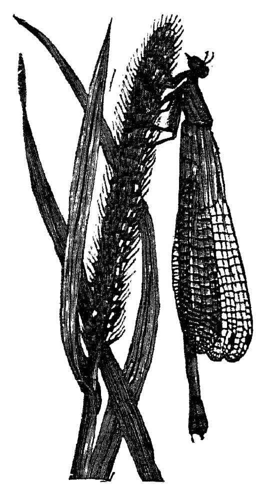
Till the dragon fly, in light gauzy armor
burnished bright,
Came tilting down the waters in a wild,
bewildered flight.

Tennyson drew inspiration for one of his most beautiful poems from the two stages of dragonfly life. But perhaps Lowell in that exquisite poem, *The Fountain of Youth*, gives us the perfect description of these insects:

In summer-noon flushes
When all the wood hushes,
Blue dragon-flies knitting
To and fro in the sun,
With sidelong jerk flitting,
Sink down on the rushes.
And, motionless sitting,
Hear it bubble and run,
Hear its low inward singing
With level wings swinging
On green tasselled rushes,
To dream in the sun.

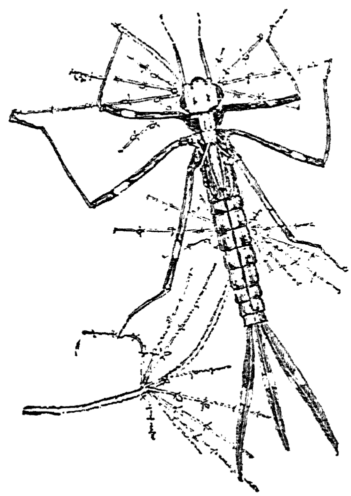
It is while we, ourselves, are dreaming in the sun by the margin of some pond, that these swift children of the air seem but a natural part of the dream. Yet if we waken to note them more closely, we find many things very real to interest us. First, they are truly children of the sun, and if some cloud throws its shadow on the waters for some moments, the dragonflies disappear as if they wore the invisible cloak of the fairy tale. Only a few of the common species fly alike in shade and sunshine, and early and late. The best known of these is the big, green skimmer which does not care so much for ponds, but darts over fields and even dashes into our houses now and then. Probably it is this species which has started all of the dragonfly slander, for it is full of curiosity, and will hold itself on wings whirring too rapidly to make even a blur, while it examines our faces or inspects the pictures or furniture or other objects which attract it.

Another thing we may note when dreaming by the pond is that the larger species of dragonflies keep to the higher regions above the water, while the smaller species and the damsel flies flit near its surface. Well may the smaller species keep



A damsel fly

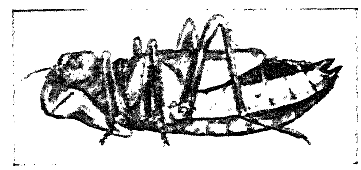
below their fierce kindred; otherwise they would surely be utilized to sate their hunger, for these insects are well named dragons, and dragons do not stop to inquire whether their victims are relatives or not. It is when they are resting that the dragonflies and damsel flies reveal their most noticeable differences. The dragonfly extends both wings as if in flight while it basks in the sun or rests in the shadow. There is a big, white-bodied species called the whitetail which slants its wings forward and down when it rests; but the damsel flies fold their wings together over the back when resting. The damsel flies



Nymph of a damsel fly on an aquatic plant

have more brilliantly colored bodies than do the dragonflies, many of them being iridescent green or coppery; they are more slender and delicate in form. The damsel fly has eyes which are so placed on the sides of the head as to make it look like a cross on the front of the body fastened to the slender neck, and with an eye at the tip of each arm. There are very many species of dragonflies and damsel flies, but they all have the same general habits.

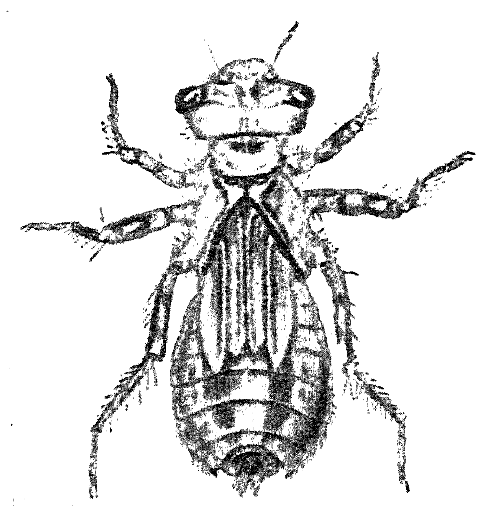
The dragonfly nymphs are the ogres of the pond or stream. To anyone unused to them and their ways in the aquarium, there is a surprise in store, so ferocious are they in their attacks upon creatures twice their size. The dragonfly's eggs are laid in the water; in some instances they are simply dropped and sink to the bottom; but in the case of damsel flies, the mother punctures the stems of aquatic plants and places the eggs within them. The nymph in no wise resembles the parent dragonfly. It is a dingy little creature, with six



From *Outdoor Studies*, Needham

Nymph of a dragonfly, showing the position of the large lower lip folded beneath the head

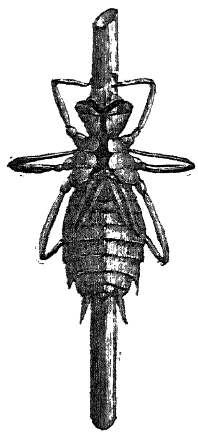
queer, spider-like legs and no wings, although there are four little wing pads extending down its back, which encase the growing wings. It may remain hidden in the rubbish at the bottom of the pond or may cling to water weeds at the sides, for different species have different habits. But in them all we find a most amazing lower lip. This is so large that it covers the lower part of the face like a mask, and when folded back it reaches down between the front legs. It is in reality a grappling organ with hooks and spines for holding prey; it is hinged in such a manner that it can be thrust out far beyond the head to seize some insect, unsuspecting of danger. These nymphs move so slowly and look so much like their background, that they are



From *Outdoor Studies*, Needham

The same dragonfly nymph seen from above always practically in ambush awaiting their victims.

The breathing of the dragonfly nymphs is peculiar; there is an enlargement of the rear end of the alimentary canal, in the walls of which tracheæ or breathing-tubes extend in all directions. The nymph draws water into this cavity and then expels it, thus bathing the tracheæ with the air mixed with water and purifying the air within them. Expelling the water so forcibly propels the nymph ahead, so this act



The cast skin of a dragonfly nymph. The skin splits along the back and the adult emerges, leaving the empty skin attached to the object upon which the transformation took place

serves as a method of swimming as well as of breathing. Damsel fly nymphs, on the other hand, have at the rear end of the body three long, platelike gills, each ramified with tracheæ.

Nymphs grow by shedding the skin as fast as it becomes too small; and when finally ready to emerge, they crawl up on some object out of the water and molt for the last time, and are thereafter swift creatures of the air.

Suggested Reading — *Do You Know?* by Janet Smalley; *First Lessons in Nature Study*, by Edith M. Patch; *Holiday Pond*, by Edith M. Patch; *Insect People*, by Eleanor King and Wellmer Pessels; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 3, *Surprises;* also, readings on pages 300 and 400.

LESSON 103

The Dragonflies and Damsel Flies

Leading Thought — The dragonflies are among the swiftest of all winged creatures and their rapid, darting flight enables them to hawk their prey, which consists of other flying insects. Their first stages are passed in the bottoms of ponds where they feed voraciously on aquatic creatures. The dragonflies are beneficial to us because, when very young and when full grown, they feed largely upon mosquitoes.

Method — The work of observing the habits of adult dragonflies should be largely done in the field during late summer and early autumn. The points for observation should be given the pupils for summer vacation use, and the results placed in the field notebook.

The nymphs may be studied in the spring, when getting material for the aquarium. April and May are good months for securing them. They are collected by using a dip net, and are found in the bottoms of reedy ponds or along the edges of slow-flowing streams. These nymphs are so voracious that they cannot be trusted in the aquarium with other insects; each must be kept by itself. They may be fed by placing other water insects in the aquarium with them or by giving them pieces of fresh meat. In the latter case, tie the meat to a thread so that it may be removed after a few hours, if not eaten, since it soon renders the water foul.

The dragonfly aquarium should have sand at the bottom and some water weeds planted in it, and there should be some object in it which extends above the surface of the water which the nymphs, when ready to change to adults, can climb upon while they are shedding the last nymphal skin and spreading their new wings.

Observations on the Young of Dragonflies and Damsel Flies — 1. Where did you find these insects? Were they at the bottom of the pond or along the edges among the water weeds?

2. Are there any plumelike gills at the

end of the body? If so, how many? Are these platelike gills used for swimming? If there are three of these, which is the longer? Do you know whether the nymphs with these long gills develop into dragonflies or into damsel flies?

3. If there are no plumelike gills at the end of the body, how do the insects move? Can they swim? What is the general color of the body? Explain how this color protects them from observation. What enemies does it protect them from?

4. Are the eyes large? Can you see the little wing pads on the back in which the wings are developing? Are the antennæ long?

5. Observe how the nymphs of both dragonflies and damsel flies seize their prey. Describe the great lower lip when extended for prey. How does it look when folded up?

6. Can you see how a nymph without the plumelike gills breathes? Notice if the water is drawn into the rear end of the body and then expelled. Does this process help the insect in swimming?

7. When the dragonfly or damsel fly nymph has reached its full growth, where does it go to change to the winged form? How does this change take place? Look on the rushes and reeds along the pond margin, and see if you can find the empty nymph skins from which the adults emerged. Where is the opening in them?

Observations on the Adult Dragonflies — 1. Catch a dragonfly, place it under a tumbler, and see how it is fitted for life in the air. Which is the widest part of its body? Note the size of the eyes compared with the remainder of the head. Do they almost meet at the top of the head? How far do they extend down the sides of the head? Why does the dragonfly need such large eyes? Why does a creature with such eyes not need long antennæ? Can you see the dragonfly's antennæ? Look with a lens at the little, swollen triangle between the place where the two eyes join and the forehead; can you see the little, simple eyes? Can you see the mouth-parts?

2. Next to the head, which is the widest and strongest part of the body? Why does the thorax need to be so big and strong? Study the wings. How do the hind wings differ in shape from the front wings? How is the thin membrane of the wings made strong? Are the wings spotted or colored? If so, how? Can you see if the wings are folded along the front edges? Does this give strength to the part of the wing which cuts the air? Take a piece of writing paper and see how easily it bends; fold it two or three times like a fan and note how much stiffer it is. Is it this principle which strengthens the dragonfly's wings? Why do these wings need to be strong?

3. Is the dragonfly's abdomen as wide as the front part of the body? What help is it to the insect when flying to have such a long abdomen?

Outline for Field Notes — Go to a pond or sluggish stream when the sun is shining, preferably at midday, and note as far as possible the following things:

1. Do you see dragonflies darting over the pond? Describe their flight. They are hunting flies and mosquitoes and other insects on the wing; note how they do it. If the sky becomes cloudy, can you see the dragonflies hunting? In looking over a pond where there are many dragonflies darting about, do the larger species fly higher than the smaller ones?

2. Note the way the dragonflies hold their wings when they are resting. Do they rest with their wings folded together over the abdomen or are they extended out at an angle to the abdomen? Do you know how this difference in attitude of resting determines one difference between the damsel flies and the dragonflies?

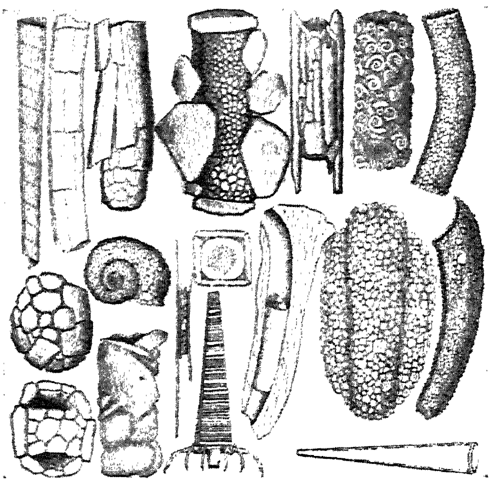
3. The damsel flies are those which hold their wings folded above the back when resting. Are these as large and strong-bodied as the dragonflies? Are their bodies more brilliantly colored? How does the shape of the head and eyes differ from those of the dragonflies? How many different-colored damsel flies can you find?

4. Do you see some dragonflies dipping down in the water as they fly? If so, they

are laying their eggs. Note if you find others clinging to reeds or other plants with the abdomen thrust below the surface of the water. If so, these are damsel flies inserting their eggs into the stem of the plant.

THE CADDIS WORMS AND THE CADDIS FLIES

People who have never tried to fathom the mysteries of the bottom of brook or pond are to be pitied. Just to lie flat, face downward, and watch for a time all that happens down there in that water world



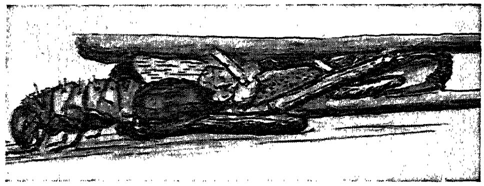
From *A Guide to the Study of Freshwater Biology*, Needham

Types of caddis-worm cases

is far more interesting than witnessing any play ever given at matinee. At first one sees nothing, since all the swift-moving creatures have whisked out of sight, because they have learned to be shy of moving shadows; but soon the crayfish thrusts out his boxing gloves from some crevice, then a school of tiny minnows " stay their wavy bodies 'gainst the stream "; and then something strange happens. A bit of rubbish on the bottom of the brook walks off. Perhaps it is a dream, or we are under the enchantment of the water witches! But no, there goes another, and now a little bundle of sand and pebbles takes unto itself legs. These mysteries can only be solved with a dip net and a pail half filled with water, in which we may carry home the treasure trove.

When we finally lodge our catch in the aquarium jar, our mysterious moving sticks and stones resolve themselves into little houses built in various fashions, and each containing one inmate. Some of the houses are made of sticks fastened together lengthwise; some are built like log cabins, crosswise; some consist simply of a hollow stem cut a convenient length; some are made of sand and pebbles; and one, the liveliest of all, is a little tube made of bits of rubbish and silk spun in a spiral, making a little cornucopia.

On the whole, the species which live in the log cabins are the most convenient to study. Whatever the shape of the case or house, it has a very tough lining of silk, which is smooth within, and forms the framework to which the sticks and stones are fastened. These little dwellings always have a front door and a back door. Out of the front door may protrude the dark-colored head followed by two dark segments and six perfectly active legs, the front pair being so much shorter than the other two pairs that they look almost like mouth palpi. In time of utter peace, more of the little hermit is thrust out, and we see the hind segment of the thorax, which is whitish, and behind this the abdomen of nine segments. At the sides of the abdomen, and apparently between the segments, are little tassels of short, white, threadlike gills. These are filled with air, impure from contact with the blood, which exchanges its impurities speedily for the oxygen from the air that is mixed with the water. Water is kept flowing in

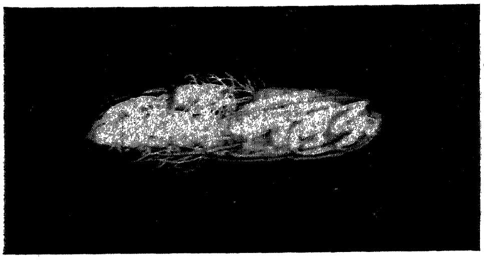


A caddis worm in its case

at the front door of the cabin, over the gills and out at the back door, by the rhythmic movement of the body of the little hermit, and thus a supply of oxygen is steadily maintained.

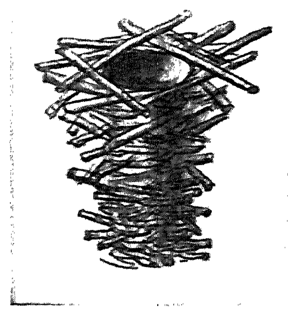
The caddis worm is not grown fast to its case as is the snail to its shell. If we hold down with forceps a case in which the occupant is wrong side up, after a few struggles to turn itself over, case and all, it will turn over within the case. It keeps its hold upon the case by two forward-curving hooks, one on each side of the tip of the rear segment. These hooks are inserted in the tough silk and hold fast. It also has on top of the first segment of the abdomen a tubercle, which may be extended at will; this helps to brace the larva in its stronghold, and also permits the water to flow freely around the insect. So the little hermit is entrenched in its cell at both ends. When the log-cabin species wishes to swim, it pushes almost its entire body out of the case, thrusts back the head, spreads the legs wide apart, and then doubles up, thus moving through the water spasmodically, in a manner that reminds us of the crayfish's swimming except that the caddis worm goes head first. This log-cabin species can turn its case over dexterously by movements of its legs.

The front legs of the caddis worm are so much shorter than the other two pairs that they look like palpi, and their use is to hold close to the jaws bits of food which are being eaten. The other legs are used for this too if the little legs cannot manage it; perhaps also these short front legs help hold the bits of building material in place while the web is woven to hold it there.



Pupa of caddis fly removed from its case. Note the threadlike gills

The caddis worm, like the true caterpillars, has the opening of the silk gland near the lower lip. The food of most caddis worms is vegetable, usually the various



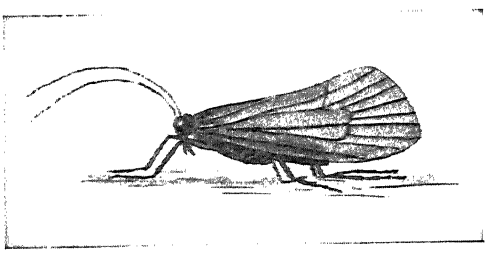
Log-cabin type of case

species of water plants; but there are some species which are carnivorous, like the net-builder, which is a fisherman.

The caddis-worm case protects its inmate in two ways, first, from the sight of the enemy, and second, from its jaws. A fish comes along and sees a nice white worm and darts after it, only to find a bundle of unappetizing sticks where the worm was. All of the hungry predatory creatures of the pond and stream would be glad to get the caddis worm, if they knew where it went. Sometimes caddis-worm cases have been found in the stomachs of fishes.

While it is difficult to see the exact operation of building the caddis-worm house, the general proceeding may be readily observed. Take a vigorous half-grown larva, tear off part of the sticks and bits of leaves that make the log cabin, and then place the little builder in a tumbler with half an inch of water at the bottom, in which are many bright flower petals cut into strips, fit for caddis lumber. In a few hours the little house will look like a blossom with several rows of bright petals set around its doorway.

When the caddis worm gets ready to pupate, it fastens its case to some object in the water and then closes its front and back doors. Different species accomplish this in different ways; some spin and fasten a silken covering over the doors, which is often in the form of a pretty grating; others simply fasten the material of which the case is made across the door. But though the door be shut, it is so arranged as to allow the water to flow through and to bring oxygen to the threadlike gills, which are on the pupæ as well as on the larvæ. When ready to emerge, the pupa crawls out of its case and climbs to some object above the water and sheds its pupa skin, and the adult insect flies off. In some species, living in swift water, the adult issues directly from the water, its wings expanding as soon as touched by the air.



A caddis fly

Caddis flies are familiar to us all even if we do not know them by name. They are night fliers and flame worshipers. Their parchment-like or leathery wings are folded like a roof over the back, and from the side the caddis fly appears as an elongated triangle with unequal sides. The front wings are long and the hind ones shorter and wider; the antennæ are long and threadlike and always waving about for impressions; the eyes are round and beadlike; the tarsi, or feet, are long and these insects have an awkward way of walking on the entire tarsus which gives them an appearance of kneeling. Most of the species are dull-colored, brownish or gray, the entire insect often being of one color. The mother caddis flies lay their eggs in the water. Perhaps some species drop the eggs in when hovering above, but in some cases the insect must make a diving bell of her wings and go down into the water to place her eggs securely. The wings are covered with hairs and not with scales, and therefore they are better fitted for diving than would be those of the moth. I have seen caddis flies swim vigorously.

Suggested Reading — *First Lessons in Nature Study*, by Edith M. Patch; also, readings on pages 300 and 400.

LESSON 104

The Caddis Worms and Caddis Flies

Leading Thought — The caddis worms build around themselves little houses out of bits of sticks, leaves, or stones. They crawl about on the bottom of the pond or stream, protected from sight, and able to withdraw into their houses when attacked. The adults of the caddis worm are winged mothlike creatures which come in numbers to the light at night.

Method — With a dip net the caddis worms may be captured and then may be placed in the school aquarium. Duckweed and other water plants should be kept growing in the aquarium. The log-cabin species is best for this study, because it lives in stagnant water and will therefore thrive in an aquarium.

Observations — 1. Where do you find the caddis worms? Can you see them easily on the bottom of the stream or pond? Why?

2. Of what are the caddis-worm houses made? How many kinds have you ever found? How many kinds of material can you find on one case? Describe one as exactly as possible. Find an empty case and describe it inside. Why is it so smooth inside? How is it made so smooth? Are all the cases the same size?

3. What does the caddis worm do when it wishes to walk around? What is the color of the head and the two segments back of it? What is the color of the body? Why is this difference of color between the head and body protective? Is the caddis worm grown fast to its case, as the turtle is to its shell?

4. Note the legs. Which is the shorter pair? How many pairs? What is the use of the legs so much shorter than the others? If the caddis-worm case happens to be wrong side up, how does it turn over?

5. When it wishes to come to the surface or swim, what does the caddis worm do? When reaching far out of its case does

it ever lose its hold? How does it hold on? Pull the caddis worm out of its case and see the hooks at the end of the body with which it holds fast.

6. How does the caddis worm breathe? When it reaches far out of its case, note the breathing gills. Describe them. Can you see how many there are on the segments? How is the blood purified through these gills?

7. What are the caddis worm's enemies? How does it escape them? Touch one when it is walking; what does it do?

8. On top of the first segment of the abdomen is a tubercle. Do you suppose that this helps to hold the caddis worm in its case?

9. What does the caddis worm eat? Describe how it acts when eating.

10. How does the caddis worm build its case? Watch one when it makes an addition to its case, and describe all that you can see.

11. Can you find any of the cases with the front and back doors closed? How are they closed? Open one and see if there is a pupa within it. Can you see the growing wings, antennæ, and legs? Has it breathing filaments like the larva? Cover the aquarium with mosquito netting so as to get all the moths which emerge. See if you can discover how the pupa changes into a caddis fly.

12. How does the caddis fly fold its wings? What is the general shape of the insect when seen from the side with wings closed? What is the texture of the wings? How many wings are there? Which pair is the longer?

13. Describe the eyes; the antennæ. Does the caddis fly walk on its toes, or on its complete foot?

14. Examine the insects which come around the lights at night in the spring and summer. Can you tell the caddis flies from the other insects? Do they dash into the light? Do they seem anxious to burn themselves?

Little brook, so simple, so unassuming — and yet how many things love thee!

Lo! Sun and Moon look down and glass themselves in thy waters.

And the trout balances itself hour-long against the stream, watching for its prey; or retires under a stone to rest.

And the water-rats nibble off the willow leaves and carry them below the wave to their nests — or sit on a dry stone to trim their whiskers.

And the May-fly practices for the millionth time the miracle of the resurrection, floating up an ungainly grub from the mud below, and in an instant, in the twinkling of an eye (even from the jaws of the baffled trout) emerging, an aerial fairy with pearl-green wings.

And the caddis-fly from its quaint disguise likewise emerges.

And the prick-eared earth-people, the rabbits, in the stillness of early morning play beside thee undisturbed, while the level sunbeams yet grope through the dewy grass.

And the squirrel on a tree-root — its tail stretched far behind — leans forward to kiss thee,

Little brook, for so many things love thee.

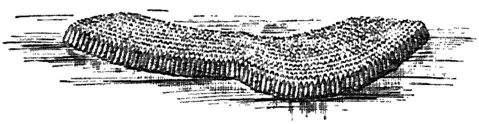
— Edward Carpenter

THE MOSQUITO

In defiance of the adage, the mother of our most common mosquitoes does not hesitate to put her eggs all in one basket, but perhaps she knows it is about the safest little basket for eggs in this world of uncertainties. If it were possible to begin this lesson with the little boat-shaped egg baskets, I should advise it. They may be found in almost any rain barrel, and the eggs look like a lot of tiny cartridges set side by side, points up, and lashed or glued together, so there shall be no spilling. Like a certain famous soap, they "float," coming up as dry as varnished corks when water is poured upon them.

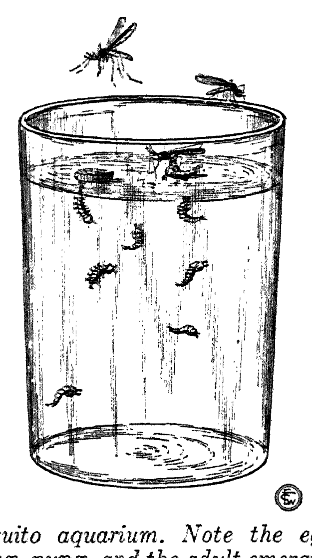
The young mosquito, or wriggler, breaks

through the shell of the lower end of the egg and passes down into the water, and from the first, it is a most interesting creature to view through a hand lens. The



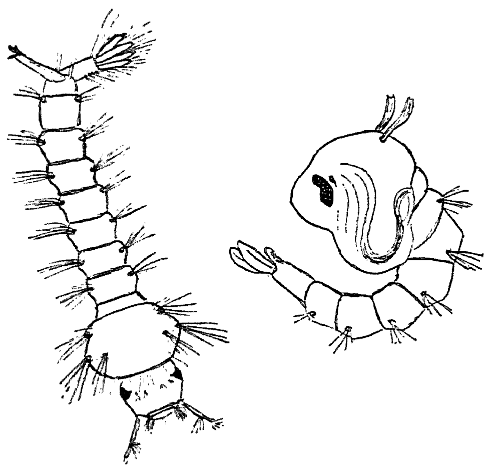
The egg-raft of a mosquito

head and the thorax are rather large while the body is tapering and armed with bunches of hairs. At the rear of the body are two tubes very different in shape; one is long, straight, and unadorned; this is the breathing-tube through which air passes to the tracheæ of the body. This tube has at the tip a star-shaped valve, which can be opened and shut; when it is opened at the surface of the water, it keeps the little creature afloat and meanwhile allows air to pass into the body. When the wriggler is thus hanging to the surface of the water, it feeds upon small particles of decaying vegetation; it has a remarkable pair of jaws armed with brushes, which in our common species, by moving rapidly, set up currents and bring the food to the mouth. This process can be seen plainly with a lens. When disturbed, the wriggler shuts the valve to its breathing-tube, and sinks. However, it is not much heavier than the



A mosquito aquarium. Note the egg-raft, larvæ, pupæ, and the adult emerging

water; I have often seen one rise for some distance without apparent effort. The other tube at the end of the body supports the swimming organs, which consist of four finger-like processes and various bunches of hairs. When swimming, the wriggler goes tail first, the swimming organs seeming to take hold of the water and to pull the creature backward, in a series of spasmodic jerks; in fact, the insect seems simply to "throw somersaults," like an acrobat. I have often observed wrigglers standing on their heads in the bot-



At the left is a larva and at the right a pupa of the mosquito

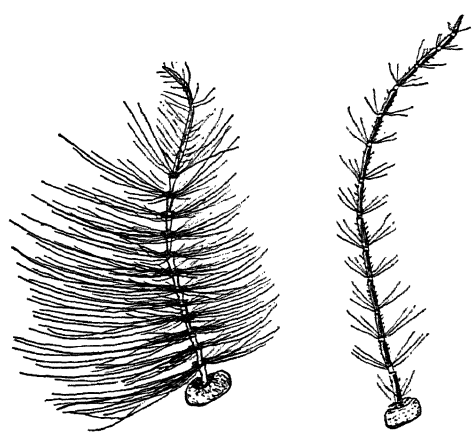
tom of the aquarium, with their jaws bent under, revolving their brushes briskly; but they never remain very long below the surface, as it is necessary for them to take in fresh air often.

The pupa has the head and thoracic segments much enlarged making it all "head and shoulders" with a quite insignificant body attached. Upon the thorax are two breathing-tubes, which look like two ears, and therefore when the pupa rests at the surface of the water, it remains head up so that these tubes may take in the air; at the end of the body are two swimming organs which are little, leaflike projections. At this stage the insect is getting ready to live its life in the air, and for this reason, probably, the pupa rests for long periods at the surface of the water and does not swim about much, unless disturbed. However, it is a very strange habit for a pupa to move about at all. In the case of other flies, butterflies, and moths, the pupa stage is quiet.

When fully mature, the pupa rises to the surface of the water, the skeleton skin breaks open down its back and the mosquito carefully works itself out; until its wings are free and dry, it rests upon the floating pupa skin. This is indeed a frail bark, and if the slightest breeze ruffles the water, the insect is likely to drown before its wings are hard enough for flight.

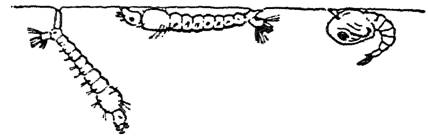
The reason that kerosene oil put upon the surface of the water where mosquitoes breed kills the insects is that both the larvæ and pupæ of mosquitoes are obliged to rise to the surface and push their breathing-tubes through the surface film so that they will open to the air; a coating of oil on the water prevents this, and they are suffocated. Also when the mosquito emerges from the pupa skin, if it is even touched by the oil, it is unable to fly and soon dies.

The male mosquitoes have bushy or feathery antennæ. These antennæ are hearing organs of very remarkable construction. The Anopheles may be distinguished from the Culex by the following



Antennæ of the mosquito; left, male; right, female

characteristics: Its wings are spotted instead of plain. When at rest it is perfectly straight, and is likely to have the hind legs in the air. It may also rest at an angle to the surface to which it clings. The Culex is not spotted on the wings and is likely to be humped up when at rest. In our climate the Anopheles is more dan-



Normal resting position of mosquito larvæ and pupæ. Left; larva of Culex, *the common house mosquito. Middle; larva of* Anopheles, *the carrier of malaria. Right; pupa of* Culex. *Note the breathing-tubes*

gerous than the Culex because it carries the germs of malaria. A mosquito's wing under a microscope is a most beautiful object, as it is " trimmed " with ornamental scales about the edges and along the veins. The male mosquitoes neither sing nor bite; the song of the female mosquito is supposed to be made by the rapid vibration of the wings, and her musical performances are for the purpose of attracting her mate, as it has been shown that he can hear through his antennæ a range of notes covering the middle and next higher octaves of the piano.

Science has shown us that the mosquitoes are in a very strange way a menace to health. Through a heroism, as great as ever shown on field of battle, men have imperiled their lives to prove that the germs of the terrible yellow fever are transmitted by the biting mosquito, and with almost equal bravery other men have demonstrated that the germs of malaria are also thus carried.

In the North, our greatest danger is from the mosquitoes which carry the malarial germs. These are the mosquitoes with spotted wings and belong to the genus *Anopheles*. This mosquito in order to be of danger to us must first feed upon the blood of some person suffering from malaria and thus take the germ of the disease into its stomach. Here the germ develops and multiplies into many minute germs, which pass through another stage and finally get into the blood of the mosquito and accumulate in the salivary glands. The reason any mosquito bite or insect bite swells and itches is that, as the insect's beak is inserted into the flesh, it carries with it some of the saliva from the insect's mouth. In the case of Anopheles these malarial germs are carried with the saliva into the blood of the victim. It has been proved that in the most malarial

Normal position of Culex *and* Anopheles *on a wall;* Culex *above and* Anopheles *below*

countries, like Italy and India, people are entirely free from malaria if they are not bitten by mosquitoes. Thus the mosquito is the sole carrier of the malaria germs.

After this explanation has been made, it would be well for the teacher to take the pupils on a tour of inspection through the neighborhood to see if there are any mosquito larvæ in rain barrels, ponds, or pools of stagnant water. If such places are found, let the pupils themselves apply the following remedies.

1. Rain barrels should be securely covered.

2. Stagnant pools should be drained and filled up if possible.

3. Wherever there are ponds or pools where mosquitoes breed that cannot be filled or drained, the surface of the water should be covered with a spray of kerosene oil. This may be applied with a spray pump or from a watering can.

4. If it is impracticable to cover such places with oil, introduce into such pools the following fish: minnows, sticklebacks, sunfish, and goldfish.

The effect of this lesson upon the children should be to impress them with the danger to life and health from mosquitoes and to implant in them a determination to rid the premises about their homes of these pests.

Suggested Reading — *Common Pests*, by Rennie W. Doane; *Insects Injurious to the Household and Annoying to Man*, by Glenn W. Herrick; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 2, *Some Animal Neighbors; Scientific Living Series, Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on pages 300 and 400.

LESSON 105

The Mosquito

Leading Thought — The wrigglers, or wigglers, which we find in rain barrels and stagnant water are the larvæ of mosquitoes. We should study their life history carefully if we would know how to get rid of mosquitoes.

Method — There is no better way to interest the pupils in mosquitoes than to place in an aquarium jar in the schoolroom a family of wrigglers from some pond or rain barrel. For the pupils' personal observation, take some of the wrigglers from the aquarium with a pipette and place them in a homeopathic vial; fill the vial three-fourths full of water and cork it. Pass it around with a hand lens and give each pupil the opportunity to observe it for five or ten minutes. It would be well if this vial could be left on each desk for an hour or so during study periods, so that the observations may be made casually and leisurely. While the pupils are studying the wrigglers, the following questions should be placed upon the blackboard, and each pupil should make notes which may finally be given at a lesson period. This is particularly available work for September.

In studying the adult mosquito, a lens or microscope is necessary. But it is of great importance that the pupils be taught to discriminate between the comparatively harmless species of Culex and the dangerous Anopheles; and therefore they should be taught to be observant of the way mosquitoes rest upon the walls, and whether they have mottled or clear wings.

The Larva

Observations — 1. Note if all the wrigglers are of the same general shape, or if some of them have a very large head; these latter are the pupæ and the former are the larvæ. We will study the larvæ first. Where do they rest when undisturbed? Do they rest head up or down? Is there any part of their body that comes to the surface of the water?

2. When disturbed what do they do? When they swim, do they go head or tail first?

3. Observe one resting at the top. At what angle does it hold itself to the surface of the water? Observe its head. Can you see the jaw brushes revolving rapidly? What is the purpose of this? Describe its eyes. Can you see its antennæ?

4. Note the two peculiar tubes at the end of the body and see if you can make out their use.

5. Note especially the tube that is thrust up to the surface of the water when the creatures are resting. Can you see how the opening of this tube helps to keep the wriggler afloat? What do you think is the purpose of this tube? Why does it not become filled with water when the wriggler is swimming? Can you see the two air vessels, or tracheæ, extending from this tube along the back the whole length of the body?

6. Note the peculiarities of the other tube at the rear end of the body. Do you think the little finger-like projections are an aid in swimming? How many are there?

7. Can you see the long hairs along the side of the body?

8. Does the mosquito rest at the bottom of the bottle or aquarium?

The Pupa

1. What is the most noticeable difference in appearance between the larva and pupa?

2. When the pupa rests at the surface of the water, is it the same end up as the wriggler?

3. Note on the "head" of the pupa two little tubes extending up like ears. These are the breathing-tubes. Note if these open to the air when the pupa rests at the surface of the water.

4. Can you see the swimming organs at the rear of the body of the pupa? Does the pupa spend a longer time resting at the surface than the larva? How does it act differently from the pupæ of other flies and moths and butterflies?

5. How does the mosquito emerge from the pupa skin? Why does kerosene oil poured on the surface of the water kill mosquitoes?

The Adult Mosquito

1. Has the mosquito feathery antennæ extending out in front? If so, what kind of mosquito is it?

2. Do the mosquitoes with bushy antennæ bite? Do they sing?

3. Are the wings of the mosquito spotted or plain? How many has it?

4. When at rest, is it shortened and humpbacked or does it stand straight out with perhaps its hind legs in the air?

5. What are the characteristics by which you can tell the dangerous Anopheles?

6. Why is the Anopheles more dangerous than the Culex?

7. Examine a mosquito's wing under a microscope and describe it.

8. Examine the antennæ of a male and of a female mosquito under a microscope, and describe the difference.

9. Which sex of the mosquito does the biting and the singing?

10. How is the singing done?

INVERTEBRATE ANIMALS OTHER THAN INSECTS

This group includes backboneless animals other than insects. Among these are spiders and their relatives, centipedes and millipedes, crustaceans, mollusks or shelled animals, worms, and seashore creatures representing several other groups.

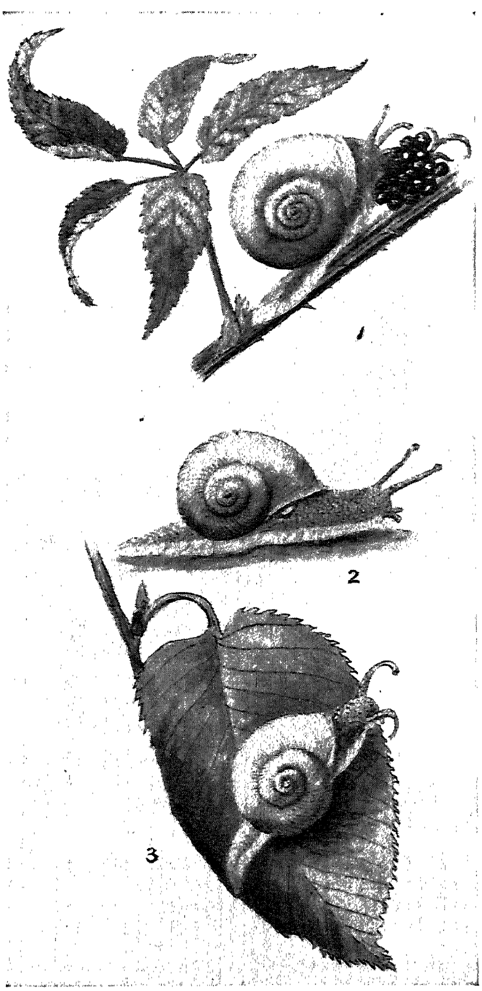
Suggested Reading — *Animals of the Seashore*, by Horace G. Richards; *Backyard Exploration*, by Paul G. Howes; *The Burgess Seashore Book for Children*, by Thornton W. Burgess; *Field Book of Ponds and Streams*, by Ann H. Morgan; *Hand Book for the Curious*, by Paul G. Howes; *Holiday Shore*, by Edith M. Patch and Carroll Lane Fenton; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes*, Book 2, *Some Animal Neighbors*; *Parade of the Animal Kingdom*, by Robert Hegner; *Sea-Beach at Ebb-Tide*, by Augusta F. Arnold; *Strange Sea-Shells and Their Stories*, by A. Hyatt Verrill; *The Wonders of the Sea*, by F. Martin Duncan and L. T. Duncan; additional references are to be found in the bibliography in the back of the Handbook, under various headings: Insects and Other Invertebrates, Animals in General, Nature-Study in General, Textbooks and Readers, Nature Poetry, Magazines and Periodicals, Books for Parents and Teachers.

THE GARDEN SNAIL

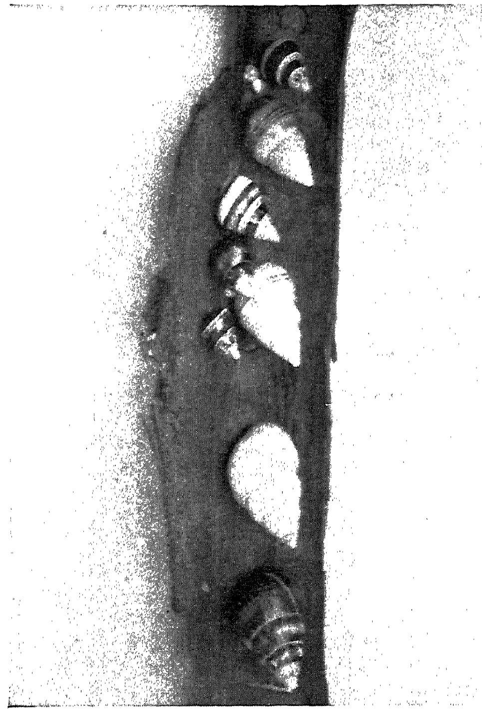
Perchance if those who speak so glibly of a " snail's pace " should study it, they would not sneer at it, for, carefully observed, it seems to be one of the most wonderful methods of locomotion ever devised by animal. Naturally enough, the snail cannot gallop, since it has but one foot; but it is safe to assert that this foot, which is the entire lower side of the body, is a remarkable organ of locomotion. Let a snail crawl up the side of a tumbler and note how this foot stretches out and holds on. It has flanges along the sides, which secrete an adhesive substance that enables the snail to cling, and yet it also has the power of letting go at will. The slow, even, pushing forward of the whole body, weighted by the unbalanced shell, is as mysterious, and seemingly as inevitable, as the march of fate, so little is the motion connected with any apparent muscular effort. But when his snailship wishes to let go and retire from the world, this foot performs a feat which is certainly worthy of a juggler; it folds itself lengthwise, and the end on which the head is retires first into the shell, the tail end of the foot being the last to disappear. And now find your snail!

Never was an animal so capable of stretching out and then folding up all its organs, as is this little tramp who carries his house with him. Turn one on his back when he has withdrawn into his little hermitage, and watch what happens. Soon he concludes he will find out where he is, and why he is bottomside up; as the first evidence of this, the hind end of the foot, which was folded together, pushes forth; then the head and horns come bubbling out. The horns are not horns at all, but each is a stalk bearing an eye on the tip. This is arranged conveniently, like a marble fastened to the tip of a glove finger. When a snail wishes to see, it stretches forth the stalk as if it were made of rubber;

but if danger is perceived, the eye is pulled back exactly as if the marble were pulled back through the middle of the glove finger; or as a boy would say, "it goes into the hole and pulls the hole in after it." Just below the stalked eyes is another pair of shorter horns, which are feelers, and which may be drawn back in the same manner; they are used constantly for testing the nature of the surface on which the snail is crawling. It is an interesting experiment to see how near to the eyes and the feelers we can place an object, before driving them back in. With these two pairs of sense organs pushed out in front



Snail sketches. 1, *The thorny path to bliss.* 2, *Snail showing the breathing pore.* 3, *Prospecting*



E. Morton Miller

Tree snails æstivating on the under side of a piece of bark

of him, the snail is well equipped to observe the topography of his immediate vicinity; if he wishes to explore above, he can stand on the tip of his tail and reach far up; and if there is anything to take hold of, he can glue his foot fast to it and pull himself up. Moreover, I am convinced that snails have decided views about where they wish to go, for I have tried by the hour to keep them marching lengthwise on the porch railing, so as to study them; and every snail was determined to go crosswise and crawl under the edge, where it was nice and dark.

It is interesting to observe through a lens the way a snail takes his dinner; place before him a piece of sweet apple or other soft fruit, and he will lift himself on his foot and begin to work his way into the fruit. He has an efficient set of upper teeth, which look like a saw and are colored as if he chewed tobacco; with these teeth and with his round tongue, which we can see popping out, he soon makes

SHELLS OF FLORIDA AND THE EAST COAST

1. Crown Melongena, Melongena corona, *Gmelin. Reported from Florida and West Indies. The species lives in brackish water and is fond of the razor-back clam and oyster. It obtains its name from the crownlike appearance of the projections on the shell whorls. Length, 2 to 5 inches.*

2. Brown-mouth Cymatium, Cymatium chlorostomum, *Lamarck. This species is commonly found in the West Indies and Florida Keys. Length, 3 inches.*

3. White-mouth Cymatium, Cymatium tuberosum, *Lamarck. The illustration shows an immature individual. A mature specimen is similar to Figure 2. The species is distributed in Florida Keys and West Indies. Length, 2 to 3 inches.*

4. Lined Murex, Murex cobritti, *Bernardii. Collected at depths of from 10 to 150 fathoms from Cedar Keys to Texas and the West Indies. Length, 3 inches.*

5. Mossy Ark, Arca umbonata, *Lamarck. These bivalves are distributed from North Carolina to the West Indies and Gulf of Mexico. They are often cast up on the Florida beaches by storms. Length, 2 to 3 inches.*

6. Black Lace Murex, Murex rufus, *Lamarck. This species is gathered in water from 1 to 30 fathoms in depth from North Carolina to the West Indies. Length, 2 inches.*

7. Apple Murex, Murex pomum, *Gmelin. Abundant in West Indies; also reported from North Carolina and the Gulf of Mexico. The shell mouth is lined with bright yellow. Length, 2 to 5 inches.*

8. White-spike Murex, Murex fulvescens, *Sowerby. The color varies from white to pink. The shell is found from North Carolina to Florida and the West Indies. Length, 6 inches.*

9. Moon Shell, Polinicies duplicata, *Say. The species ranges from New England to the Gulf of California. It possesses a chitinous operculum, and is either bluish or brownish tinged on the upper surface. Diameter, 3 inches.*

10. Rock Worm Shell, Vermetus nigricans, *Dall. This mollusk forms a much-coiled and cylindrical shell. It is commonly found attached to rocks, and even contributes to reef building. Distributed from West Florida to Florida Keys.*

11. Mouse Cone, Conus mus, *Hwass. This mottled chestnut-colored cone possesses a striated body-whorl. It is commonly found in shallow bays in Florida and the West Indies. Length, 1 to 2 inches.*

12. Florida Cone, Conus floridanus, *Gabb. This species is referred to as " chinese tops," since the surface markings resemble the characters of the Chinese alphabet. It ranges from North Carolina to the Gulf of California. Length, 1¼ inches.*

13. Giant Band Shell, Fasciolaria gigantea, *Kiener. The illustration shows a young shell 2 to 3 inches long; a mature one may reach a length of 24 inches. The surface is yellowish and the aperture orange-red. It is found in North Carolina, West Indies, and Brazil.*

14. Lettered Olive, Oliva litterata, *Lamarck. These polished shells with hieroglyphic markings are fairly common from North Carolina to Texas and the West Indies. They live in colonies and are sand burrowers. Length, 1½ to 2½ inches.*

15. Netted Olive, Oliva reticularis, *Lamarck. This shell possesses a woven pattern of fine brown lines on a white background. It occurs in the West Indies and Florida. Length, 1 to 2½ inches.*

16. Mottled Top Shell, Calliostoma jujubinum, *Gmelin. The shell is conical, and is pearly within the mouth. Distributed from North Carolina to the West Indies. Length, 1 inch.*

17. Ridged Chione, Chione cancellata, *Linnœus. This shell occurs in abundance in the Gulf of California. It is distributed from North Carolina to Brazil. Diameter, 1 inch.*

18. Beaming Scallop, Pecten irradians, *Lamarck. This common edible species ranges from New England to Cape Hatteras. The exterior is brown marked by bars of red, purple, or orange. Diameter, 2 to 3 inches.*

19. Vase Shell, Vasum muricatum, *Born. The shell color is white lined with pink. It is found in the Florida Keys, West Indies, and Panama. Length, 3 inches.*

20. Ponderous Ark, Arca ponderosa, *Say. This species is distributed from Cape Cod to Texas and the West Indies. In the fossil state it is found in New Jersey. Diameter, 2 inches.*

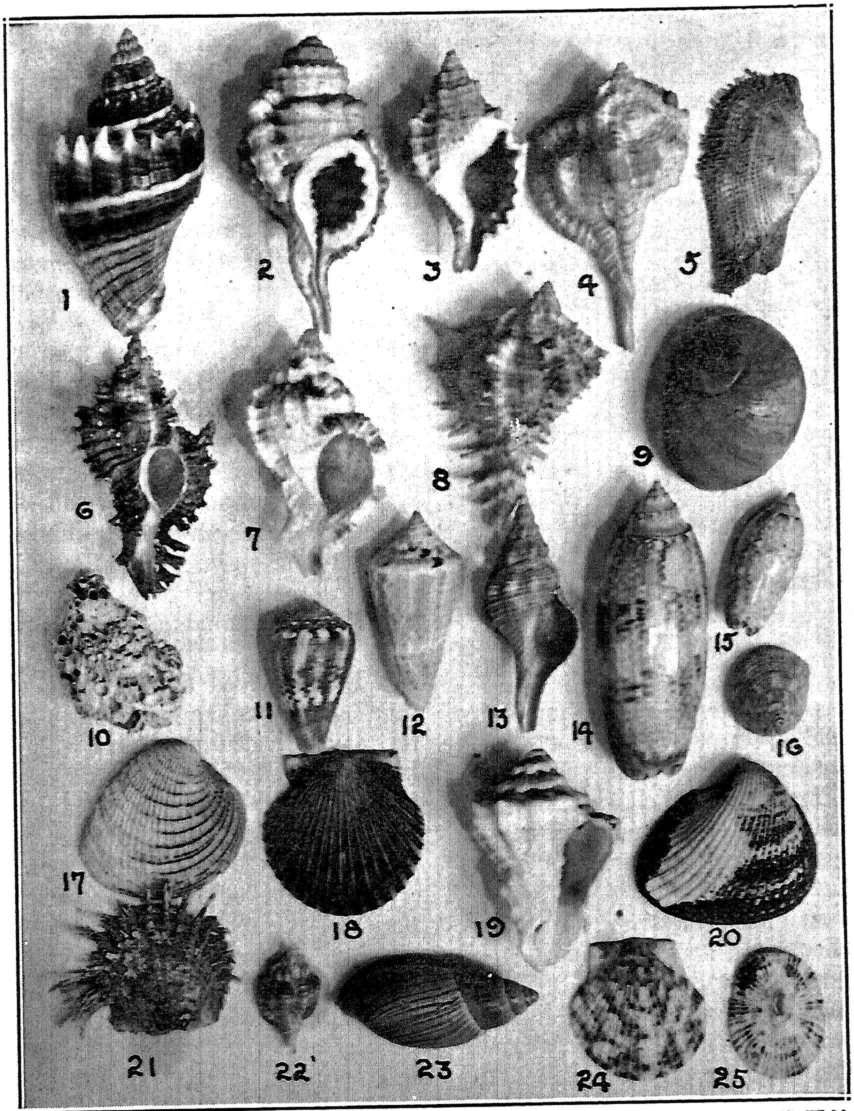
21. Spiny Pearl Shell, Margitifera radiata, *Leach. Distributed from Georgia to the West Indies. They are found associated with the sponges in Florida. Diameter, 1½ inches.*

22. Little Red Murex, Murex messorius, *Reeve. This shell is found in the Florida Keys and West Indies. Length, about 1 inch.*

23. Rose Euglandina, Euglandina rosea, *Ferussac. This rose-colored land shell is found in Western Florida. It conceals itself in brush during the rainy season.*

24. Calico Scallop, Pecten gibbus, *Linnœus. The shell is mottled with red, brown, and orange. Distributed in North Carolina and the West Indies. Diameter, 1½ to 2 inches.*

25. Volcano Shell, Fissurella fasicularis, *Lamarck. The common name is based on the resemblance of the shell to a volcano; it is found in the Florida Keys and West Indies. Diameter, 1 inch.*



From *Handbook for Shell Collectors*, Walter F. Webb an appreciable hole in the pulp; but his table manners are not nice, since he is a hopeless slobberer.

There are right and left spiraled snails. All those observed for this lesson show the spiral wound about the center from left over to right, or in the direction of the movement of the hands of a clock, and this is usually the case. With the spiral like this, the breathing pore is on the right side of the snail and may be

Hugh Spencer

Slugs with eye-stalks extended. Slugs are relatives of land snails but they have no shells

seen as an opening where the snail joins the shell. This pore may be seen to open and contract slowly; by this motion, the air is sucked into the shell where it bathes the snail's lung, and is then forced out — a process very similar to our own breathing.

The snail acts quickly when attacked; at the first scare, he simply draws in his eyes and feelers and withdraws his head, so that nothing can be seen of him from above except a hard shell which would not attract the passing bird. But if the attack continues, he lets go all hold on the world, and nothing can be seen of him but a little mass which blocks the door to his house; and if he is obliged to experience a drought, he makes a pane of glass out of mucus across his door, and thus stops evaporation. This is a very wise precaution, because the snail is made up largely of moisture and much water is needed to keep his mucilage factory running.

The way the snail uses his eyes is comical; he goes to the edge of a leaf and pokes one eye over to see what the new territory is like; but if his eye strikes an object, he pulls that one back, and prospects for a time with the other. He can lengthen the eyestalk amazingly if he has need. How convenient for us if we could thus see around a corner! If a small boy were as well off as a snail, he could see the entire ball game through a knothole in the fence. In fact, the more we study the snail, the more we admire, first his powers of ascertaining what there is in the world, and then his power of getting around in the world by climbing recklessly and relentlessly over obstacles, not caring whether he is right side up on the floor or hanging wrong side up from the ceiling; and, finally, we admire his utter reticence when things do not go to suit him. I think the reason I always call a snail " he " is that he seems such a philosopher — a Diogenes in his tub. However, since the snail combines both sexes in one individual the pronoun is surely applicable.

When observed through a lens, the snail's skin looks like that of the alligator, rough and divided into plates, with a surface like pebbled leather; and no insect intruder can crawl up his foot and get into the shell " unbeknownst," for the shell is grown fast to the flange that grows out of the middle of the snail's back. The smoother the surface the snail is crawling upon, the harder to make him let go. The reason for this lies in the mucus which he secretes as he goes, and which enables him to fasten himself anywhere; he can crawl up walls or beneath any horizontal surface, shell downward, and he leaves a shining trail behind him wherever he goes.

Snail eggs are as large as small peas, almost transparent, covered with very soft shells, and fastened together by mucus. They are laid under stones and decaying leaves. As soon as the baby snail hatches, it has a shell with only one spiral turn in it; as it grows, it adds layer after layer to the shell on the rim about the opening — which is called the lip; these layers we can see as ridges on the shell. If we open an empty shell, we can see the progress of growth in the size of the spirals. Snails eat succulent leaves and other soft vegetable matter. During the winter, they bury themselves beneath objects or retire into soft humus. In preparing for the winter, the snail makes a door of mucus and lime, or sometimes three doors, one behind another, across the entrance to his shell, leaving a tiny hole to admit the air. There are varieties of snails which are eaten as dainties in Europe and are grown on snail farms for the markets. The species most commonly used is the same as that which was regarded as a table luxury by the ancient Romans.

SUGGESTED READING — *First Lessons in Nature Study*, by Edith M. Patch; also, readings on page 416.

LESSON 106

THE GARDEN SNAIL

LEADING THOUGHT — The snail carries his dwelling with him, and retires within it in time of danger. He can climb on any smooth surface.

METHOD — The pupils should make a snailery, which may consist of any glass jar, with a little soil and some moss or leaves at the bottom, and a shallow dish of water at one side. The moss and soil should be kept moist. Place the snails in this and give them fresh leaves or pulpy fruit, and they will live comfortably in confinement. A bit of cheesecloth fastened with a rubber band should be placed over the top of the jar. A tumbler inverted over a dish, on which is a leaf or two, makes a good observation cage to pass around the room for closer examination. An empty shell should be at hand, which may be opened and examined.

OBSERVATIONS — 1. Where do you find snails? Why do they like to live in such places?

2. How does a snail walk? Describe its "foot." How can it move with only one foot? Describe how it climbs the side of the glass jar. How does it cling?

3. What sort of track does a snail leave behind it? What is the use of this mucus?

4. Where are the snail's eyes? Why is this arrangement convenient? If we touch one of the eyes what happens? What advantage is this to the snail? Can it pull in one eye and leave the other out?

5. Look below the eyes for a pair of feelers. What happens to these if you touch them?

6. What is the use of its shell to a snail? What does the snail do if startled? If attacked? When a snail is withdrawn into its shell can you see any part of the body? Is the shell attached to the middle of the foot? How did the shell grow on the snail's back? How many spiral turns are there in the full-grown shell? Are there as many in the shell of a young snail? Can you see the little ridges on the shell? Do you think that these show the way the shell grew?

7. Can you find the opening through which the snail draws its breath? Where is this opening? Describe its action.

8. Put the snail in a dry place for two or three days, and see what happens. Do you think this is for the purpose of keeping in moisture? What does the snail do during the winter?

9. Place a snail on its back and see how it rights itself. Describe the way it eats. Can you see the horny upper jaw? Can you see the rasping tongue? What do snails live on?

10. Do you know how the snail eggs look and where they are laid? How large is the shell of the smallest garden snail you ever saw? How many spiral turns were there in it? Open an empty snail shell and see how the spirals widened as the snail grew. Do you think the shell grew by layers added to the lip?

11. Do all snails have shells? Describe all the kinds of snails you know. What people consider snails a table delicacy?

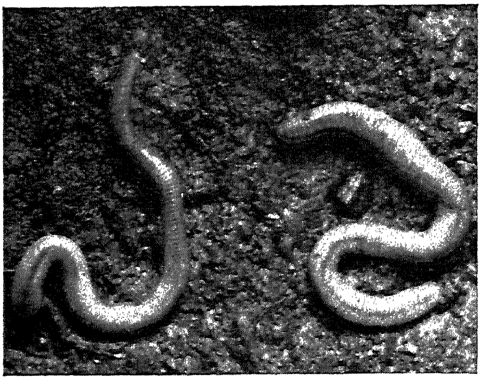
TO A SNAIL

Little Diogenes bearing your tub, whither
away so gay,
With your eyes on stalks, and a foot that
walks, tell me this I pray!

Is it an honest snail you seek that makes
you go so slow,
And over the edges of all things peek?
Have you found him, I want to know,
Or do you go slow because you know, your
house is near and tight?
And there is no hurry and surely no worry
lest you stay out late at night.

THE EARTHWORM

Although not generally considered attractive, for two reasons the earthworm has an important place in nature-study: it furnishes an interesting example of lowly organized creatures, and it is of great economic importance to the agriculturist. The lesson should have special reference to the work done by earthworms and to the simplicity of the tools with which the work is done.



Hugh Spencer

Earthworms

The earthworm is, among lower animals, essentially the farmer. Long before men conceived the idea of tilling the soil, this seemingly insignificant creature was busily at work plowing, harrowing, and fertilizing the land. Nor did it overlook the importance of drainage and the addition of amendments — factors of comparatively recent development in the management of the soil by man.

Down into the depths, sometimes as far as seven or eight feet, but usually from twelve to eighteen inches, goes the little plowman, bringing to the surface the subsoil, which is exactly what we do when we plow deeply. To break up the soil as our harrows do, the earthworm grinds it in a gizzard stocked with grains of sand or fine gravel, which act as millstones. Thus it turns out soil of much finer texture than we, by harrowing or raking, can produce. In its stomach it adds the lime amendment, so much used by the modern farmer. The earthworm is apparently an adept in the use of fertilizers; it even shows discrimination in keeping the organic matter near the surface, where it may be incorporated into the soil of the root zone. It drags into its burrows dead leaves, flowers, and grasses, with which to line the upper part. Bones of dead animals, shells, and twigs are buried by it, and, being more or less decayed, furnish food for plants. These minute agriculturists have never studied any system of drainage, but they bore holes to some depth which carry off surplus water. They plant seeds by covering those that lie on the ground with soil from below the surface — good, enriched, well granulated soil it is, too. They further care for the growing plants by cultivating, that is keeping fine and granular, the soil about the roots.

It was estimated by Darwin that, in garden soil in England, there are more than fifty thousand earthworms in an acre, and that the whole superficial layer of vegetable mold passes through their bodies in the course of every few years, at the rate of eighteen tons an acre yearly.

This agricultural work of the earthworm has been going on for ages. Wild land owes much of its beauty to this diminutive creature which keeps the soil in good condition. The earthworm has undermined and buried rocks, changing greatly the aspect of the landscape. In this way it even has preserved ruins and ancient works of art. Several Roman villas in England owe their preservation to the earthworm. All this work is accomplished with the most primitive tools: a tiny proboscis, a distensible pharynx, a rather indeterminate tail, a gizzard, and the calcareous glands peculiar to this lowly creature.

An earthworm has a peculiar, crawling movement. Unlike the snake, which also moves without legs, it has no scales to function in part as legs; but it has a very special provision for locomotion. On the under side of a worm are found numerous *setæ* — tiny, bristle-like projections. These will be seen to be in double rows on each segment, excepting the first three and the last. The setæ turn so that they point in the opposite direction from that in which the worm is moving. It is this use of these clinging bristles, together with strong muscles, which enables a worm to hold tightly to its burrow when bird or man attempts its removal. A piece of round elastic furnishes an excellent example of contraction and extension, such as the earthworm exhibits. Under the skin of the worms are two sets of muscles; the outer passing in circular direction around the body, the inner running lengthwise. The movement of these may be easily seen in a good-sized living specimen. The body is lengthened by the contraction of circular and the extension of longitudinal muscles, and shortened by the opposite movement.

The number of segments may vary with the age of the worm. In the immature earthworm, the *clitellum*, a thick, whitish ring near the end, is absent. The laying of the earthworm's eggs is an interesting performance. A saclike ring is formed about the body in the region of the clitellum. This girdle is gradually worked forward and, as it is cast over the head, the sac-ends snap together enclosing the eggs. These capsules, yellowish-brown, football-shaped, about the size of a grain of wheat, may be found in May or June about manure piles or under stones.

Earthworms are completely deaf, although sensitive to vibration. They have no eyes, but can distinguish between light and darkness. The power of smell is feeble. The sense of taste is well developed; the sense of touch is very acute; and we are not so sure as is Dr. Jordan that the angleworm is at ease on the hook.

Any garden furnishes good examples of the home of the earthworm. The burrows are made straight down at first, then wind about irregularly. Usually they are about one or two feet deep, but may reach even eight feet. The burrow terminates generally in an enlargement where one or several worms pass the winter. Toward the surface, the burrow is lined with a thin layer of fine, dark colored earth, voided by the worm. This creature is an excavator and builder of no mean ability. The tower-like "castings" so characteristic of the earthworm are formed with excreted earth. Using the tail as a trowel, it places earth now on one side and now on the other. In this work, of course, the tail protrudes; in the search for food, the head is out. A worm, then, must make its home, narrow as it is, with a view to being able to turn in it.

An earthworm will bury itself in loose earth in two or three minutes and in compact soil, in fifteen minutes. Pupils should be able to make these observations easily either in the terrarium or in the garden.

In plugging the mouths of their burrows, earthworms show something that seems like intelligence. Triangular leaves are invariably drawn in by the apex, pine needles by the common base, the manner varying with the shape of the leaf. They do not drag in a leaf by the footstalk, unless its basal part is as narrow as the apex. The mouth of the burrow may be lined with leaves for several inches.

The burrows are not found in dry ground or in loose sand. The earthworm lives in the finer, moderately wet soils. It must have moisture, since it breathes through the skin, and it has sufficient knowledge of soil texture and plasticity to recognize the futility of attempts at burrow building with unmanageable, large grains of sand.

These creatures are nocturnal, rarely appearing by day unless "drowned out" of the burrows. During the day they lie near the surface extended at full length, the head uppermost. Here they are discovered by keen-eyed birds and sacrificed by thousands, notwithstanding the strong muscular protest of which they are capable.

Seemingly conscious of its inability to find the way back to its home, an earthworm anchors tight by its tail while stretching its elastic length in a foraging expedition. It is an omnivorous creature, including in its diet earth, leaves, flowers, raw meat, fat, and even showing cannibalistic designs on fellow earthworms. In the schoolroom, earthworms may be fed on pieces of lettuce or cabbage leaves. A feeding worm will show the proboscis, an extension of the upper lip used to push food into the mouth. The earthworm has no hard jaws or teeth, yet it eats through the hardest soil. Inside the mouth opening is a very muscular pharynx, which can be extended or withdrawn. Applied to the surface of any small object it acts as a suction pump, drawing food into the food tube. The earth taken in furnishes some organic matter for food; calcareous matter is added to the remainder before being voided. This process is unique among animals. The calcareous matter is supposed to be derived from leaves which the worms eat. Generally the earth is swallowed at some distance below the surface and finally ejected in characteristic "castings." Thus, the soil is slowly worked over and kept in good condition by earthworms, of which Darwin says: "It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures."

Suggested Reading — *Backyard Exploration*, by Paul G. Howes; *First Lessons in Nature Study*, by Edith M. Patch; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 2, *Some Animal Neighbors*; *Our Plant and Animal Neighbors*, by Frank B. Younger; also, readings on page 416.

Fly fishing is an art, a fine art beyond a doubt, but it is an art and, like all art, it is artificial. Fishing with an angleworm is natural. It fits into the need of the occasion. It fits in with the spirit of the boy. It is not by chance that the angleworm, earthworm, fishworm, is found in every damp bank, in every handy bit of sod, the green earth over, where there are races whose boys are real boys with energy enough to catch a fish. It is not by chance that the angleworm makes a perfect fit on a hook, with no anatomy with which to feel pains, and no arms or legs to be broken off or to be waved helplessly in the air. Its skin is tough enough so as not to tear, not so tough as to receive unseemly bruises, when the boy is placing it on the hook. The angleworm is perfectly at home on the hook. It is not quite comfortable anywhere else. It crawls about on sidewalks after rain, bleached and emaciated. It is never quite at ease even in the ground, but on the hook it rests peacefully, with the apparent feeling that its natural mission is performed.

— "Boys' Fish and Boys' Fishing,"
David Starr Jordan

LESSON 107

The Earthworm

Leading Thought — The earthworm is a creature of the soil and is of great economic importance.

Method — Any garden furnishes abundant material for the study of earthworms. They are nocturnal workers and may be observed by lantern or flashlight. To form some estimate of the work done in a single night, remove the "casts" from a square yard of earth one day, and examine that piece of earth the next. It is well to have a terrarium in the schoolroom for frequent observation. Scatter grass or dead leaves on top of the soil, and note what happens. For the study of the individual worm and its movements, each pupil should have a worm with some earth upon his desk.

Observations — 1. How does the earthworm crawl? How does it turn over? Has it legs? Compare its movement with that of a snake, another legless animal. What special provision for locomotion has the earthworm?

2. Compare the lengths of the contracted and extended body. How can the change be accounted for?

3. Describe the body — its shape and color — above and below. Examine the segments. Do all the worms have the same number? Compare the head end with the tail end of the body. Has every worm a "saddle," or clitellum?

4. Does the earthworm hear easily? Has it eyes? Is it sensible to smell or to touch? What sense is most strongly developed?

5. Describe the home of the earthworm. Is it occupied by more than one worm? How long does it take a worm to make a burrow? How does it protect its home? How does it make a burrow? In what kind of soil do you find earthworms at work?

6. Is the earthworm seen most often at night or by day? Where is it the rest of the time? How does it hold to its burrow? When is the tail end at the top? When the head end?

7. What is the food of the earthworm? How does it get its food?

8. Look for the eggs of the earthworm about manure piles or under stones.

9. What are the enemies of the earthworm? Is it a friend or an enemy to us? Why?

10. The earthworm is a good agriculturist. Why?

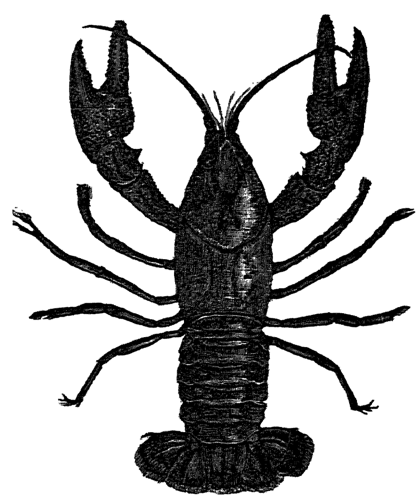
THE CRAYFISH

When I look at a crayfish I envy it, so rich is it in organs with which to do all that it has to do. From the head to the tail, it is crowded with a large assortment of executive appendages. In this day of multiplicity of duties, if we poor human creatures only had the crayfish's capabilities, then might we hope to achieve what lies before us.

The most striking thing in the appearance of the crayfish is the great pair of nippers on each of the front legs. Wonderfully are its "thumb and finger" put together; the "thumb" is jointed so that it can move back and forth freely; and both are armed, along the inside edge, with saw teeth and with a sharp claw at the tip so that they can get a firm grip upon an object. Five segments in these great legs can be easily seen; that joining the body is small, but each successive one is wider and larger, to the great forceps at the end. The two stout segments behind the nippers give strength, and also a suppleness that enables the claws to be bent in any direction.

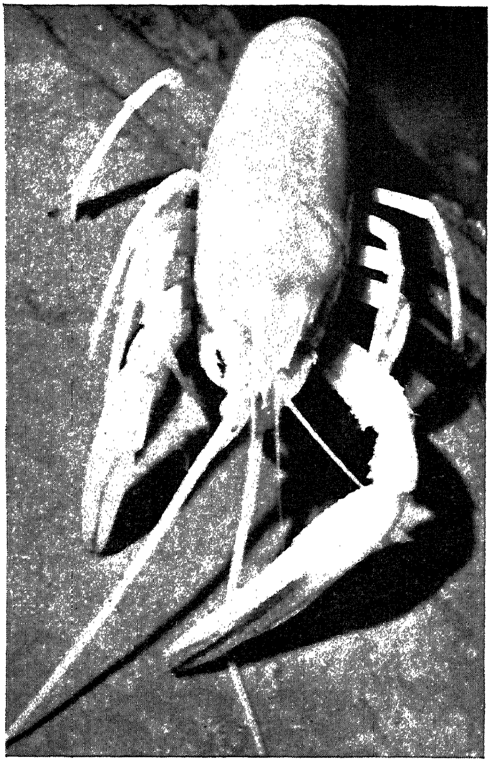
The legs of the pair behind the big nippers have five segments readily visible; but these legs are slender and the nippers at the end are small; the third pair of legs is armed like the second pair; but the fourth and fifth pairs lack the pincers, and end in a single claw.

But the tale of the crayfish's legs is by no means told; for between and above the great pincers is a pair of short, small legs



The crayfish

tipped with single claws, and fringed on their inner edges. These are the maxillipeds, or jaw-feet; and behind them, but too close to be seen easily, are two more pairs of jaw-feet. As all of these jaw-feet assist at meals, the crayfish apparently always has a "three-fork" dinner; and as



Charles E. Mohr

A blind white crayfish found living in the darkness of a cave in Kentucky

if to provide accommodations for so many eating utensils, it has three pairs of jaws all working sidewise, one behind the other. Two of these pairs are maxillæ and one, mandibles. The mandibles are the only ones we see as we look in between the jaw-feet; they are notched along the biting edge. Connected with the maxillæ, on each side, are two pairs of threadlike flappers that wave back and forth vigorously and have to do with setting up currents of water over the gills.

Thus we see that, in all, the crayfish has three pairs of jaw-feet, one pair of great nippers, and four pairs of walking feet, two of which also have nippers and are used for digging and carrying.

When we look upon the crayfish from above, we see that the head and thorax are fastened solidly together, making what is called a cephalothorax. The cephalothorax is covered with a shell called the carapace, which is the name given also to the upper part of the turtle's shell. The suture where the head joins the thorax is quite evident. In looking at the head, the eyes first attract our attention; each is black and oval and placed on the tip of a stalk, so it can be extended or retracted or pushed in any direction, to look for danger. These eyes are like the compound eyes of insects, in that they are made up of many small eyes, set together in a honeycomb pattern.

The long antennæ are as flexible as braided whiplashes, large at the base and ending in a threadlike tip. They are composed of many segments, the basal ones being quite large. Above the antennæ on each side is a pair of shorter ones called antennules, which come from the same basal segment; the lower one is the more slender and is usually directed forward; the upper one is stouter, curves upward, and is kept always moving, as if it were constantly on the alert for impressions. The antennæ are used for exploring far ahead or behind the creature, and are often thrust down into the mud and gravel at the bottom of the aquarium, as if probing for treasure. The antennules seem to give warning of things closer at hand. Between the antennæ and antennules is a pair of finger-like organs that are hinged at the outer ends and can be lifted back, if we do it carefully.

In looking down upon a crayfish, we can see six abdominal segments and the flaring tail at the end, which is really another segment greatly modified. The first segment, or that next to the cephalothorax, is narrow; the others are about equal in size, each graceful in shape, with a widened part at each side which extends down along the sides of the creature. These segments are well hinged together so that the abdomen may be completely curled beneath the cephalothorax. The plates along the sides are edged with fringe. The tail consists of five parts, one semicircular in the center, and two fan-shaped pieces at each side, and all are margined with fringe. This tail is a remarkable organ. It can be closed or extended sidewise like a fan; it can be lifted up or curled beneath.

Looking at the crayfish from below, we see on the abdomen some very beautiful feather-like organs called swimmerets. Each swimmeret consists of a basal segment with twin paddles joined to its tip, each paddle being narrow and long and fringed with hairs. The mother crayfish has four pairs of these, one pair on each of the second, third, fourth, and fifth segments; her mate has an additional larger pair on the first segment. These swimmerets, when at rest, lie close to the abdomen and are directed forward and slightly inward. When in motion, they paddle with a backward, rhythmic motion, the first pair setting the stroke and the other pairs following in succession. This motion sends the body forward, and the swimmerets are chiefly used to aid the legs in forward locomotion. A crayfish, on the bottom of a pond, seems to glide about with great ease; but place it on land, and it is an awkward walker. The reason for this difference lies, I believe, in the aid given by the swimmerets when the creature is in water. Latter says: "In walking, the first three pairs of legs pull and the fourth pair pushes. Their order of movement is as follows: The first on the right and the third on the left side move together, next the third right and the first left, then the second right and fourth left, and lastly the fourth right and second left."

When the crayfish really wishes to swim, the tail is suddenly brought into use; it is thrust out backward, lays hold of the water by spreading out widely, and then doubles under with a spasmodic jerk which pulls the creature swiftly backward.

The crayfish's appearance is magically transformed when it begins to swim; it is no longer a creature of sprawling awkward legs and great clumsy nippers; now, its many legs lie side by side supinely and the great claws are limp and flow along in graceful lines after the body, all obedient to the force which sends the creature flying through the water. I cannot discover that the swimmerets help in this movement.

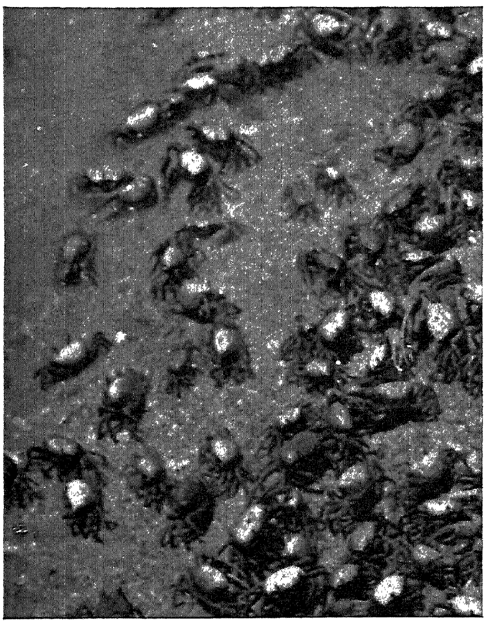
The mother crayfish has another use for her swimmerets; in the spring, when she is ready to lay eggs, she cleans off her paddles with her hind legs, covers them with waterproof glue, and then plasters her eggs on them in grapelike clusters of little dark globules. What a nice way to look after her family! The little ones hatch, but remain clinging to the maternal swimmerets until they are large enough to scuttle around on the brook bottom and look out for themselves.

The breathing apparatus of the crayfish cannot be seen without dissection. All the walking legs, except the last pair, have gills attached to that portion of them which joins the body, and which lies hidden underneath the sides of the carapace or shell. The blood is forced into these gills, sends off its impurities through their thin walls, and takes in the oxygen from the water, currents of which are kept steadily flowing forward.

Crayfishes haunt still pools along brooksides and river margins and the shallow ponds of our fresh waters. There they hide beneath sticks and stones, or in caves of their own making, the doors of which they guard with the big and threatening nippers, which stand ready to grapple with anybody that comes to inquire if the folks are at home. The upper surface of the crayfish's body is always so nearly the color of the brook bottom that the eye seldom detects the creature until it moves;

E. Morton Miller

A land crab, a relative of the crayfish. Note the eye-stalks and if some enemy surprises one, it swims off with terrific jerks which roil all the water around; thus it covers its retreat. In the winter, our brook forms hibernate in the muddy bottoms of their summer haunts. There are many species; some in our southern states, when the dry season comes on, live in little wells which they dig deep enough to reach water. They heap up the soil which they excavate



E. Morton Miller

Fiddler crabs, so called from the position in which the male often holds the enlarged claw, are burrowing crabs of the Atlantic coast

around the mouth of the well, making well-curbs of mud; these are ordinarily called "crawfish chimneys." The crayfishes find their food in the flotsam and jetsam of the pool. They seem fond of the flesh of dead fishes and are often trapped by its use as bait.

The growth of the crayfish is like that of insects; as its outer covering is a hard skeleton that will not stretch, it is shed as often as necessary; it breaks open down the middle of the back of the carapace, and the soft-bodied creature pulls itself out, even to the last one of its claws. While its new skin is yet elastic, it stretches to its utmost; but this skin also hardens after a time and is, in its turn, shed. Woe to the crayfish caught in this helpless, soft condition after molting! For it then has no way to protect itself. We sometimes find the old skin floating, perfect in every detail, and so transparent that it seems the ghost of a crayfish.

Not only is the crayfish armed in the beginning with a great number of legs, antennæ, etc., but if it happens to lose any of these organs they will grow again. We have often found one of these creatures with one of the front claws much larger than the other; it had probably lost its big claw in a fight, and the new growth was not yet completed.

I have been greatly entertained by watching a female crayfish make her nest in my aquarium, which has, for her comfort, a bottom of three inches of clean gravel. She always commences at one side by thrusting down her antennæ and nippers between the glass and stones; she seizes a pebble in each claw and pulls it up and in this way starts her excavation; but when she gets ready to carry off her load, she comes to the task with her tail tucked under her body, as a lady tucks up her skirts when she has something to do that requires freedom of movement. Then with her great nippers and the two pairs of walking feet, also armed with nippers, she loads up as much as she can carry between her great claws and her breast. She keeps her load from overflowing by holding it down with her first pair of jaw-feet, just as I have seen a schoolboy use his chin, when carrying a too large load of books; and she keeps the load from falling out by supporting it from beneath with her first pair of walking legs. Thus, she starts off with her "apron" full, walking on three pairs of feet, until she gets to the dumping place; then she suddenly lets go and at the same time her tail straightens out with a gesture which says plainly, "There!" Sometimes when she gets a very large load, she uses her second pair of walking legs to hold up the burden, and crawls off successfully, if not with ease, on two pairs of legs, — a most unnatural quadruped.

I had two crayfishes in a cage in an aquarium, and each made a nest in the gravel at opposite ends of the cage, heaping up the debris into a partition between them. I gave one an earthworm, which she promptly seized with her nippers; she then took up a good-sized pebble in the nippers of her front pair of walking legs, glided over to the other nest, spitefully threw down both worm and pebble on top of her fellow prisoner, and then sped homeward. Her victim responded to the act by rising up and expressing perfectly, in his attitude and the gestures of his great claws, the most eloquent of crayfish profanity. In watching crayfishes carry pebbles, I have been astonished to see how constantly the larger pair of jaw-feet are used to help pick up and carry the loads.

SUGGESTED READING — *The Pond Book*, by Walter P. Porter and Einar A. Hansen; *Scientific Living Series, Winter Comes and Goes*, by George W. Frasier, Helen Dolman, and Kathryne Van Noy; also, readings on page 416.

LESSON 108

THE CRAYFISH

LEADING THOUGHT — The crayfish, or crawfish, as it is sometimes called, has one pair of legs developed into great pincers for seizing and tearing its food and for defending itself from enemies. It can live in mud or water. It belongs to the same animal group as do the insects, and it is a near cousin of the lobster.

METHOD — Place a crayfish in an aquarium (a battery jar or a two-quart Mason jar) in the schoolroom, keeping it in clear water until the pupils have studied its form. It will rise to explore the sides of the aquarium at first, and thus show its mouth-parts, legs, and swimmerets. Afterwards, place gravel and stone in the bottom of the aquarium, so that it can hide itself in a little cavity which it will make by carrying pebbles from one side. Wash the gravel well before it is put in, so that the water will be unclouded and the children can watch the process of excavation.

OBSERVATIONS — 1. What is there peculiar about the crayfish which makes it difficult to pick it up? Examine one of these great front legs carefully and see how wonderfully it is made. How many parts are there to it? Note how each succeeding part is larger from the body to the claws. Note the tips which form the nippers, or chelæ, as they are called. How are they armed? How are the gripping edges formed to take hold of an object? How wide can the nippers be opened, and how is this done? Note the two segments behind the great claw and describe how they help the work of the nippers.

2. Study the pair of legs behind the great claws or chelæ, and compare the two pairs, segment by segment. How do they differ except as to size? How do the nippers at the end compare with the big ones? Look at the next pair of legs behind these; are they similar? How do the two pairs of hind legs differ in shape from the two pairs in front of them?

3. Look between the great front claws and see if you can find another pair of small legs. Can you see anything more behind or above these little legs?

4. When the crayfish lifts itself up against the side of the jar, study its mouth. Can you see a pair of notched jaws that work sidewise? Can you see two or three pairs of threadlike organs that wave back and forth in and out of the mouth?

5. How many legs, in all, has the crayfish? What are the short legs near the mouth used for? What are the great nippers used for? How many legs does the crayfish use when walking? In what order are they moved? Is the hind pair used for pushing? What use does it make of the pincers on the first and second pairs of walking legs?

6. Look at the crayfish from above; the head and the covering of the thorax are soldered together into one piece. When this occurs, the whole is called a cephalothorax; and the cover is called by the same name as the upper shell of the turtle, the carapace. Can you see where the head is joined to the thorax?

7. Look carefully at the eyes. Describe how they are set. Can they be pushed out

SEASHORE CREATURES

1. Sea Urchin, Strongylocentrotus. *The sea urchin is found along the Atlantic, Arctic, and Pacific coasts. Its habitat varies from tide pools and shallow waters to very deep water. The body of the living animal is a flattened hemisphere covered with short spines. What is usually described as a sea urchin is really the skeleton or "test."*

2. Fiddler Crab, Uca. *Fiddler crabs are common along the Atlantic coast of the United States. Above high tide great numbers of these crustaceans are found rushing into their burrows for shelter as one approaches.*

3. Common Starfish, Asterias. *One or the other of the two common varieties may be expected along the coast from the Gulf of Mexico to Labrador. The mouth is at the center of the lower surface of the animal and through the mouth the stomach is turned inside out to engulf and digest food. Its ability to devour mollusks makes the starfish a great enemy of oyster beds; it can force open the shells of an oyster, mussel, or other mollusk by pulling steadily with its strong arms and tubular feet. For that reason starfish caught at oyster beds are destroyed by plunging them into boiling water. Oystermen used to chop them in two and throw the pieces back into the water until they learned that each of the pieces could become a new starfish.*

4. Egg Cases *or* Fisherman's Purses, Elasmobranch. *These queer egg cases of sharks and skates are found empty along the shore.*

5. The Notch-side Shell, Pleurotoma nana. *This species belongs to a large family of shells with a world-wide distribution.*

6. Sand Dollar, Echinarachnius. *While sand dollars are capable of moving about over the ocean bottom by means of suckerlike feet, they do not seem able to right themselves if they are turned on their backs; and so thousands are cast helpless upon the shores by storms. They are found mostly from New Jersey northward to the Arctic Ocean. The specimens picked up on the shore are usually only the skeleton or "test." The skeleton shows a design in five rays branching from a common center, a clear indication that sand dollars and starfish are related.*

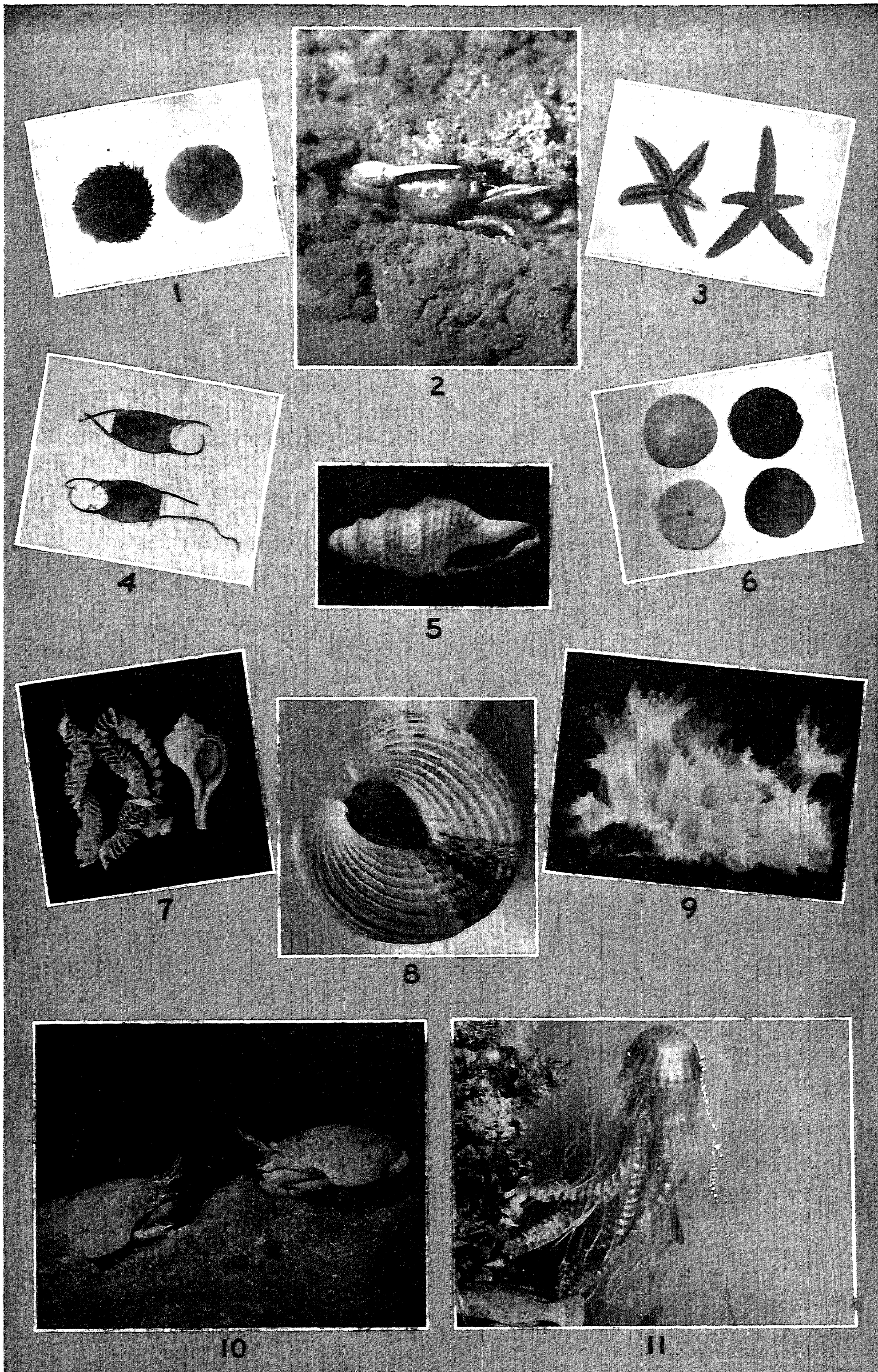
7. Giant Whelk, Busycon *or* Fulgur. *These whelks may be found from Cape Cod to the Gulf of Mexico, being most abundant along the coast of New Jersey and Long Island Sound on sandy or gravelly beaches near the low-tide level. The strings of egg capsules which are often found on the beach are unique; each tough capsule may contain about two dozen eggs or young whelks.*

8. Great Ark Shell, Arca. *The ark shells are cosmopolitan in their distribution; in addition to being distributed in both the Atlantic and Pacific oceans they are found in the Mediterranean.*

9. Star Coral, Astrangia danæ. *What one usually knows as coral is only the stony skeletal remains of coral animals; but pictured here are the living animal forms, known as polyps. They are glassy in appearance and each polyp has eighteen to twenty-four tentacles or stinging organs by means of which it captures its prey.*

10. Sand Crab, Hippa. *This very common yellowish-white crustacean, sometimes used for fish bait, lives in shallow water along the sandy beaches from New Jersey to Long Island. With its pointed abdomen as a tool a sand crab digs a burrow very quickly.*

11. Jellyfish. *The jellyfish is shaped like an umbrella and has its mouth and stomach in the position occupied by the handle of a real umbrella; the tentacles and other sense organs are attached to the outer edge of the umbrella. By means of its tentacles the jellyfish captures the small animals upon which it feeds.*



Courtesy of American Museum of Natural History or pulled in? Can they be moved in all directions? Of what advantage is this to the crayfish?

8. How many antennæ has the crayfish? Describe the long ones and tell how they are used. Do the two short ones on each side come from the same basal segment? These little ones are called the antennules. Describe the antennules of each side and tell how they differ. Can you see the little finger-like organs which clasp above the antennæ and below the antennules on each side of the head? Can these be moved?

9. Look at the crayfish from above. How many segments are there in the abdomen? Note how graceful is the shape of each segment. Note that each has a fan-shaped piece down the side. Describe how the edges of the segments along the sides are margined.

10. Of how many pieces is the tail made? Make a sketch of it. How are the pieces bordered? Can the pieces shut and spread out sidewise? Is the tail hinged so it can be lifted up against the back or curled under the body?

11. Look underneath the abdomen and describe the little fringed organs called the swimmerets. How many are there?

12. How does the crayfish swim? With what does it make the stroke? Describe carefully this action of the tail. When it is swimming, does it use its swimmerets? Why do not the many legs and big nippers obstruct the progress of the crayfish when it is swimming?

13. When does the crayfish use its swimmerets? Do they work so as to push the body backward or forward? Do you know to what use the mother crayfish puts her swimmerets?

14. Do you know how crayfishes breathe? Do you know what they eat and where they find it?

15. Where do you find crayfishes? Where do they like to hide? Do they go headfirst into their hiding place, or do they back in? Do they stand ready to defend their retreat? When you look down into the brook, are the crayfishes usually seen until they move? Why is this? Where do the crayfishes pass the winter? Did you ever see the crayfish burrows or mud chimneys?

16. If the crayfish loses one of its legs or antennæ, does it grow out again? How does the crayfish grow?

17. Put a crayfish in an aquarium which has three inches of coarse gravel on the bottom, and watch it make its den. How does it loosen up a stone? With how many legs does it carry its burden of pebbles when digging its cave? How does it use its jaw-feet, its nippers, and its first and second pairs of walking legs in this work?

A rock-lined, wood-embosomed nook,
Dim cloister of the chanting brook!
A chamber within the channeled hills,
Where the cold crystal brims and spills,
By dark-browed caverns blackly flows,
Falls from the cleft like crumbling snows,
And purls and splashes, breathing round
A soft, suffusing mist of sound.

— J. T. Trowbridge

DADDY LONGLEGS OR GRANDFATHER GREYBEARD

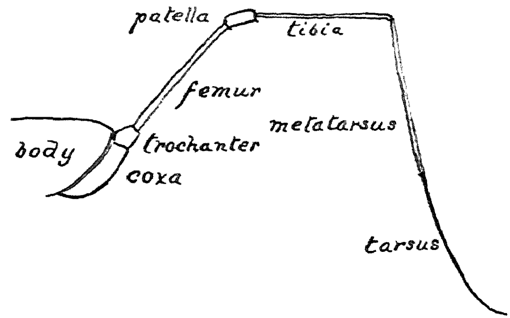
I wonder if there ever was a country child who has not grasped firmly the leg of one of these little sprawling creatures and demanded: "Grandfather Greybeard, tell me where the cows are or I'll kill you," and Grandfather Greybeard, striving to get away, puts out one of his long legs this way, and another that way, and points in so many directions that he usually saves his life, since the cows must be somewhere. It would be more interesting to the children and less embarrassing to the "daddy" if they were taught to look more closely at those slender, hairlike legs.

"Daddy's" long legs are seven-jointed. The first segment is seemingly soldered fast to the lower side of his body, and is called the coxa. The next segment is a mere knob, usually black and ornamental, and is called the trochanter. Then comes the femur, a rather long segment directed upward; next is a short swollen segment — the "knee joint" or patella; next the tibia, which is also rather long. Then come the metatarsus and tarsus, which seemingly make one long downward-directed segment, outcurving at the tips, on which the "daddy" tiptoes along.

I have seen a "daddy" walk into a drop of water, and his foot was never wetted, so light was his touch on the water surface film. The second pair of legs is the longest; the fourth pair next, and the first pair usually the shortest. The legs of the second pair are ordinarily used in exploring the surroundings. Notice that, when the "daddy" is running, these two legs are spread wide apart and keep in rapid motion; their tips, far more sensitive than any nerves of our own, tell him the nature of his surroundings, by a touch so light that we cannot feel it on the hand. We have more respect for one of these hairlike legs, when we know it is capable of transmitting intelligence from its tip.

Daddy longlegs

The "daddy" is a good traveler and moves with remarkable rapidity. And why not? If our legs were as long in comparison as his, they would be about forty feet in length. When the "daddy" is running, the body is always held a little distance above the ground; but when the second pair of legs suggests to him that there may be something good to eat in the neighborhood, he commences a peculiar teetering motion of the body, apparently touching it to the ground at every step; as the body is carried tilted with the head down, this movement enables the creature to explore the surface below him with his palpi, which he ordinarily carries bent beneath his face, with the ends curled up under his "chin." The palpi have four segments that are easily seen, and although they are ordinarily carried bent up beneath the head, they can be extended quite a distance if "daddy" wishes to test a substance. The end segment of the palpus is tipped with a single claw.



One of "daddy's" long legs with segments named

Beneath the palpi is a pair of jaws; these, in some species, extend beyond the palpi. I have seen a daddy longlegs hold food to his jaws with his palpi and he seemed also to use them for stuffing it into his mouth.

The body of the daddy longlegs is a little oblong object, looking more like a big grain of wheat than anything else, because in these creatures the head, thorax, and abdomen are all grown together compactly. On top of the body, between the feeler-legs, is a little black dot, and to the naked eye it would seem that if this were an organ of sight the creature must be a Cyclops with only one eye. But under the lens this is seen to be a raised knob, and there is on each side of it a little shining black eye. We hardly see the use of two eyes set so closely together, but probably the "daddy" does.

The most entertaining thing which a "daddy" in captivity is likely to do is to clean his legs; he is very particular about his legs, and he will grasp one close to the basal joint in his jaws and slowly pull it through, meanwhile holding the leg up to the jaws with the palpi, while he industriously nibbles it clean for the whole length to the very toe. Owing to the likelihood of his losing one of his legs, he has the power of growing a new one; so we often see a " daddy " with one or more legs only half grown.

There are many species of daddy longlegs in the United States, and some of them do not have the characteristic long legs. In the North, all except one species die at the approach of winter; but not until after the female, which, by the way, ought to be called " granny longlegs," has laid her eggs in the ground, or under some protecting stone, or in some safe crevice of wood or bark. In the spring the eggs hatch into tiny creatures which look just like the old daddy longlegs, except for their size. They get their growth like insects, by shedding their skins as fast as they outgrow them. It is interesting to study one of these cast skins with a lens. There it stands with a slit down its back, and with the skin of each leg absolutely perfect to the tiny claw! Again we marvel at these legs that seem so threadlike, and which have an outer covering that can be shed. Some say that the daddy longlegs live on small insects which they straddle over and pounce down upon, and some say they feed upon decaying matter and vegetable juices. This would be an interesting line of investigation for pupils, since they might be able to give many new facts about the food of these creatures. The " daddies " are night prowlers, and like to hide in crevices by day, waiting for the dark to hunt for their food. They have several common names. Besides the two given they are called " harvestmen " and the French call them " haymakers." Both of these names were very probably given because the creatures appear in greater numbers at the time of haying and harvesting.

SUGGESTED READING — *First Lessons in Nature Study*, by Edith M. Patch; also, readings on page 416.

LESSON 109

THE DADDY LONGLEGS

LEADING THOUGHT — These long-legged creatures have one pair of legs too many to allow them to be classed with the insects. They are more nearly related to the spiders, which also have eight legs. They are pretty creatures when examined closely, and they do many interesting things.

METHOD — Put a grandfather greybeard in a breeding cage or under a large tumbler, and let the pupils observe him at leisure. If you place a few drops of sweetened water at one side of the cage, the children will surely have an opportunity to see this amusing creature clean his legs.

OBSERVATIONS — 1. Where did you find the harvestman? What did it do as soon as it was disturbed? How many names do you know for this little creature?

2. A " daddy " with such long legs certainly ought to have them studied. How many segments in each leg? How do the segments look? How do the legs look where they are fastened to the body? Which is the longest pair of legs? The next? The next? The shortest?

3. If you had such long stilts as he has, they would be about forty feet long. Would you lift yourself that high in the air? Does the " daddy " lift his body high or swing it near the ground? What shape is the body? Can you see if there is a distinct head? Can you see a black dot on top of the front end of the body? If you should see this dot through a microscope it would prove to be two bright black eyes. Why should the daddy's eyes be on top?

4. Do you see a pair of organs that look like feelers at the front end of the body? These are called palpi. How does he use his palpi? Give him a little bruised or decaying fruit, and see him eat. Where do you think his mouth is? Where does he keep his palpi when he is not using them for eating?

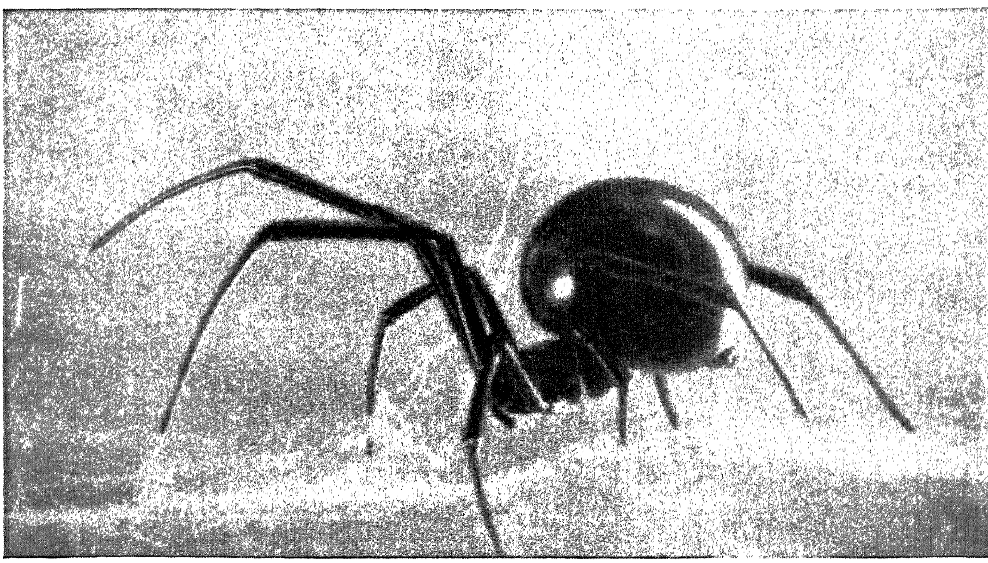
5. Note what care he takes of his legs. How does he clean them? Which does he clean the oftenest? Do you think the very long second pair of legs is used as much for feeling as for walking? Put some object in front of the " daddy " and see him explore it with his legs. How much of the leg is used as a foot when the " daddy " stands or runs?

6. When running fast, how does the

"daddy" carry his body? When exploring how does he carry it? Do you ever find the "daddy" with his body resting on the surface on which he is standing? When resting, are all eight of his legs on the ground? Which are in the air? Is the head end usually tilted up or down?

7. Do you see the daddy longlegs early in the spring? When do you find him most often? How do you suppose he passes the winter in our climate? Have you ever seen a "daddy" with one leg much shorter than the other? How could you explain this?

8. Try to discover what the daddy longlegs eats, and where he finds his food.



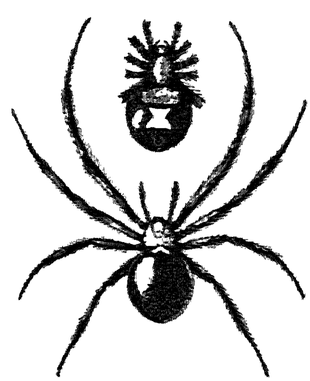
G. E. Jenks

The poisonous black widow or hourglass spider. It and the tarantula are the only dangerous spiders in the United States

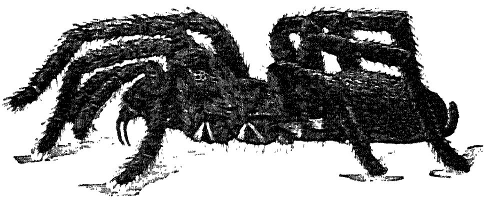
SPIDERS

The spiders are the civil engineers among the small inhabitants of our fields and woods. They build strong suspension bridges, from which they hang nets made with exquisite precision; and they build airplanes and balloons, which are more efficient than any that we have yet constructed; for although they are not exactly dirigible, yet they carry the little balloonists where they wish to go, and there are few fatal accidents. Moreover, the spiders are of much economic importance, since they destroy countless millions of insects every year, most of which are noxious — like flies, mosquitoes, bugs, and grasshoppers.

There is an impression abroad that all spiders are dangerous to handle. This is a mistake; the bite of any of our common spiders is not nearly so dangerous as the bite of a malaria-laden mosquito. Al-



Another view of the black widow. Above is the underside to show the red hourglass though there is a little venom injected into the wound by the bite of any spider, yet there are few species found in the United States whose bite is sufficiently



The tarantula, a large, dark-colored, hairy spider found in the Southwest. It is poisonous

venomous to be feared. With the exception of the tarantulas of the Southwest, and the hourglass or black widow, which seems now to be extending its range from the South, the spiders of the United States are really as harmless to handle as are most of our common insects.

There is no need for studying the anatomy of the spider closely in nature-study. Our interest lies much more in the wonderful structures made by the spiders, than in a detailed study of the little creatures themselves.

COBWEBS

Here shy Arachne winds her endless thread,
And weaves her silken tapestry unseen,
Veiling the rough-hewn timbers overhead,
And looping gossamer festoons between.

— Elizabeth Akers

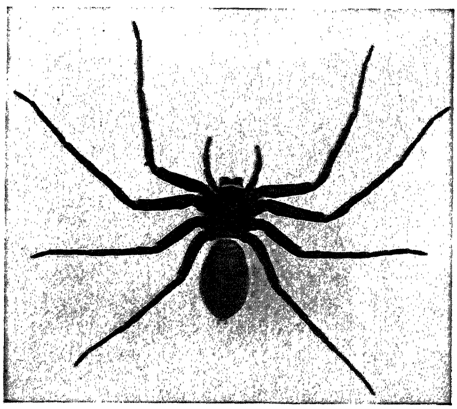
Our house spiders are indefatigable curtain-weavers. We never suspect their presence, until suddenly their curtains appear before our eyes, in the angles of the ceilings — invisible until laden with dust. The cobwebs are made of crisscrossed lines, which are so placed as to entangle any fly that comes near. The lines are stayed to the sides of the wall and to each other quite firmly, and thus they are able to hold a fly that touches them. The spider is likely to be in its little den at the side of the web; this den may be in a crevice in the corner or in a tunnel made of the silk. As soon as a fly becomes entangled in the web, the spider runs to it, seizes it in its jaws, sucks its blood, and then throws away the shell, the wings, and the legs. If a spider is frightened, it at first tries to hide and then may drop by a thread to the floor. If we catch the little acrobat it will usually "play possum" and we may examine it more closely through a lens. We shall find it is quite different in form from an insect. First to be noted, it has eight legs; but most important of all, it has only two parts to the body. The head and thorax are consolidated into one piece, which is called the cephalothorax. The abdomen has no segments like that of the insects, and is joined to the cephalothorax by a short, narrow stalk. At the front of the head is the mouth, guarded by two mandibles, each ending in a sharp claw, at the tip of which the poison gland opens. It is by thrusting these mandibles into its prey that it kills its victims. On each side of the mandible is a palpus, which in the males is of very strange shape. The eyes are situated on the top of the head. There are usually four pairs of these eyes, and each looks as beady and alert as if it were the only one.

The spinning organs of the spider are situated near the tip of the abdomen, while the spinning organ of the caterpillar

An orange garden spider and web. This spider is common in the United States; its web is spun in fields and gardens.

is situated near its lower lip. The spider's silk comes from two or three pairs of spinnerets which are finger-like in form, and upon the end of each are many small tubes from which the silk is spun. The silk is in a fluid state as it issues from the spinnerets, but it hardens immediately on contact with the air. In making their webs, spiders produce two kinds of silk: one is dry and inelastic, making the framework of the web; the other is sticky and elastic, clinging to anything that it touches. The body and the legs of spiders are usually hairy.

SUGGESTED READING — *Do you Know?* by Janet Smalley; *Fields and Fencerows,*



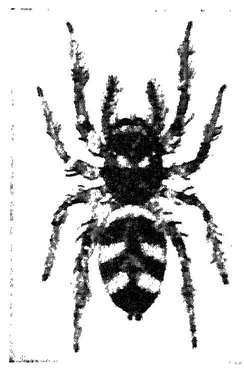
The banana spider. These spiders differ from other Arachnida by having the abdomen unsegmented and joined to the thorax by a short, narrow stalk as shown here

by Walter P. Porter and Einar A. Hansen; *First Lessons in Nature Study*, by Edith M. Patch; *Insect People*, by Eleanor King and Wellmer Pessels; *A Manual for the Study of Insects*, by John Henry Comstock, Anna B. Comstock, and Glenn W. Herrick; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 1, *Some Animals and Their Homes; Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 1, *Hunting*, Book 2, *Outdoor Visits*, Book 3, *Surprises*, Book 5, *Science at Home; Our Insect Friends and Foes and Spiders*, published by the National Geographic Society; *The Spider Book*, by John Henry Comstock (out of print); *Spider Webs and Sunflowers*, by Mary G. Phillips; also, readings on page 416.

LESSON 110

COBWEBS

LEADING THOUGHT — The cobwebs which are found in the corners of ceilings and in other dark places in our houses are



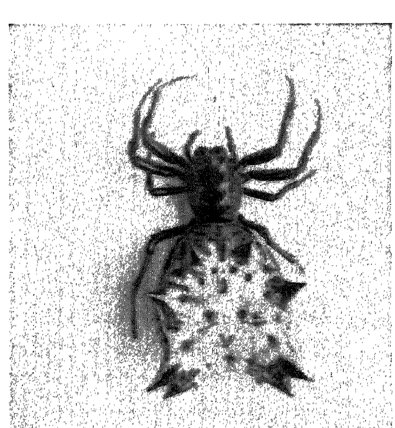
A jumping spider

made by the house spider, which spins its web in these situations for the purpose of catching insects.

METHOD — The pupils should have under observation a cobweb in a corner of a room, preferably with a spider in it.

OBSERVATIONS — 1. Is the web in a sheet or is it a mass of crisscrossed, tangled threads? How are the threads held in place?

2. What is the purpose of this web? Where does the spider hide? Describe its den.



The spiny-bellied spider

3. If a fly becomes tangled in a web, describe the action of the spider. Does the spider eat all of the fly? What does it do with the remains?

4. If the spider is frightened, what does it do? Where does the silken thread come from, and how does its source differ from the source of the silken thread spun by caterpillars?

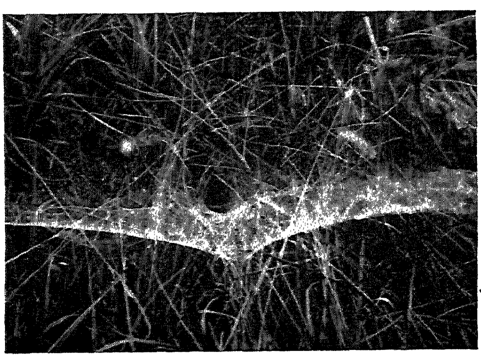
5. Imprison a spider under a tumbler or in a vial, and look at it very carefully. How many legs has it? How does the spider differ from insects in this respect? How many sections are there to the body? How does the spider differ from insects in this respect?

6. Look closely at the head. Can you see the hooked jaws, or fangs? Can you see the palpi on each side of the jaws? Where are the spider's eyes? How many pairs of eyes does it have?

When the tangled cobweb pulls
The cornflower's cap awry,
And the lilies tall lean over the wall
To bow to the butterfly,
It is July.
— Susan Hartley Swett

THE FUNNEL WEB OF A GRASS SPIDER

And dew-bright webs festoon the grass
In roadside fields at morning.
— Elizabeth Akers



The funnel web of a grass spider

Sometimes, on a dewy morning, a field will seem carpeted with these webs, each with its opening stretched wide, and each with its narrow hallway of retreat. The general shape of the web is like that of a broad funnel with a tube leading down at one side. This tube is used as a hiding place by the architect, the grass spider, which thus escapes the eyes of its enemies, and also keeps out of sight of any insects that might be frightened at seeing it, and so avoid the web. But the tube is no cul-de-sac; quite to the contrary, it has a rear exit, through which the spider, if frightened, escapes from attack.

The web is formed of many lines of silk crossing each other irregularly, forming a firm sheet. This sheet is held in place by many guy-lines, which fasten it to surrounding objects. If the web is touched lightly, the spider rushes forth from its lair to seize its prey; but if the web be jarred roughly, the spider speeds out through its back door and can be found only with difficulty. The smaller insects of the field, such as flies and bugs, are the chief food of this spider; it rarely attempts to seize a grown grasshopper.

The funnel-shaped webs in dark corners of cellars are made by a species which is closely related to the grass spider and has the same general habits, but which builds in these locations instead of in the grass.

Suggested Reading — *Holiday Meadow*, by Edith M. Patch; also, readings on page 437.

LESSON 111

The Funnel Web

Leading Thought — The grass spider spins funnel-shaped webs in the grass to entrap the insects of the field. This web has a back door.

METHOD — Ask the pupils to observe a web on the grass with a spider within it.

OBSERVATIONS — 1. What is the general shape of the web? Is there a tunnel leading down from it? Why is it called a funnel web?

2. Of what use is the funnel tube, and what is its shape? Where does it lead, and of what use is it to the spider? Can you corner a spider in its funnel tube? Why not?

3. How is the web made? Is there any regularity in the position of the threads that make it? By what means is it stayed in place?

4. Touch the web lightly, and note how the spider acts. Jar the web roughly, and what does the spider do?

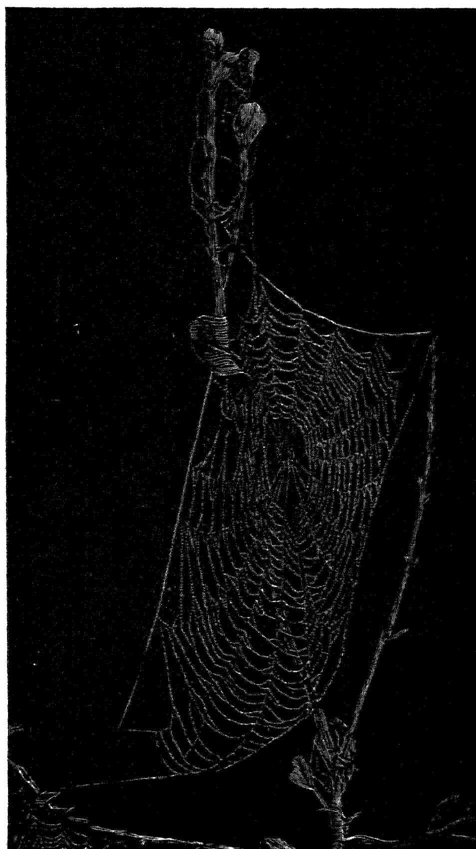
5. What insects become entangled in this web?

6. Compare this web with similar funnel webs found in corners of cellars, sheds, or porches, and see if you think the same kind of spider made both.

THE ORB WEB

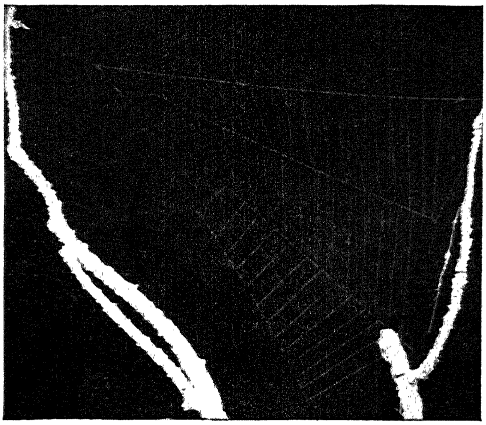
Of all the structures made by the lower creatures, the orb web of the spider is, beyond question, the most intricate and beautiful in design, and the most exquisite in workmanship. The watching of the construction of one of these webs is an experience that brings us close to those mysteries which seem to be as fundamental as they are inexplicable in the plan of the universe. It is akin to watching the growth of a crystal, or the stars wheeling across the heavens in their appointed courses.

The orb web of the large black and yellow garden spider is, perhaps, the best subject for this study, although many of the smaller orbs are far more delicate in structure. These orb webs are most often placed vertically, since they are thus more likely to be in the path of flying insects. The number of radii, or spokes, differs with the different species of spiders, and they are usually fastened to a silken framework, which in turn is fastened by guy-lines to surrounding objects. These radii or spokes are connected by a continuous spiral line, spaced regularly except at the center or hub; this hub or center is of more solid silk, and is usually surrounded by an open space; and it may be merely an irregular network, or it may have wide bands of silk laid across it.



An orb web on a dewy morning

The radii or spokes, the guy-lines, the framework, and the center of the web are all made of inelastic silk, which does not adhere to an object that touches it. The spiral line, on the contrary, is very elastic, and adheres to any object brought in contact with it. An insect which touches one of these spirals and tries to escape becomes entangled in the neighboring lines and is thus held fast until the spider can

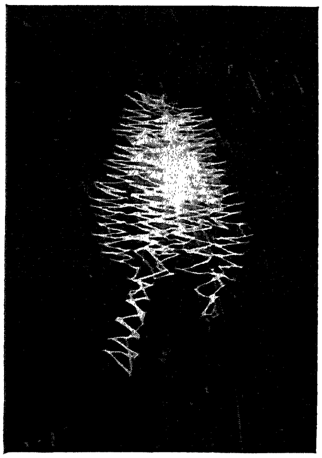


The finished web of a triangle spider

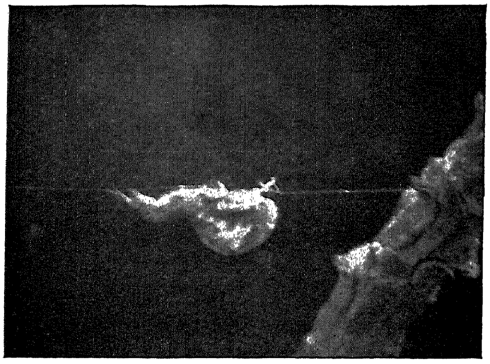
reach it. If one of these elastic lines be examined with a microscope, it is a most beautiful object. There are strung upon it, like pearls, little drops of sticky fluid which render it not only elastic but adhesive.

Some species of orb weavers remain at the center of the web, while others hide in some little retreat near at hand. If in the middle, the spider always keeps watchful claws upon the radii of the web so that if there is any jarring of the structure by an entrapped insect, it is at once apprised of the fact; if the spider is in a den at one side, it keeps a claw upon a trap line which is stretched tightly from the hub of the web to the den, and thus communicates any vibration of the web to the hidden sentinel. When the insect becomes entangled, the spider rushes out and envelops it in a band of silk, which feat it accomplishes by turning the insect over and over rapidly, meanwhile spinning a broad, silken band which swathes it. It may bite the insect before it begins to swathe it in silk or afterwards. It usually hangs the swathed insect to the web near where it was caught, until ready to eat it; it then takes the prey to the center of the web, if the spider usually sits there, or to its den at one side, if it is a den-making species, and there sucks the insect's blood, carefully throwing away the hard parts.

The spider does not became entangled in the web, because when it runs it steps upon the dry radii and not upon the sticky spiral lines. During the busy season, the spider is likely to make a new web every



Some of the orb weavers strengthen their orb webs by spinning a zigzag ribbon, as pictured above, across the center

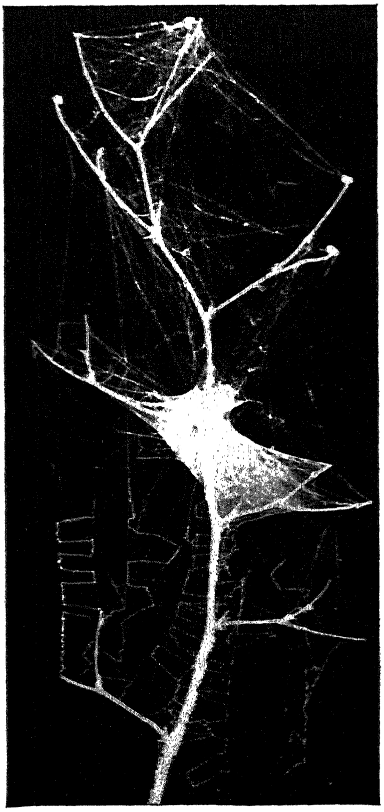


The triangle spider usually rests on the single line of the web

twenty-four hours, but this depends largely upon whether the web has meanwhile been destroyed by large insects.

The spider's method of making its first bridge is to place itself upon some high point and, lifting its abdomen in the air, to spin out on the breeze a thread of silk. When this touches any object, it adheres, and the spider draws in the slack until the linc is " taut "; it then travels across this bridge, which is to support its web, and makes it stronger by doubling the line. From this line, it stretches other lines by fastening a thread to one point, and then walking along to some other point, spinning the thread as it goes and holding the line clear of the object on which it is walking by means of one of its hind legs. When the right point is reached, it pulls the line tight, fastens it, and then, in a similar fashion, proceeds to make another. It may make its first radius by dropping from its bridge to some point below; then climbing back to the center, it fastens the line for another radius, and spinning as it goes, walks down and out to some other point, holding the thread clear and then pulling it tight before fastening it. Having thus selected the center of the web, it goes back and forth to and from it, spinning lines until all of the radii are completed and fastened at one center. It then starts at the center and spins a spiral, laying it on to the radii to hold them firm. However, the lines of this spiral are farther apart and much more irregular than the final spiral. Thus far, all of the threads the spider has spun are inelastic and not sticky; and this first or temporary spiral is used by the spider to walk upon when spinning the final spiral. It begins the latter at the outer edge instead of at the center, and works toward the middle. As the second spiral progresses, the spider with its jaws cuts away the spiral which it first made, and which it has used as a scaffolding. A careful observer may often see remnants of this first spiral on the radii between the lines of the permanent spiral. The spider works very rapidly and will complete a web in a very short time. The final spiral is made of the elastic and adhesive silk.

The spinner of this web, Amaurobius, *lives in a crevice in the cliff. The web was spun about the entrance*



The irregular web of a dictynid

Suggested Reading — Readings on page 437.

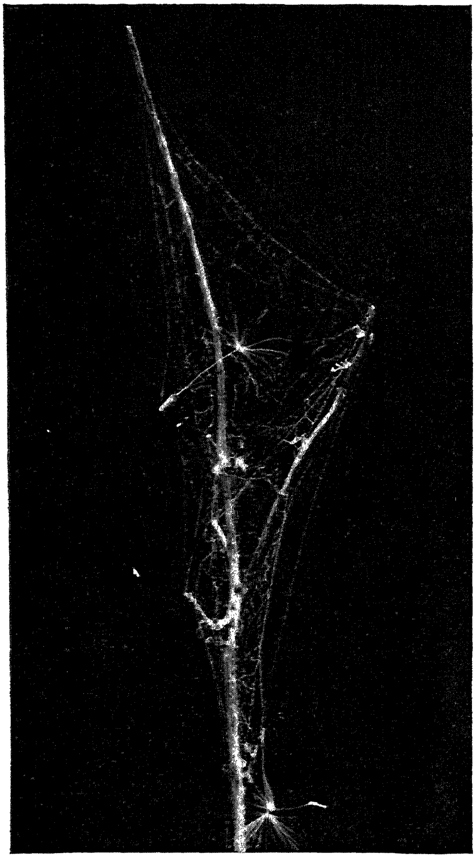
LESSON 112

The Orb Web

Leading Thought — Perhaps no structure made by a creature lower than man is so exquisitely perfect as the orb web of the spider.

Method — There should be an orb web where the pupils can observe it, preferably with the spider in attendance.

Observations — 1. Is the orb web usually hung horizontally or vertically?



Web of a hackled-band spider

2. Observe the radii, or "spokes," of the web. How many are there? How are they fastened to surrounding objects? Is each spoke fastened to some object or to a framework of silken lines?

3. Observe the silken thread laid around the spokes. Is it a spiral line or is each circle complete? Are the lines the same distance apart on the outer part of the web as at the center? How many of the circling lines are there?

4. Is the center of the web merely an irregular net, or are there bands of silk put on in zigzag shape?

5. Touch any of the "spokes" lightly with the point of a pencil. Does it adhere to the pencil and stretch out as you pull the pencil away? Touch one of the circling lines with a pencil point, and see if it adheres to the point and is elastic. What is the reason for this difference in the stickiness and elasticity of the different kinds of silk in the orb web?

6. If an insect touches the web, how does it become more entangled by seeking to get away?

7. Where does the spider stay, at the center of the web or in a little retreat at one side?

8. If an insect becomes entangled in the web, how does the spider discover the fact and act?

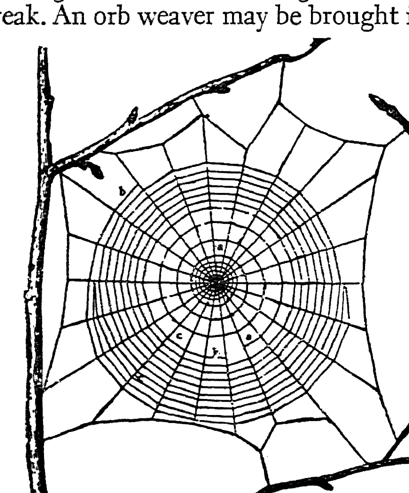
9. If the spider sits at the middle of the orb, it has a different method for discovering when an insect strikes the web than does the spider that hides in a den at one side. Describe the method of each.

10. How does the spider make fast an insect? Does it bite the insect before it envelops it in silk? Where does it carry the insect to feed upon it?

11. How does the spider manage to run about its web without becoming entangled in the sticky thread? How often does the orb weaver make a new web?

How an Orb Web is Made

Spiders may be seen making their webs in the early morning or in the evening. Find an orb web with a spider in attendance; break the web without frightening the spider and see it replace it in the early evening, or in the morning about daybreak. An orb weaver may be brought into



A partially completed orb web

a, the temporary spiral stay-line, b, the sticky spiral line, c, the fragments of the temporary spiral hanging to a radius the house on its web, when the web is on a branch, and placed where it will not be disturbed, and thus be watched at leisure.

OBSERVATIONS — 1. How does the spider manage to place the supporting line between two points?

2. How does it make the framework for holding the web in place?

3. How does it make the first radius?

4. How does it make the other radii and select the point which is to be the center of the web?

5. How does it keep the line which it is spinning clear of the line it walks upon?

6. After the radii are all made, are they fastened at the center?

7. How and where does the spider first begin to spin a spiral? Are the lines of this spiral close together or far apart? For what is the first spiral that the spider spins used?

8. Where does it begin to spin the permanent spiral? Where does it walk when spinning it? By the way it walks on the first spiral, do you think it is sticky and elastic? What does it do with the first spiral while the second one is being finished?

9. If the center of the web has a zigzag ribbon of silk, when was it put on?

10. How many minutes did it take the spider to complete the web?

THE FILMY DOME

Like bubbles cut in half, these delicate domes catch the light rays and separate them like a prism into waves of rainbow colors. One of these domes is usually about the size of an ordinary bowl, and is suspended with the opening on the lower side. It is held in place by many guy-lines which attach it to surrounding objects. Above a filmy dome are always stretched many crisscrossed threads for some distance up. These are for the purpose of hindering the flight of insects, so that they will fall into the web. The little spider, which always hangs, back downward, just below the center of the dome, rushes to its prey from the lower side, pulls it through the meshes of the web, and feeds upon it. But any remains of the insect or pieces of sticks or leaves which may drop upon the web, it carefully cuts out and drops to the ground, mending the hole very neatly.

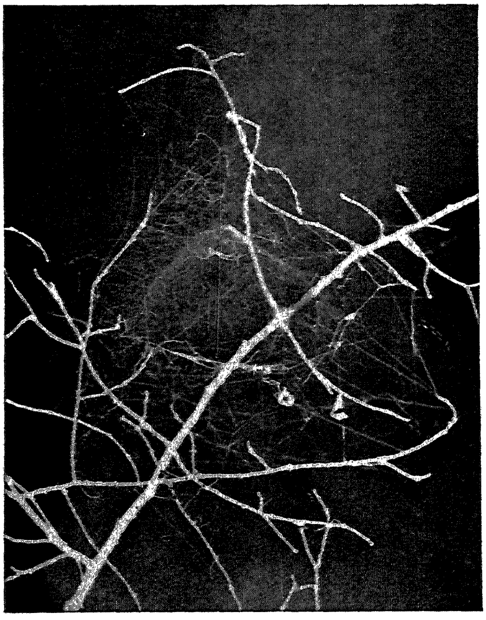
SUGGESTED READING — Readings on page 437.

LESSON 113

THE FILMY DOME

LEADING THOUGHT — One little spider spins a filmy dome, beneath the apex of which it hangs, back downward, awaiting its prey.

METHOD — On a sunny day in late summer or early autumn, while walking along woodland paths, the careful observer is sure to see suspended among the bushes or in the tops of weeds, or among dead branches of young hemlocks, the filmy dome webs. They are about as large as a small bowl, and usually so delicate that they cannot be seen unless the sun shines upon them; they are likely to be exquisitely iridescent under the sun's rays. Such a dome may be studied by a class or by the pupils individually.



A filmy dome web with its maker

OBSERVATIONS — 1. Where did you discover the filmy dome? What is the size of the dome? Does it open above or below? How is it held in place?

2. Are there many crisscrossed threads extending above the dome? If so, what do you think they are for?

3. Where does the spider stay? Is the spider large and heavy, or small and delicate?

4. What does the spider do if an insect becomes entangled in its web?

5. Throw a bit of stick or leaf upon a filmy dome web, and note what becomes of it.

With spiders I had friendship made,
And watch'd them in their sullen trade.

— "THE PRISONER OF CHILLON,"
LORD BYRON

BALLOONING SPIDERS

If we look across the grass some warm sunny morning or evening of early fall, we see threads of spider silk clinging every-

A sea of gossamer. The webs of ballooning spiders

where; these are not regular webs for trapping insects, but are single threads spun from grass stalk to grass stalk until the fields are carpeted with glistening silk. We have a photograph of a plowed field, taken in autumn, which looks like the waves of a lake; so completely is the ground covered with spider threads that it shows the " path of the sun " like water.

When we see so many of these random threads, it is a sign that the young spiders have started on their travels, and it is not difficult then to find one in the act. The spiderling climbs up some tall object, like a twig or a blade of grass, and sends out its thread of silk upon the air. If the thread becomes entangled, the spiderling sometimes walks off on it, using it as a bridge, or sometimes it begins again. If the thread does not become entangled with any object, there is soon enough given off for the friction of the air current upon it to support the weight of the body of the little creature, which promptly lets go its hold of earth as soon as it feels safely buoyed up, and off it floats to lands unknown. Spiders thus sailing through the air have been discovered in midocean.

Thus we see that the spiders have the same way of distributing their species over the globe as have the thistles and dandelions. It has been asked what the spiders live upon while they are making these long journeys, especially those that have drifted out to sea. The spider has very convenient habits of eating. When it finds plenty of food it eats a great deal; but in time of famine it lives on, apparently comfortably, without eating. One of our captive spiders was mislaid for six months and when we found her she was as full of " grit " as ever, and she did not seem to be abnormally hungry when food was offered her.

SUGGESTED READING — Readings on page 437.

A noiseless, patient spider,
I mark'd where on a little promontory it stood isolated,
Mark'd how to explore the vacant vast surrounding,
It launch'd forth filament, filament, filament out of itself:
Ever unreeling them, ever tirelessly speeding them.

And you O my soul where you stand,
Surrounded, detached, in measureless oceans of space,
Ceaselessly, musing, venturing, throwing, seeking the spheres to connect them,
Till the bridge you will need be form'd, till the ductile anchor hold;
Till the gossamer thread you fling catch somewhere, O my soul.

— Walt Whitman

LESSON 114

Ballooning Spiders

Leading Thought — The young of many species of spiders scatter themselves like thistle seeds in balloons which they make of silk.

Method — These observations should be made out-of-doors during some warm sunny day in October.

Observations — 1. Look across the grass some warm sunny morning or evening of early fall, and note the threads of spider silk gleaming everywhere, not regular webs, but single threads spun from grass stalk to grass stalk, or from one object to another, until the ground seems glistening with silk threads.

2. Find a small spider on a bush, fence post, or at the top of some tall grass stalk; watch it until it begins to spin out its thread.

3. What happens to the thread as it is spun out?

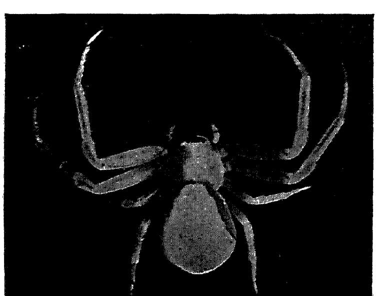
4. If the thread does not become entangled in any surrounding object what happens? If the thread does become entangled, what happens?

5. How far do you suppose a spider can travel on this silken airplane? Why should the young spider wish to travel?

THE WHITE CRAB SPIDER

There are certain spiders which are crab-like in form, and their legs are so arranged that they can walk more easily sidewise or backward than forward. These spiders spin no webs, but lie in wait for their prey. Many of them live upon plants and fences and, in winter, hide in protected places.

The white crab spider is a little rascal that has discovered the advantage of protective coloring as a means of hiding itself from the view of its victims, until it is too



The white crab spider

late for them to save themselves; the small assassin always takes on the color of the flower in which it lies concealed. In the

A white crab spider with a bee it has captured

white trillium, it is greenish white; while in the goldenrod its decorations are yellow. It waits in the heart of the flower, or in the flower clusters, until the visiting insect alights and seeks to probe for the nectar; it then leaps forward and fastens its fangs into its struggling victim. I have seen a crab spider in a milkweed attack a bee three times its size. This spider was white with lilac or purple markings. If disturbed, the crab spider can walk off awkwardly or it may drop by a silken thread. It is especially interesting, since it illustrates another use for protective coloring; and also because this species seems to be able to change its colors to suit its surroundings.

Suggested Reading — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*; also, readings on page 437.

LESSON 115

The White Crab Spider

Leading Thought — The white crab spider has markings upon its body of the same color as the flower in which it rests and is thus enabled to hide in ambush out of the sight of its victims — the insects which come to the flower for nectar.

Method — Ask the children to bring one of these spiders to school in the flower in which it was found; note how inconspicuous it is, and arouse an interest in the different colors which these spiders assume in different flowers.

Observations — 1. What is the shape of the body of the crab spider? Which of the legs are the longest? Are these legs directed forward or backward?

2. How is the body marked? What colors do you find upon it? Are the colors the same in the spiders found in the trilliums as those in other flowers? Why is this? Do you think that the color of the spider keeps it from being seen?

3. Place the white spider which you may find in a trillium or in a daffodil, and note if the color changes.

4. Do the crab spiders make webs? How do they trap their prey?

HOW THE SPIDER MOTHERS TAKE CARE OF THEIR EGGS

M. V. Slingerland

A crab spider on a goldenrod, upper right. The spider is white when lurking in the white trillium and yellow when among the flowers of the goldenrod

Protecting her eggs from the vicissitudes of the weather seems to be the spider mother's chief care; though at the same time and by the same means she protects them from the attacks of predacious insects. Many of the species make silken egg-sacs, which are often elaborate in construction, and are carefully placed in protected situations.

Often a little silvery disc may be seen attached to a stone in a field. It resembles a circular lichen on the stone, but if it is examined it is found to consist of an upper, very smooth, waterproof coat, while below is a soft, downy nest, completely enfolding the spider's eggs.

The egg-sacs of the cobweb weavers are often found suspended in their webs. One of the large orb weavers makes a very remarkable nest, which it attaches to the branches of weeds or shrubs. This sac is about as large as a hickory nut, and opens like a vase at the top. It is very securely suspended by many strong threads of silk,

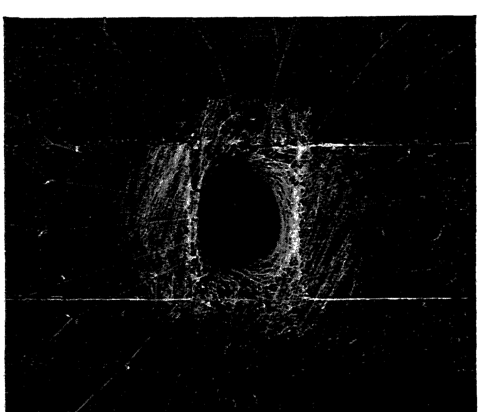
Entrance to the underground nest of a turret spider so that the blasts of winter cannot tear it loose. The outside is shining and waterproof, while inside it has a fit lining for a spiderling cradle.

A female turret spider with egg-sac

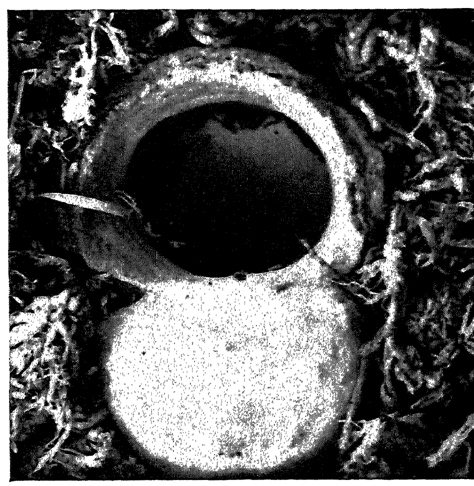
Dr. Burt G. Wilder studied the development of the inmates of one of these nests by cutting open different nests at different periods of the winter. In the autumn, the nest contained five hundred or more eggs. These eggs hatched in early winter but it seemed foreordained that some of the little spiders were born to serve as food for their stronger brethren. They seemed resigned to their fate, for when one of these victims was seized by its cannibalistic brother, it curled up its legs and submitted meekly. The result of this process was that, out of the five hundred little spiders hatched from the eggs, only a few healthy and apparently happy young spiders emerged from the nest in the spring, sustained by the nourishment afforded them by their own family, and fitted for their life in the outside world.

Some spiders make a nest for their eggs within folded leaves, and some build them in crevices of rocks and boards.

The running spiders, which are the large



The nest of Ariadna, *a long, slender tube of silk in a crack in a wood block*



Ward's Natural Science Establishment, Inc.

The trap-door spider and her nest. The spider digs a tunnel in the ground, coats the walls with earth and saliva, and then spins a lining of silk. The hinged door is a continuation of the walls with the outer surface covered with earth

ones found under stones, make globular egg-sacs; the mother spider drags after her this egg-sac attached to her spinnerets; the young, when they hatch, climb upon their mother's back, and there remain for a time.

Suggested Reading — Readings on page 437.

LESSON 116

The Nests of Spiders

Leading Thought — The spider mothers have many interesting ways of protect-

INVERTEBRATES

1. Water Spider, Lycosa. *This is one of very few spiders that frequent the water.*

2. House Centipede, Scutigera. *Each segment of the flattened body of this centipede bears a single pair of very long legs.*

3. Scorpion, Scorpionida. *A scorpion is characterized by a long, slender, flattened body which ends in a curved, venomous stinger. The sting causes much pain but is seldom if ever fatal to man.*

4. Millipede, Spirobolus. *These animals live in damp places and feed chiefly on decaying matter.*

5. Water Sow Bug, Asellus. *In the decaying vegetation and bottom trash of stagnant, shallow water, one often finds these flattened crustaceans.*

6 and 8. Fairy Shrimps, Eubranchipus. *These crustaceans always swim on their backs; they are about one inch long.*

7. Tadpole Shrimp, Apus. *This near relative of the fairy shrimp is an aquatic animal. It is shield-shaped like the horseshoe crab.*

9. Dog Louse, Linognathus piliferus. *This is the common louse of dogs; to the casual observer it could not be distinguished from the lice which infest other animals.*

10. Scud, Gammarus. *In the eastern United States, these may be found the year round in streams or ponds.*

11. Water Flea, Daphnia. *Daphnia is one of the many kinds of crustaceans called water fleas. They are usually found in quiet water where they feed on algæ. Water fleas are an important source of food for fish and aquatic insects.*

12. Pleurocera. *This mollusk is found in great variety and abundance in rivers in the eastern United States from the Great Lakes south.*

13. Copepod, Cyclops. *Cyclops represents a group of tiny crustaceans known as copepods.*

14. Fresh-water Limpet, Ancylus. *These snails are generally distributed; they live in streams as well as in quiet water.*

15. Goniobasis. *Full grown fresh-water snails of this species are 1¼ inches long; they are found in rapid currents as well as among plant growth of quiet waters.*

16. Vivipara. *These snails may reach a length of 2 inches; they are found on the muddy bottoms of streams and lakes.*

17. Wheel Snails, Helisoma (Planorbis). *The shell is coiled in a flat spiral with a sunken center.*

18. Campeloma. *This snail is found from the St. Lawrence River to the Gulf of Mexico. The young are born alive.*

19. Valvata. *This small, widely distributed snail exists in great numbers in both deep and shallow water.*

20. Bythinia. *This European snail has been introduced, by the operations of commerce, into the Hudson River and the Great Lakes region.*

21. Amnicola. *On sandy bottoms and among water vegetation, these snails are widely distributed in shallow water.*

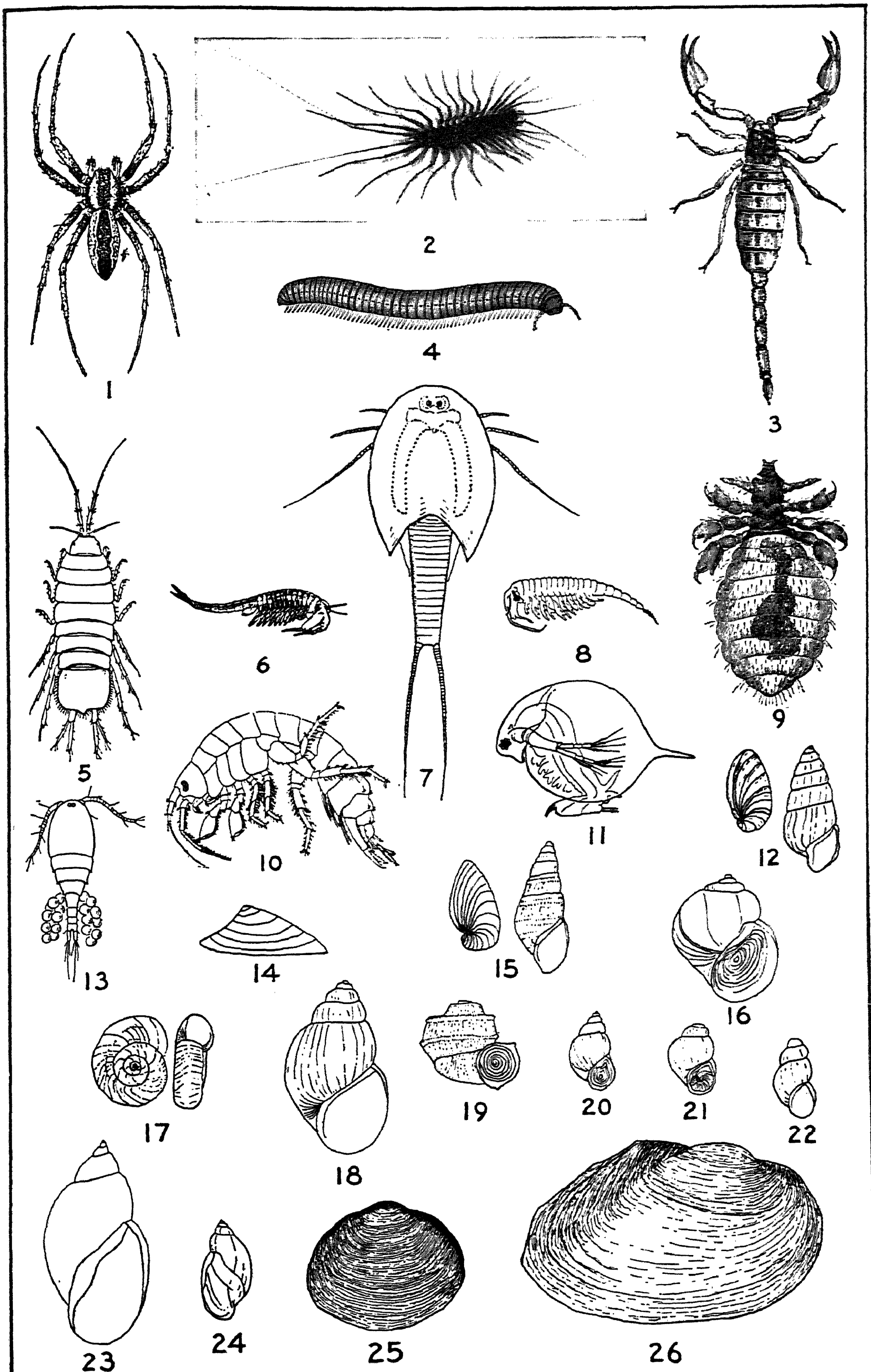
22. Paludestrina. *These tiny snails, about one-sixth of an inch long, are distributed from the Atlantic to the Pacific in fresh water.*

23. Common Pond Snail, Lymnæa. This *snail represents a widely distributed group of common snails which differ greatly in size; they form an important item in the food of water birds, fishes, and frogs.*

24. Pouch Snail, Physa. *Pouch snails are remarkably active. In color and shape they vary so greatly that it is often difficult to identify them. They are interesting to observe and may be kept easily in an aquarium.*

25. Fingernail Clam, Sphærium. *These small white mussels are about half an inch long; they are widely distributed, being found in the fresh water of almost any pond, stream, or lake.*

26. Paper-shell Mussel, Anodonta. *The shell of this snail is thin, usually smooth, and often marked by concentric rings. They are found from the Atlantic to the Pacific Ocean.*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The egg-sac of one of the orb weavers. It is made in the autumn and contains 500 or more eggs. The eggs hatch early in the winter but no spiders emerge until spring. During the winter the stronger spiders calmly devour their weaker brothers, and in the spring those which survive emerge well nourished to fight their battles in the outside world

ing their eggs, which they envelop in silken sacs and place in safety.

METHOD — Ask the pupils to bring in all the spider egg-sacs that they can find. Keep some of them unopened, and open others of the same kind, and thus discover how many eggs are in the sac and how many spiderlings come out. This is a good lesson for September and October.

OBSERVATIONS — 1. In what situation did you find the nest? How was it protected from rain and snow? To what was it attached?

2. Of what texture is the outside of the sac? Is the outside made of waterproof silk? What is the texture of the lining?

3. How many eggs in this sac? What is the color of the eggs? When do the spiderlings hatch? Do as many spiders come out of the sac as there were eggs? Why is this?

PART III
PLANTS

HOW TO BEGIN THE STUDY OF PLANTS AND THEIR FLOWERS

W. C. Muenscher

Mountain laurel

The only right way to begin plant study with young children is through awakening their interest in and love for flowers. Most children love flowers naturally; they enjoy bringing flowers to school, and here, by teaching the recognition of flowers by name, may be begun this delightful study. This should be done naturally and informally. The teacher may say: "Thank you, John, for this bouquet. Why, here is a pansy, a bachelor's button, a larkspur, and a poppy." Or, "Julia has brought me a beautiful flower. What is its name, I wonder?" Then may follow a little discussion, which the teacher leads to the proper conclusion. If this course is consistently followed, the children will learn the names of the common flowers of wood, field, and garden, and never realize that they are studying anything.

The next step is to inspire the child with a desire to care for and preserve his bouquet. The posies brought in the perspiring little hand may be wilted and look dejected; ask their owner to place the stems in water, and call attention to the way they lift their drooping heads. Parents and teachers should very early inculcate in children this respect for the flowers which they gather; no matter how tired the child or how disinclined to further effort, when he returns from the woods or fields or garden with plucked flowers, he should be made to place their stems in water immediately. This is a lesson in duty as well as in plant study. Attention to the behavior of the thirsty flowers may be gained by asking the following questions:

1. When a plant is wilted how does it look? How does its stem act? Do its

Columbine, Aquilegia

leaves stand up? What happens to the flowers?

2. Place the cut end of the stem in water and look at it occasionally during an hour; describe what happens to the stem, the leaves, the blossom.

Some Needs of Plants

Another step in plant study comes naturally from planting the seeds in window-boxes or garden. This may be done in the kindergarten or in the primary grades. As soon as the children have had some experience in the growing of flowers, they should conduct some experiments which will teach them about the needs of plants. These experiments are fit for the work of the second or third grade. Uncle John says, "All plants want to grow; all they ask is that they shall be made comfortable." The following experiments should be made vital and full of interest, by impressing upon the children that through them they will learn to give their plants what they need for growth.

Experiment 1. *To find out in what kind of soil plants grow best* — Have the children of a class, or individuals representing a class, prepare four little pots or boxes, as follows: Fill one with rich, woods humus, or with potting earth from a florist's; another with poor, hard soil, which may be found near excavations; another with clean sand; another with sawdust. Plant the same kind of seeds in all four, and place them where they will get plenty of light. It is best to select seeds that germinate quickly, such as beans, radishes, lettuce, or calendula. Water them as often as needful. Note which plants grow the best. This trial should cover six weeks at least and attention should now and then be called to the relative growth of the plants.

Experiment 2. *To prove that plants need light in order to grow* — Fill two pots with the same rich soil; plant in these the same kind of seeds. Keep the soil moist; place one pot in the window and place the other in a dark closet or under a box, and note what happens; in which pot do the plants have the more normal growth? Or take two potted geraniums which look equally thrifty; keep one in the light and the other in darkness. What happens?

Experiment 3. *To show that the leaves turn toward light* — Place a geranium in a window and let it remain in the same position for two weeks. Which way do all the leaves face? Turn it around, and note what the leaves have done after a few days.

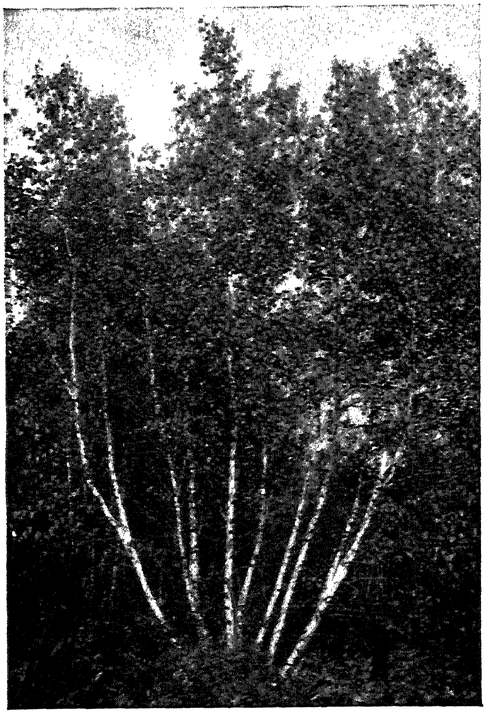
Experiment 4. *To show that plants need water* — Fill three pots with rich earth, plant the same kind of seeds in each, and place them all in the same window. Give one water sufficient to keep

Eva L. Gordon

A terrarium. This glass box with a hinged lid is easily made of six pieces of glass and some adhesive tape. When some soil is placed in such a box, various plants can be grown, and many kinds of insects, reptiles, or amphibians will be perfectly at home there the soil moist, keep another flooded with water, and give the other none at all. What happens to the seeds in the three pots?

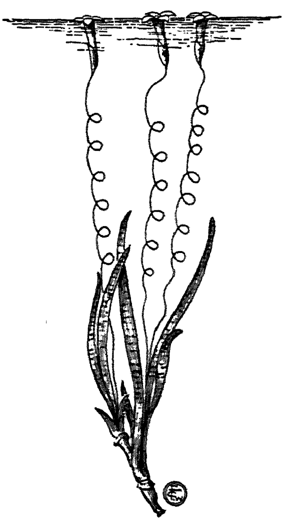
The success of these four experiments depends chiefly upon the genius of the teacher. The interest in the results should be keen; every child should feel that every seed planted is a living thing and that it is struggling to grow; every look at the experiments should be like another chapter in a continued story.

The explanations of these experiments should be simple, with no attempt to teach the details of plant physiology. The need of plants for rich, loose earth and for water is easily understood by the children; but the need for light is not so apparent, and Uncle John's story of the starch factory is the most simple and graphic way of making known to the children the processes of plant nourishment. He tells us that plants are like us; they have to have food to make them grow; where is the food and how do they find it? Every green leaf is a factory to make food for the plant; the green pulp in the



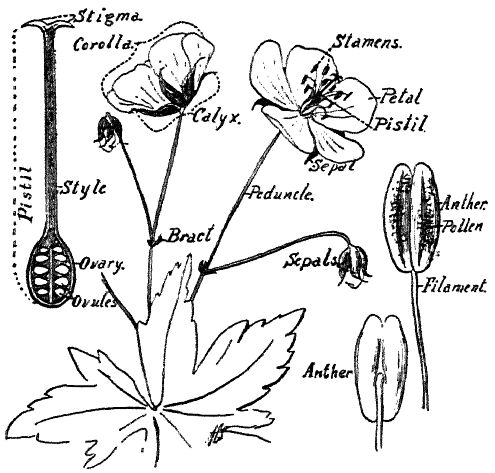
W. C. Muenscher

Gray or old field birch. Although these birches grow in clumps, several trunks from a common root, observe that the trunks soon separate widely, thus providing abundant light for the leaves



Eel grass, Vallisneria. *A quiet-water plant, eel grass produces its male flowers under water; its female flowers bloom at the top. When mature, the male flowers float to the surface, where pollination occurs; the female flowers are then retracted to mature the fruits under water. This plant is the favorite food of canvas-back ducks*

leaf is the machinery; the leaves get the raw materials from the sap and from the air, and the machinery unites them and makes them into plant food. This is mostly starch, for this is the chief food of plants, although they require some other kinds of food also. The machinery is run by sunshine-power, so the leaf-factory can make nothing without the aid of light; the leaf-factories begin to work as the sun rises, and stop working when it sets. But the starch has to be changed to sugar before the plant can use it for nourishment and growth; and so the leaves, after making the starch from the sap and the air, are obliged to digest it, changing the starch to sugar; for the growing parts of the plant feed upon sweet sap. Although the starch-factory in the leaves can work only during the daytime, the leaves can change the starch to sugar during the night. So far as we know, there is no starch



A flower with the parts named

in the whole world which is not made in the leaf-factories.

This story should be told and repeated often, until the children realize the work done by leaves for the plants and their need of light.

The clouds are at play in the azure space
And their shadows at play on the bright
green vale.
And here they stretch to the frolic chase;
And there they roll on the easy gale.

There's a dance of leaves in that aspen
bower,
There's a titter of winds in that beechen
tree,
There's a smile on the fruit and a smile
on the flower,
And a laugh from the brook that runs to
the sea.

— Bryant

How to Teach the Names of the Parts of a Flower and of the Plant

The scientific names given to the parts of plants have been the stumbling block to many teachers, and yet this part of plant study should be easily accomplished. First of all, the teacher should have in mind clearly the names of the parts which she wishes to teach; the illustrations here given are for her convenience. When talking with the pupils about flowers let her use these names naturally:

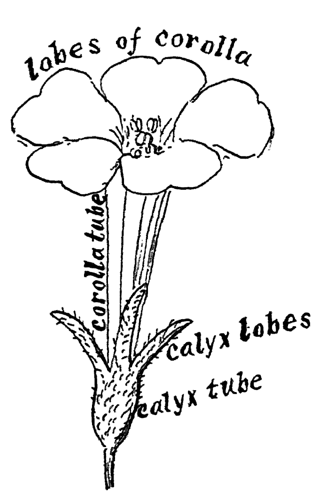
"See how many geraniums we have; the corolla of this one is red and of that one is pink. The red corolla has fourteen petals and the pink one only five," etc.

"This arbutus which James brought has a pretty little pink bell for a corolla."

"The purple trillium has a purple corolla, the white trillium a white corolla; and both have green sepals."

The points to be borne in mind are that children like to call things by their names because they are *real* names, and they also like to use "grownup" names for things; but they do not like to commit to memory names which to them are meaningless. Circumlocution is a waste of breath; calling a petal a "leaf of a flower" or the petiole "the stem of a leaf," is like calling a boy's arm "the projecting part of James's body" or Molly's golden hair "the yellow top" to her head. All the names should be taught gradually by constant unemphasized use on the part of the teacher; and if the child does not learn the names naturally then do not make him do it unnaturally.

The lesson on the garden or horseshoe geranium with single flowers may be given first in teaching the structure of a flower, since the geranium blossom is simple and easily understood.



A flower with petals united forming a tube, and with sepals likewise united

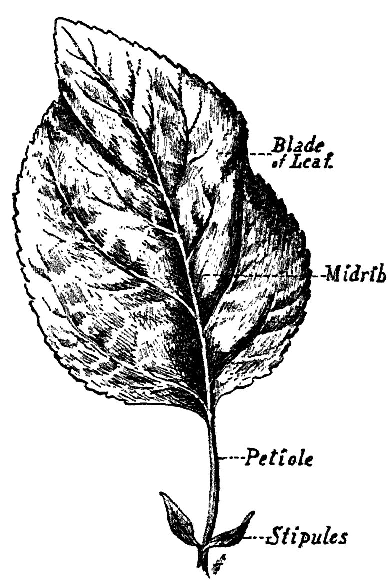
Teach the Use of the Flower

From first to last the children should be taught that the object of the flower is to develop seed. They should look eagerly into the maturing flower for the growing fruit. Poetry is full of the sadness of the fading flower, whereas rightly it should be the gladness of the flower that fades, because its work is done for the precious seed at its heart. The whole attention of the child should be fixed upon the developing fruit instead of the fading and falling petals.

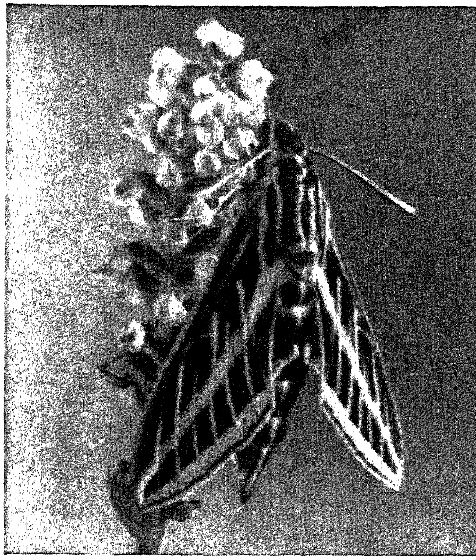
In all places then and in all seasons,
Flowers expand their light and soul-like wings,
Teaching us by most persuasive reasons,
How akin they are to human things.
— Longfellow

Flower and Insect Partners

It is undoubtedly true that the processes of cross-pollination and the complicated devices of flowers for insuring it can only be well taught to older pupils and only fully understood in the college laboratory; yet there are a few simple facts which even the young child may know, as follows:



A leaf with parts named



A hawk moth or sphinx. A moth may carry pollen from one flower to another

1. Pollen is needed to make most seeds form; some flowers need the pollen from other flowers of the same kind to produce their seeds; but many flowers use the pollen from their own flowers to pollinate their ovules, which grow into seeds.

2. Flowers have neither legs like some animals, nor have they wings like butterflies, therefore they cannot go after pollen; in seeking food and drink from flowers insects carry pollen from one flower to another.

I taught this to a four-year-old once in the following manner: A pine tree in the yard was sifting its pollen over us and little Jack asked what the yellow dust was; we went to the tree and saw where it came from, and then I found a tiny young cone and explained to him that this was a pine blossom, and that in order to become a cone with seeds, it must have some pollen fall upon it. We saw that the wind sifted the pollen over it and then we examined a ripe cone and found the seeds. Then we looked at the clovers in the lawn. They did not have so much pollen and they were so low in the grass that the wind could not carry it for them; but right there was a bee. What was she doing? She was getting honey for her hive or pollen

A skipper visiting flowering heads of English plantain

for her brood, and she went from one clover head to another; we caught her in a glass fruit jar, and found she was dusted with pollen and that she had pollen packed in the baskets on her hind legs; and we concluded that she carried plenty of pollen on her clothes for the clovers, and that the pollen in her baskets was for her own use. After that he was always watching the bees at work. We found afterwards, that insects seem to be called to the flowers by color or by fragrance, or by both of these means. The dandelion we watched was very bright and the insects were busy there; then we found bees working on mignonette whose blossoms were so small that Jack did not think they were blossoms at all, and we concluded that in this case the bees were attracted by fragrance. We found other flowers which attracted bees by both color and fragrance; and this insect-flower partnership remained a factor of great interest in the child's mind.

The Relation of Plants to Geography

There should be from first to last a steady growth in the intelligence of the child as to the places where certain plants grow. He finds hepaticas and trilliums in the woods, daisies and buttercups in the sunny fields, mullein on the dry hillsides, cattails in the swamp, and water lilies floating on the pond. This may all be taught by simply asking the pupils questions relating to the soil and the special conditions of the locality where they found the flowers they bring to school.

Seed Germination

In the early days of nature-study, this one feature of plant life came near " gobbling up " all of nature-study, and yet it is merely an incident in the growth of the plant. To sprout seeds is absurd as an object in itself; it is incidental as is the breaking of the egg-shell to the study of the chicken. The peeping into a seed like a bean or a pea to see that the plant is really there, with food material for its

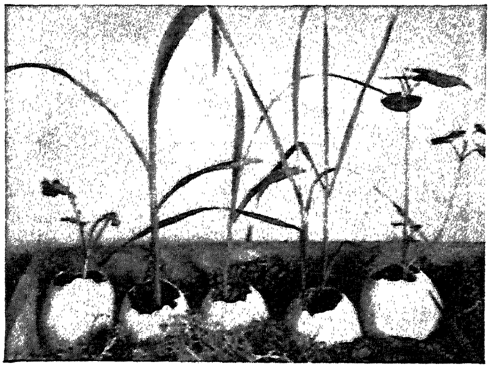
W. P. Alexander

Early saxifrage. This spring flower is at home on exposed rocks and dry hillsides future growth packed all around it, is interesting to the child. To watch the little plant develop, to study its seed leaves and what becomes of them, to know that they give the plant its first food and to know how a young plant looks and acts, are all items of legitimate interest in the study of the life of a plant; in fact the struggle of the little plant to get free from its seed coats may be a truly dramatic story. But to regard this feature as the chief object of planting seed is manifestly absurd.

The object of planting any seed should be to rear a plant which shall fulfill its whole duty and produce other seed. The following observations regarding the germination of seeds should be made while the children are eagerly watching the coming of the plants in their gardens or window-boxes:

1. Which comes out of the seed first, the root or the shoot and leaves? Which way does the root grow, up or down? Which way do the leaves grow, no matter which side up the seed is planted?

2. How do the seed leaves get out of the seed coat, or shell? How do the seed leaves differ in form from the leaves which come later? What becomes of the seed leaves after the young plant begins to grow?



Egg-shell experiment farm. The plants from left to right: cabbage, field corn, popcorn, wheat, buckwheat

SUGGESTED READING — *The Book of Plants*, by Bertha M. Parker and Henry C. Cowles; *Discovering Our World*, by Wilbur L. Beauchamp and Co-authors, Book 1; *First Studies of Plant Life*, by George Francis Atkinson; *The Flyaways and Other Seed Travelers*, by Francis M. Fultz; *How to Know the Wild Fruits*, by Maude G. Peterson; *Nature — by Seaside and Wayside*, by Mary G. Phillips and Julia M. Wright, Book 3, *Plants and Animals*, Book 4, *Our Earth and Its Life*; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 6, *The Work of Scientists*; *Nature Stories for Children*, by Nora B. Albright, Eva L. Gordon, and Jennie Hall, *Spring, Autumn*, and Books 1 and 2; *Plants and Their Children*, by Mrs. William Starr Dana (Frances Theodora Parsons); *Plants Useful to Man*, by Wilfred W. Robbins and Francis Ramaley; *Science of Plant Life*, by Edgar N. Transeau; *Science Stories*, by Wilbur L. Beauchamp and Co-authors, Books 1, 2, and 3; *Useful Wild Plants of the United States and Canada*, by Charles F. Saunders; *Wild Flowers and Ferns in Their Homes and in Our Gardens*, by Herbert Durand. Additional references are to be found in the bibliography in the back of this Handbook, under various headings: Plant Life, Nature-study in General, Textbooks and Readers, Nature Poetry, Magazines and Periodicals, Books for Parents and Teachers.

WILD FLOWERS

Because of their beauty and scientific value, special need exists for the protection of our native wild flowers and shrubs. It is understandable that these uncultivated

O. L. Foster

Spring beauty

plants should attract the visitor, but in too many instances he is not satisfied to enjoy their beauty as they exist in their natural habitats. All too frequently he picks flowers in large numbers, only to discard them faded and wilted a few hours later. Often valuable plants are dug out or pulled up by their roots, probably with the idea that these flowers or shrubs would have the same beauty in a garden as in the woods or fields where they grow naturally. Such practices are to be discouraged. In the first place, wild flowers are almost always most attractive in their natural surroundings. Furthermore the transplanting of flowers and shrubs from woods or swamps to a cultivated garden is a delicate operation, and there is very little likelihood of its being accomplished successfully.

Extensive removal of these plants whether from field, marsh, or woods is likely to bring about the extinction of certain species and from both scientific and æsthetic standpoints this is highly unfortunate.

The malicious destruction of flowering plants should, of course, not be allowed. Some plants are so rare, or otherwise in danger of extinction, that state laws have been enacted which protect them. For example in New York State, trailing arbutus, flowering dogwood, fringed gentian, pink lady's-slipper, yellow lady's-slipper, and mountain laurel are protected by law.

Some flowers are so abundant that they can be picked in moderation if the roots are not disturbed, if plenty of flowers are left for seed, and if the plant itself is not taken with the flower. Trilliums, for example, cannot be picked without seriously harming the plant, for the food-producing leaves and stem are taken with the flower. Everyone should have the privilege of en-

O. L. Foster

Cut-leaved toothwort or pepper-root

joying the natural beauty of the countryside. Such enjoyment is impossible if a relatively small number of people insist upon picking and destroying native plants for their own selfish interests.

SUGGESTED READING — *Book of Wild Flowers for Young People*, by F. Schuyler Mathews; *Field Book of American Wild Flowers*, by F. Schuyler Mathews; *The Flower Finder*, by George L. Walton; *Flower Guide: Wild Flowers East of the Rockies*, by Chester A. Reed; *A Guide to the Wild Flowers*, by Alice Lounsberry; *A Guide to the Wild Flowers East of the Mississippi and North of Virginia*, by Norman Taylor; *How to Know the Wild Flowers*, and *According to Season*, both by Mrs. William Starr Dana (Frances Theodora Parsons); *My Wild Flower Garden*, by Herbert Durand; *Flowers of the Wild: Their Culture and Requirements*, by Frank C. Pellett; *National Geographic Book of Wild Flowers*, by E. J. Showalter; *Our Early Wild Flowers*, *The Wayside Flowers of Summer*, *Our Northern Autumn*, all by Harriet L. Keeler; *Wild Flowers*, by Homer D. House; also, readings on page 459.

THE HEPATICA

The wise men say the hepatica flower has no petals but has pink, white or purple sepals instead: and they say, too, that the three leaflets of the cup which holds the flower are not sepals but are bracts; and they offer as proof the fact that they do not grow close to the blossom, but are placed a little way down the stem. But the hepatica does not care what names the wise men give to the parts of its blossom: it says as plainly as if it could talk: "The bees do not care whether they are sepals or petals since they are pretty in color, and show where the pollen is to be found. I will teach the world that bracts are just as good to wrap around flower-buds as are sepals, and that sepals may be just as beautiful as petals. Since my petticoat is pretty enough for a dress why should not I wear it thus?" — "THE CHILD'S OWN BOOK OF WILD FLOWERS"

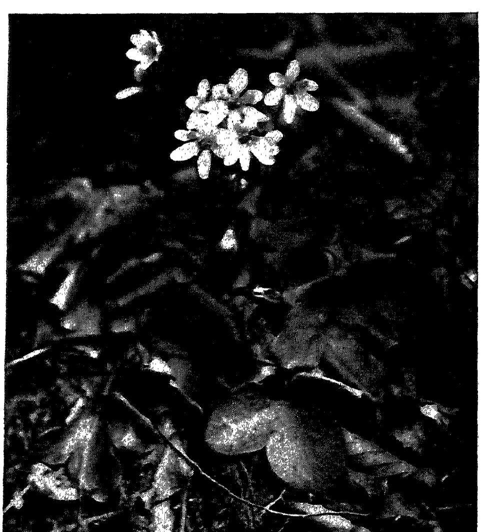
We seek the hepatica in its own haunts, because there is a longing for spring in our hearts that awakens with the first warm sunshine. As we thread our way into sodden woods, avoiding the streams and puddles which are little glacial rivers and lakes, having their sources in the snowdrifts still heaped on the north side of things, we look eagerly for signs of returning life. Our eyes slowly distinguish among the various shades of brown in the floor of the forest, a bit of pale blue or pink-purple that at first seems like an optical illusion; but as we look again to make sure, lo! it is the hepatica, lifting its delicate blossoms above its mass of purple-brown leaves. These leaves, moreover, are always beautiful in shape and color and suggest patterns for sculpture like the acanthus, or for rich tapestries like the palm leaf in the Orient. It warms the heart to see these brave little flowers stand with their faces to the sun and their backs to the snowdrifts, looking out on a gray-brown world, nodding to it and calling it good.

In the spring, new leaves may appear very soon after the flowers; these leaves are present until the following spring. The hepatica flowers are white, pink, and lavender; the latter are sometimes called "blue." The colored floral parts, so-called petals, are in reality all sepals and often vary in number, from six to twelve. On dark days and during the night, the young blossoms close; but when they become old and faded they remain open all the time.

There are many stamens with greenish white anthers and pollen. They stand erect around the many pistils at the center of the flower. The number of pistils varies from six to twenty-four. Each holds aloft the little horseshoe-shaped, whitish stigma, which if pollinated usually develops into a fruit. The hepatica is a per-

Hepaticas

ennial, and its natural habitat is rich, moist woods. While it is adapted to the shade of woods, it can be successfully transplanted to suitable situations in lawns and gardens. The leaves which have passed the winter under the snow are rich purple beneath and mottled green and purple above, making beautiful subjects for water color drawings. The new hepatica leaves are put forth in the spring, before the leaves appear on the trees. The roots are quite numerous and fine.



Robert Conn

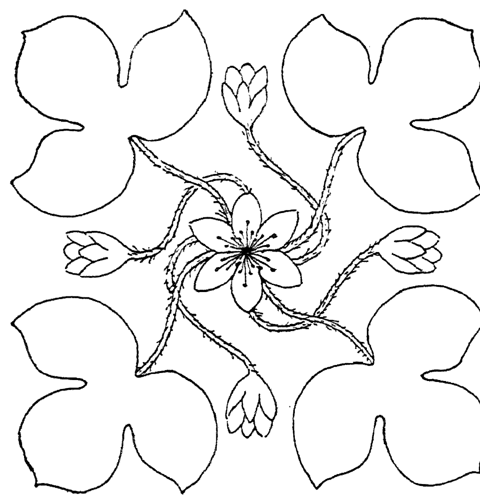
Hepaticas in natural surroundings

LESSON 117

The Hepatica

Leading Thought — The hepatica flower buds are developed in the fall, and are ready to blossom early in the spring. This plant thrives best in moist and shady woods.

Method — The pupils should have the questions before they go into the woods to observe spring flowers, and should answer them individually.



Evelyn Mitchell

Embroidery design from the hepatica

Observations — 1. Where do you find the hepaticas? Do you ever find them in the open fields? Do you ever find them in the pine woods?

2. How do the leaves look in early spring? Sketch in color one of these old leaves. How do the young leaves look? Are the leaves that come up late in the spring as fuzzy as those that appear early? What is the difference in texture and color between the leaves that remained over winter and those that appear in the spring?

3. Find a hepatica plant before it be-

gins to blossom. Look, if possible, at its very center. Describe these little flower buds.

4. How does the bud look when it begins to lift up? Describe the stems and the little bracts that hold the bud.

5. Are the hepaticas in your woods all pink, or blue, or white? Do those which are at first pink or blue fade to white later? Do the blossoms keep open during the night and in stormy weather? Are they all fragrant?

6. How many sepals has your hepatica? Turn back the three sepal-like bracts and see that they are not a part of the flower at all but join the stem below the flower.

7. Describe the stamens in the hepatica. How many pistils are there? Does each pistil develop into a fruit?

8. What insects do you find visiting the hepaticas?

9. Describe a hepatica plant in the woods; mark it so that you will know it, and visit it occasionally during the summer and autumn, noting what happens to it.

THE YELLOW ADDER'S-TONGUE

Once a prize was offered to a child if she would find two leaves of the adder's tongue that were marked exactly alike: and she sought long and faithfully, but the only prize she won was a lesson in Nature's book of variations, where no two leaves of any plant, shrub or tree are exactly alike: for even if they seemed so to our eyes, yet there would exist in them differences of strength and growth too subtle for us to detect. But this child was slow in learning this great fact, and, until she was a woman, the adder's-tongue leaves, so beautifully embroidered with purple and green, were to her a miracle, revealing the infinite diversity of Nature's patterns.

— "The Child's Own Book of Wild Flowers"

This little lily of the woods is a fascinating plant. Its leaves of pale green mottled with brownish purple often cover closely large irregular areas in the rich soil of our woodlands and it is sometimes found in open fields; yet I doubt if the underground story of these forest rugs is often thought of. The leaves are twins, and to the one who plucks them carelessly they seem to come from one slender stem. It requires muscle as well as decision of character to follow this weak stem down several inches, by digging around it, until we find the corm at its base. A corm is the swollen base of a stem and is bulblike in form; but it is not made up of layers, as is a bulb. It is a storehouse for food and also a means of spreading the species; for from the corms there grow little corms called cormels, and each cormel develops a separate plant. This underground method of reproduction is the secret of why the leaves of the adder's-tongue appear in patches, closely crowded together.

Only a few of the plants in a "patch" produce flowers, and it is interesting to see how cleverly these lily bells hide from the casual eye. Like many of the lilies, the three sepals are petal-like and are identified as sepals only by their outside position, although they are thicker in texture.

W. P. Alexander

Adder's-tongue or dog's-tooth violet

They are purplish brown outside, which makes the flower inconspicuous as we look down upon it; on the inner side, they are a pure yellow, spotted with darker yellow near where they join the stem. The three petals are pure yellow, paler outside than in, and they have dark spots like the tiger lilies near the heart of the flower; and where they join the stem, each has on each side an ear-shaped lobe.

Verne Morton

Adder's-tongue going to seed

The open flower is bell-shaped; and like other bells it has a clapper, or tongue. This is formed by six downward-hanging stamens, the yellow filaments of which have broad bases and taper to points where the oblong anthers join them. The anthers are red or yellow. It is this stamen clapper that the visiting insects cling to when probing upward for nectar from this flower at the upper end of the bell. The pale green pistil is somewhat three-sided, and the long style remains attached long after the flower disappears. The flower is slightly fragrant, and it is visited by the queen bumblebees and the solitary bees, of which there are many species. The flower closes nights and during cloudy, stormy days. The seed capsule is plump and rather triangular, and splits into three sections when ripe. The seeds are numerous and are fleshy and crescent-shaped.

But the adder's-tongue, like many other early blooming flowers, is a child of the spring. The leaves, at first so prettily mottled, fade out to plain green; and by midsummer they have entirely disappeared, the place where they were being covered with other foliage of far different pattern. But down in the rich woods soil are the plump globular corms filled with the food manufactured by the spotted leaves during their brief stay, and next spring two pairs of spotted leaves may appear where there was but one pair this year.

LESSON 118

Adder's-Tongue or Dog's-Tooth Violet

Leading Thought — The adder's-tongue is a lily, and its mottled leaves appear in the spring, each pair coming from a corm deep in the soil below. It has two ways of spreading, one underground by means of new corms growing from the larger ones, and the other by means of seeds, many of which are probably perfected through the pollen carried by insects.

METHOD — This plant should be studied in the woods, notes being made on it there. But a plant showing corm, roots, leaves, and blossom may be brought to the schoolhouse for detailed study, and then planted in a shady place in the school garden.

OBSERVATIONS — 1. Where does the adder's-tongue grow? Do you ever find it in open fields? How early do you find its leaves above ground? At what time do its blossoms appear?

2. How many leaves has each plant? What colors do you find in them? What is the color of their petioles? Do the leaves remain mottled later in the season?

3. Do the adder's-tongue plants occur singly or in patches?

4. Is the flower lifted up, or is it drooping? What is its general shape? How many sepals? How would you know they were sepals? How do they differ in color, outside and in, from the petals? How are the petals marked? Can you see the lobes at the base of each petal? When sepals and petals are so much alike the botanists call them all together the perianth.

5. If the perianth, or the sepals and petals together, makes a bell-shaped flower, what makes the clapper to the bell? How do the insects use this clapper when they visit the flower? Do the flowers stay open nights and dark days?

Adder's-tongue in natural surroundings

6. How many stamens are there? Describe or sketch one, noting its peculiar shape. Are the stamens all the same length? Can you see the pistil and its stigma? Where is it situated in relation to the stamens? Do you think the stigma is ready for pollen at the time the anthers are shedding it?

7. After the petals and sepals fall what remains? How does the ripe seed capsule look? How does it open to let out the seeds? Are there many seeds in a capsule? What is the shape of the seeds of this plant?

Verne Morton

BLOODROOT

What time the earliest ferns unfold,
And meadow cowslips count their gold;
A countless multitude they stood,
A Milky Way within the wood. — Danske Dandridge

Only a few generations ago, this land of ours was peopled by those who found it fitting to paint their bodies to represent their mental or spiritual conditions or intentions. For this purpose they had studied the plants of our forests to learn the secrets of the dyes which they yielded, and a dye that would remain on the flesh permanently, or until it wore off, was highly prized. Such a dye was found in the bloodroot, a dye appropriate in its color to represent a thirst for blood; with it they made their war paint, and with it they ornamented their tomahawks to symbolize their sanguinary purpose.

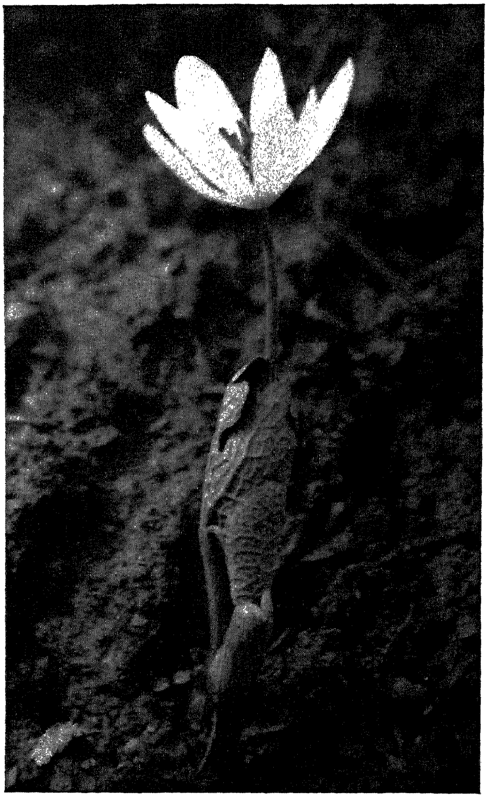
The Indian warriors have passed away from our forests, and the forests themselves are passing away, but the bloodroot still lingers, growing abundantly in rich moist woods or in shaded areas in glades, borders of meadows, and fence corners. Its beautiful white flowers, open to the morning sun in early April, attract the hungry bees which come for pollen; for, like many other early flowers, it offers no nectar. Probably many of the little wild bees prefer pollen to nectar at this time of year, for it is an important element in the food of all kinds of bee brood. But the bloodroot's fragile blossoms are elusive and do not remain long; like their relatives, the poppies, their petals soon fall, and their white masses disappear like the snowdrifts which so recently occupied the same nooks.

The way the bloodroot leaf enfolds the flower bud seems like such an obvious plan for protection, that we are unthinkingly prone to attribute consciousness to the little plants.

Not only does the leaf enfold the bud, but it continues to enfold the flowerstalk after the blossom opens. There are two sepals which enclose the bud, but fall off as the flower opens. There are ordinarily eight white petals, although there may be twelve; usually every other one of the eight petals is longer than its neighbors, and this makes the blossom rather square than circular in outline. There are many stamens, often twenty-four, and the anthers are brilliant yellow with whitish filaments. The two-lobed stigma opens to receive pollen before the pollen of its own flower is ripe. The stigma is large, yellow, and set directly on the ovary, and is quite noticeable in the freshly opened blossoms. It is likely to shrivel before its homegrown pollen is ripe. The blossoms open wide on sunny mornings; the petals rise up in the afternoon and close at night, and also remain closed during dark, stormy days until they are quite old, when they remain open; they are now ready to fall to the ground at the slightest jar, leaving the oblong, green seed pod set on the stem at a neat bevel, and perhaps still crowned with the yellowish stigma. The seed pod is oblong and pointed and remains below the protecting leaf. There are many yellowish or brownish seeds.

When the plant appears above ground, the leaf is wrapped in a cylinder about the bud, and it is a very pretty leaf, especially the "wrong side," which forms the outside of the roll; it is pale green with a network of pinkish veins, and its edges are attractively lobed; the petiole is fleshy, stout, and reddish amber in color. The flowerstalk is likewise fleshy and is tinged with raw sienna; the stalks of both leaf and flower stand side by side. After the petals of the flower have fallen, the leaf grows much larger, often measuring six inches across and having a petiole ten inches long. It is then one of the most beautiful leaves in the forest carpet, its circular form and deeply lobed edges rendering it a fit subject for decorative design.

The rootstock is large and fleshy, and in it is stored the food which enables the flower to blossom early, before any food has been made by the new leaves. There are many stout and rather short roots that fringe the rootstock. Once in clearing a path through a woodland, we happened to hack off a mass of these rootstocks, and we stood aghast at the gory results. We had admired the bloodroot flowers in this place in the spring, and we felt as guilty as if we had inadvertently hacked into a friend.


O. L. Foster

Bloodroot, showing leaf not yet unrolled

LESSON 119

Bloodroot

Leading Thought — The bloodroot has a fleshy rootstock, in which is stored food for the nourishment of the plant in early spring. The flower bud is at first protected by the folded leaf. The juice of the rootstock is a vivid light crimson, and was used by Indians as a war paint. The juice is acrid, and the bloodroot is not relished as food by grazing animals, but it is used by us as a medicine.

Method — The bloodroot should be

studied in the woods where it is to be found growing.

Observations — 1. At what time of year does bloodroot blossom? In what situations does it thrive?

2. What do we see first when the bloodroot puts its head above the soil? Where is the flower bud? How is it protected by the leaf?

3. Study the flower. How many sepals has it? What is their color? What is the position of the sepals when the flower is in bud? What is their position when the flower opens? How many petals? What is their color and texture? Describe the position of the petals in the bud and in the open flower. Look straight into the flower; is its shape circular or square?

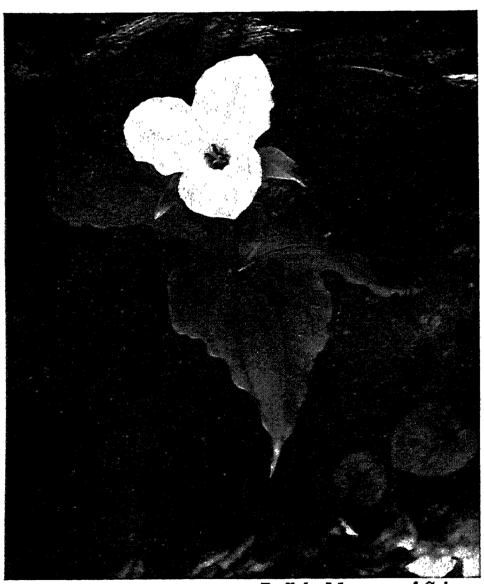
4. Do the flowers close nights and during dark days? Do the flowers longest open do this? Describe how the petals and sepals fall.

5. Describe the stamens. What is the color of the anthers? Of the pollen? Describe the pistil. Does the two-grooved stigma open before the pollen is shed, or after? What insects do you find visiting the bloodroot?

6. Sketch or describe a bloodroot leaf as it is wrapped around the stalk of the flower. How are both flowerstalk and leaf petiole protected at the base? Describe or sketch a leaf after it is unfolded and open. Describe the difference between the upper and lower surfaces of the leaf. What sort of petiole has it? Break the petiole; what sort of juice comes from it? Describe and measure the leaf later in the season; do they all have the same number of lobes?

7. Compare the bloodroot with the poppies; do you find any resemblance between the habits of these two kinds of flowers?

THE TRILLIUM



Buffalo Museum of Science

The white trillium

It would be well for the designer of tapestries to study the carpets of our forests for his patterns, for he would find there a new carpet every month, quite different in plan and design from the one spread there earlier or later. One of the most beautiful designs from Nature's looms is a trillium carpet, which is at its best when the white trilliums are in blossom. It is a fine study of the artistic possibilities of the triangle when reduced to terms of leaves, petals, and sepals.

The trillium season is a long one; it begins in April with the purple wake-robin or birthroot, the species with purple, red, or sometimes yellowish flowers. The season ends in June with the last of the great white trilliums, which flush pink instead of fading, when old age comes upon them.

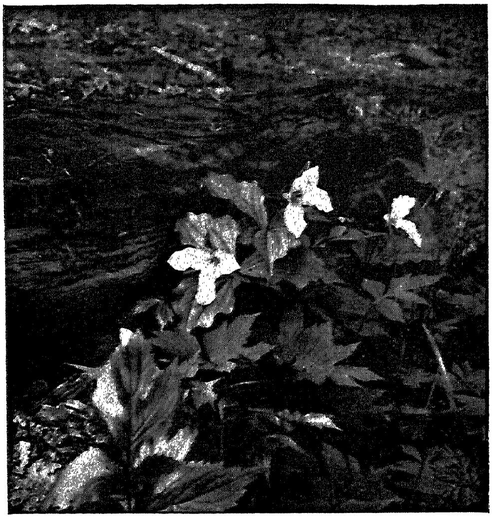
The color of the trillium flower depends upon the species studied; there are three petals, and the white and painted trilliums have the edges of the petals ruffled; the red and nodding trilliums have petals and sepals nearly the same size, but in the white trillium the sepals are narrower and shorter than the petals. The sepals are alternate to the petals, so that when we look straight into the flower we see it as a six-pointed star, three of the points being green sepals. The pistil of the trillium is six-lobed. It is dark red in the purple trillium and very large; in the white species, it is pale green and smaller; it opens at the top with three flaring stigmas. There are six stamens with long anthers, and they stand between the lobes of the pistil. The flowerstalk rises from the center where three large leaves join. The flowerstalk has a tendency to bend a little, and is rather delicate. The three leaves have an interesting venation, and make a good subject for careful drawing. The flowerstalk varies with different species, and so does the length of the stem of the plant, the latter being fleshy and green toward the top and reddish toward the root. The trilliums have a thick, fleshy, and much scarred rootstock from which extend rootlets which are often corrugated. The trilliums are perennial, and grow mostly in damp, rich woods. The painted trillium is found in cold, damp woods along the banks of brooks; the white trillium is likely to be found in large numbers in the same locality, while the purple trillium is found only here and there. Flies and beetles carry the pollen for the red trillium, apparently attracted to it by its rank odor, which is very disagreeable to us. The large white trillium is visited by bees and butterflies. The fruit of the trillium is a berry; that of the purple species is somewhat six-lobed and reddish. In late July the fruit of the white trillium is a cone with six sharp wings, or ridges, from apex to base, the latter being three-quarters of an inch across. These vertical ridges are not evenly spaced, and beneath them are packed as closely as possible the yellow-green seeds, which are as large as homeopathic pills. In cross section, it can be seen that the trillium berry is star-shaped with three compartments, the seeds growing on the partitions. This trillium fruit is very rough outside, but smooth inside, and the dried stamens often still cling to it.

The stemless trillium

Buffalo Museum of Science

Red trilliums

The trilliums are so called from the word *triplum*, meaning threefold, as there are three leaves, three petals, and three sepals.



White trilliums in natural surroundings

LESSON 120

The Trillium

Leading Thought — The trilliums are lilies, and are often called wood lilies, because of their favorite haunts. There are several species, but they are all alike in that they have three sepals, three petals, and three leaves.

Method — This lesson may be given from trilliums observed in the woods by the pupils, who should be encouraged to watch the development of the berry and also to learn all the different species common to a locality.

Observations — 1. How many leaves has the trillium? How are they arranged? Draw a leaf, showing its shape and veins. Describe the stem of the plant below the leaves, giving the length and color.

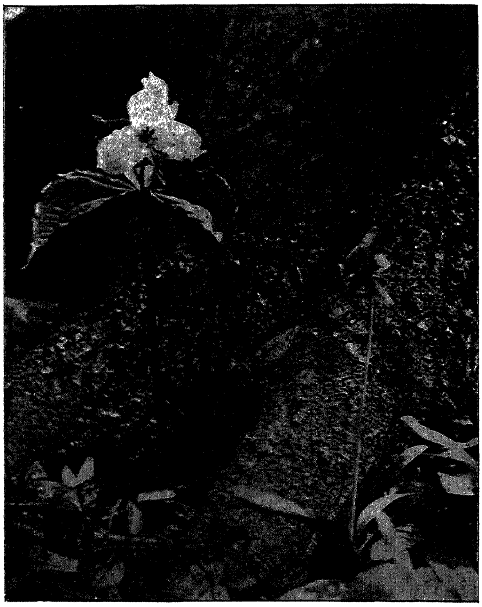
2. How far above the leaves does the flowerstalk or peduncle extend? Does the flower stand upright or droop? Describe or sketch the colors, shape, and arrangement of the petals and sepals. Do the petals have ruffled margins?

3. Describe the pistil and the stigmas. Describe the stamens and how they are placed in relation to the pistil.

4. Do the flowers remain open during cloudy days and nights?

5. What insects do you find visiting the trilliums? Do the same insects visit the purple and the white trilliums? What is the difference in odor between the purple and the white trillium? Does this seem to bring different kinds of insects to each?

6. How does the color of the white trillium change as the blossom matures? What is the color and shape of the fruit of each different species of trillium? When is the fruit ripe?



Trillium and adder's-tongue. These plants may often be found growing in the same habitat

O. L. Foster

Dutchman's-breeches

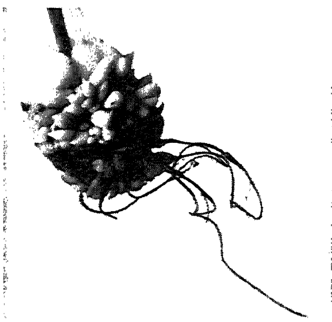
DUTCHMAN'S-BREECHES AND SQUIRREL CORN

In a gymnasium where things grow,
Jolly boys and girls in a row,
Hanging down from cross-bar stem
Builded purposely for them.
Stout little legs up in the air,
Kick at the breeze as it passes there;
Dizzy heads in collars wide
Look at the world from the underside;
Happy acrobats a-swing,
At the woodside show in early spring.
— A. B. C.

And toward the sun, which kindlier burns,
The earth awaking, looks and yearns,
And still, as in all other Aprils,
The annual miracle returns.
— Elizabeth Akers

There are many beautiful carpets spread before the feet of advancing spring, but perhaps none of them are so delicate in pattern as those woven by these two plants that spread their fernlike leaves in April and May. There is little difference in the foliage of the two; both are delicate green and lacelike above, and pale, bluish green on the under side. And each leaf, although so finely divided, is, after all, quite simple; for it has three chief divisions, and these in turn are divided into three, and all the leaves come directly from a stem under the ground. These plants grow in the woodlands, and by spreading their green leaves early, before the trees are in foliage, they have the advantage of the spring sunshine. Thus they make their food for maturing their seeds, and also store some of it in their underground parts for use early the following spring. By midsummer the leaves have entirely disappeared, and another carpet is spread in the place which they once covered.

Dutchman's-breeches and squirrel corn resemble each other so closely that they are often confused; however, they are quite different in form; the "legs" of

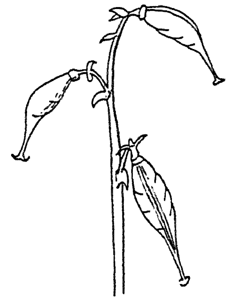


The underground storehouse of Dutchman's-breeches

the Dutchman's-breeches are quite long and spread wide apart, while the blossoms of the squirrel corn are rounded bags instead of "legs." The underground parts of the two are quite different. The Dutchman's-breeches grows from a little bulb made up of grayish scales, while the squirrel corn develops from a round, yellow tuber; these yellow, kernel-like tubers are scattered among the roots, each capable of developing a plant next year. The Dutchman's-breeches grow in thin woodlands and on rocky hillsides, but the squirrel corn is found more often in rich, moist woods. The blossom of the Dutchman's-breeches comes the earlier of the two. These flowers are white with yellow tips, and are not fragrant. The flowers of the squirrel corn are grayish with a tinge of magenta and are fragrant.

The legs of the Dutchman's-breeches are nectar pockets with tubes leading to them, and are formed by two petals. Opposite these two petals are two others more or less spoon-shaped, with the spoon bowls united to protect the anthers and stigma. There are two little sepals which are scalelike.

The seed capsule of the Dutchman's-breeches is a long pod with a slender, pointed end, and it opens lengthwise. The seed capsules of the squirrel corn are similar and I have found in one capsule twelve seeds, which were shaped like little



Seed capsule of squirrel corn

kernels of corn, black in color, and shiny like patent leather.

LESSON 121

Dutchman's-Breeches and Squirrel Corn

Leading Thought — The Dutchman's-breeches, or "boys and girls," as it is often called, is one of the earliest flowers of rich woodlands. There are interesting differences between this flower and its close relative, squirrel corn. The flowers of both of these resemble in structure the flowers of the bleeding heart.

Dutchman's-breeches in rich woodland environment

METHOD—As the Dutchman's-breeches blossoms in April and May, usually earlier than squirrel corn, we naturally study the former first and compare the latter with it in form and in habits. The questions should be given the pupils for them to answer for themselves during their spring walks in the parks or woodlands.

OBSERVATIONS — 1. Where do you find Dutchman's-breeches? Which do you prefer to call these flowers, Dutchman's-breeches or boys and girls? Are there leaves on the trees when these flowers are in bloom?

2. Which blossoms earlier in the season, Dutchman's-breeches or squirrel corn? How do the flowers of the two differ in shape? In odor?

3. In the flower of the Dutchman's-breeches find two petals which protect the nectar. How do they look? What part of the breeches do they form? Find two other petals which protect the pollen and stigma.

4. Find the two sepals. How many bracts do you find on the flower stalk?

5. What insects visit these flowers? Describe how they get the nectar.

6. Have you ever seen squirrels harvesting squirrel corn? What is the purpose of the kernels of the squirrel corn?

7. Study the leaf. How many main parts are there to it? How are these parts divided? What is the color of the leaf above? Below? Can you distinguish the leaves of the Dutchman's-breeches from those of the squirrel corn?

8. Describe the seed capsule of Dutchman's-breeches. How does it open? How many seeds has it? Compare this with the fruit of squirrel corn and describe the difference.

9. What happens to the leaves of these two plants late in summer? How do the plants get enough sunlight to make food to mature their seed? What preparations have they made for early blossoming the next spring?

Verne Morton

Squirrel corn

JACK-IN-THE-PULPIT

With hooded heads and shields of green,
Monks of the wooded glen,
I know you well; you are, I ween,
Robin Hood's merry men.
— "CHILD'S OWN BOOK OF FLOWERS"

This little preacher is a prime favorite with all children, its very shape, like that of the pitcher plant, suggesting mystery; and what child could fail to lift the striped hood to discover what might be hidden beneath! And the interest is enhanced when it is discovered that the hood is but a protection for the true flowers, standing

Verne Morton

Jack-in-the-pulpit or Indian turnip

upon a club-shaped stem, which has been made through imagination into "Jack," the little preacher.

Jack-in-the-pulpit prefers wet locations but is sometimes found on dry, wooded hillsides; an abundance of blossoms occurs in late May. This plant has another name, which it has earned by being interesting below ground as well as above. It has a solid, flattened, food-storehouse called a corm with a fringe of coarse rootlets encircling its upper portion. This corm was used as a food by the Indians, which fact gave the plant the name of Indian turnip. I think all children test the corm as a food for curiosity, and retire from the field with a new respect for the stoicism of the Indian when enduring torture; but this is an undeserved tribute. When raw, these corms are peppery because they are filled with minute, needle-like crystals which, however, soften with boiling, and the Indians boiled them before eating them.

Jack-in-the-pulpit is a near cousin to the calla lily; the white part of the calla and the striped hood over "Jack" are both spathes, and a spathe is a leaf modified for the protection of a flower or flowers. "Jack" has but one leg and his flowers are set around it, all safely enfolded in the lower part of the spathe. The pistillate flowers which make the berries are round and greenish, and are packed like berries on the stalk; they have purple stigmas with whitish centers. The pollen-bearing flowers are mere little projections, almost white in color, each usually bearing four purplish, cuplike anthers filled with white pollen. Occasionally both kinds of flowers may be found on one spadix (as "Jack" is called in the botanies), the pollen-bearing flowers being set above the others; but usually they are on separate plants. Professor Atkinson has demonstrated that when a plant becomes very strong and thrifty, its spadix will be set with the pistillate flowers and its berries will be many; but if the same plant becomes weak, it produces the pollen-bearing flowers the next year.

When "Jack" first appears in the spring it looks like a mottled, pointed peg, for it is well sheathed. Within this sheath the leaves are rolled lengthwise to a point, and at the very center of the rolled leaves is a spathe, also rolled lengthwise, which enfolds the developing flower buds. It is a most interesting process to watch the unfolding of one of these plants. On the older plants there are two, or sometimes three leaves, each with three large leaflets; on the younger plants there may be only one of these compound leaves, but the leaflets are so large that they seem like three entire leaves.

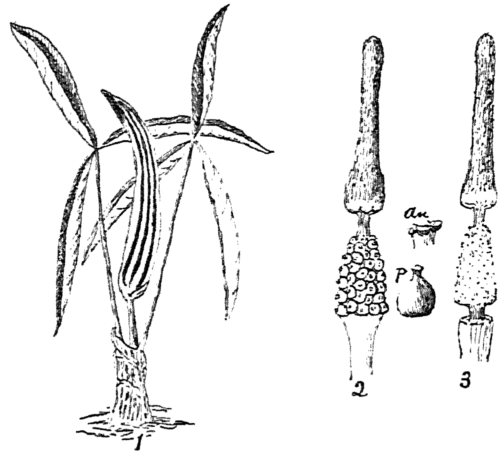
The spathes, or pulpits, vary in color,

Leonard K. Beyer

Calla lily or water arum

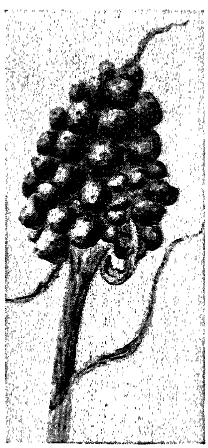
some being maroon and white or greenish, and some greenish and white. They are very pretty objects for water-color drawings.

Small flies and some beetles seem to be the pollen carriers for this plant. Various ingenious theories have been suggested to prove that our Jack-in-the-pulpit acts as a trap to imprison visiting insects, as does the English species; but I have studied the flowers in every stage, and have seen the insects crawl out of the hoods as easily as they crawled in, and by the same open, though somewhat narrow passage between the spadix and the spathe.



1, *Jack-in-the-pulpit unfolding.* 2, *Spadix with pistillate flowers.* 3, *Spadix with staminate flowers*

P, Pistillate flower, enlarged. An, a staminate flower enlarged, showing four anthers



The berries of Jack-in-the-pulpit

After a time the spathe falls away, showing the globular, green, shining berries. In August even the leaves may wither away, at which time the berries are brilliant scarlet. Jack-in-the-pulpit is a perennial. It does not blossom the first year after it is a seedling. I have known at least one case where blossoms were not produced until the third year. Below ground, the main corm gives off smaller corms and thus the plant spreads by this means as well as by seeds.

LESSON 122

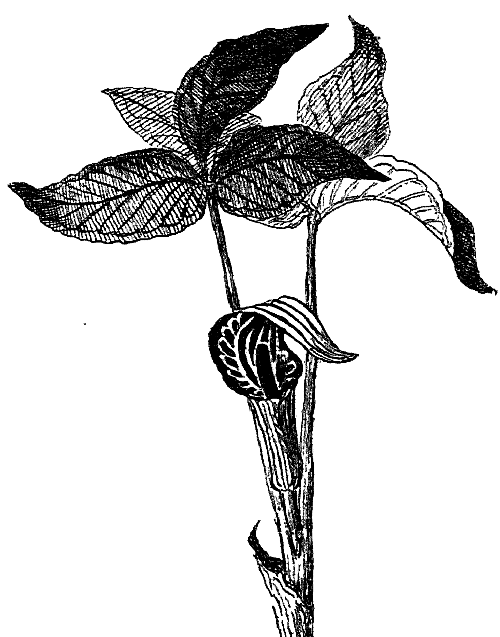
Jack-in-the-pulpit

Leading Thought — The real flowers of Jack-in-the-pulpit are hidden by the striped spathe which is usually spoken of as the flower. This plant has a peppery root which the Indians used for food.

Method — The questions should be answered from observation in the woods; a single plant may be dug up and brought to school for study, and later planted in some shady spot in the school garden.

Observations — 1. Where do you find Jack-in-the-pulpit? Is the soil dry or damp? Do you ever find it in the fields?

2. How early in the season does this plant blossom? How late?



3. How does the Jack-in-the-pulpit look when it first pushes out from the ground? How are its leaves rolled in its spring overcoat?

4. How does the pulpit, or spathe, look when the plant first unfolds? Is its tip bent over or is it straight?

5. Describe or sketch the leaves of Jack-in-the-pulpit. Note how they rise above the flower. How many leaflets has each leaf? Sketch the leaflets to show the venation. How do these stand above the flower? Can you find any of the plants with only one leaf?

6. Why is the spathe called a pulpit? What are the colors of the spathe? Are all the spathes of the same colors?

7. Open up the spathe and see the rows of blossoms around the base of the spadix; if you call the spadix " Jack," then the flowers clothe his one leg. Are all the blossoms alike? Describe, if you can, those flowers which will produce the seed and those which produce the pollen. Do you find the two on the same spadix or on different plants?

8. What insects do you find carrying the pollen for " Jack "? Do you know how its berries look in June? How do they look in August? Do the leaves last as long as the berries?

9. What other name has " Jack "? How does the plant multiply below the ground?

10. Compare the Jack-in-the-pulpit with the calla lily.

11. Write an English theme on " The Sermon That Jack Preached from His Pulpit."

THE VIOLET

It is interesting to note the flowers which have impinged upon the imagination of the poets; the violet more than most flowers has been loved by them, and they have sung in varied strains of its fragrance and loveliness.

Verne Morton

Round-leaved yellow violet

Browning says:

Such a starved bank of moss,
'Till that May morn,
Blue ran the flash across;
Violets were born.

And Wordsworth sings:

A violet by a mossy stone,
Half hidden from the eye;
Fair as a star, when only one
Is shining in the sky.

And Barry Cornwall declares that the violet

Stands first with most, but always with the lover.

But Shakespeare's tribute is the most glowing of all, since the charms of both the goddesses of beauty and of love are made to pay tribute to it:

violets dim
But sweeter than the lids
of Juno's eyes
Or Cytherea's breath.

However, the violets go on living their own lives, in their own way, quite unmindful of the poets. There are many different species, and they frequent quite different locations. Some live in the woods, others in meadows, and others in damp, marshy ground. They are divided into two distinct groups — those where the leaf-stalks come directly from the underground rootstocks, and those where the leaves come from a common stem, the latter being called the leafy-stemmed violets. Much attention should be given to sketching and studying accurately the leaves of the specimens under observation, for the differences in the shapes of the leaves, in many instances, determine the species; in some cases the size and shape of the stipules determine the species; and whether the leaves and stems are downy or smooth is another important characteristic. In the case of those species where the leaves spring from the rootstock, the flower stems rise from the same situation; but in the leafy-stemmed violets the flower stems come off at the axils of the leaves. In some species the flower stems are long enough to lift the flowers far above the foliage, while in others they are so short that the flowers are hidden.

The violet has five sepals and their shape and length is a distinguishing mark. There are five petals, one pair above, a pair one at each side, and a broad lower petal, which gives the bees and butterflies a resting place when they are seeking nectar. This lower petal is prolonged backward into a spur which holds the nectar.

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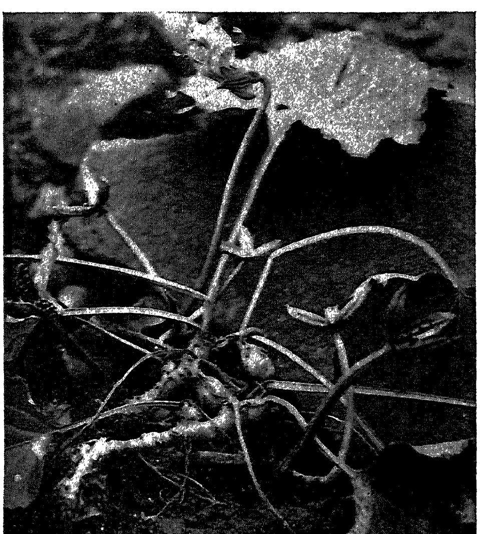
Dog violet



Verne Morton

Common blue violet, showing two of the little flowers which never open lying beneath the bare rootstocks. Note the three-valved seed capsules

The spur forms the nectary of the violet, and in order to reach the sweet treasure, which is at the rearmost point of the nectary, the insect must thrust its tongue through a little door guarded by both anthers and pistil; the insect thus becomes laden with pollen, and carries it from flower to flower. In many of the species, the side petals have at their bases a little fringe which forms an arch over the door or throat leading to the nectary. While this is considered a guard to keep out undesirable insects like ants, I am convinced that it is also useful in brushing the pollen from the tongues of the insect visitors.

Some species of violets are very fragrant, while others have little odor. The color of the anthers also differs with different species. The children should be interested in watching the development of the seeds from the flower. The seed pods are three-lobed, each one of these lobes dividing lengthwise, with a double row of seeds within. Each lobe curls back and thus scatters the seed.

At the base of most of the species of violets can be found the small flowers which never open; they have no petals, but

Verne Morton

Long-spurred violet

within them the pollen and the pistil are fully developed. These flowers seem to be developed only for self-pollination, and in the botanies they are called cleistogamous flowers; in some species they are on upright stems, in others they lie flat. There is much difference in the shape of the rootstock in the different species of violet; some are delicate and others are strong, and some are creeping.

LESSON 123

The Violet

Leading Thought — Each violet flower has a well of nectar, with lines pointing to it. Violets have also down near their roots flowers that never open, which are self-pollinated and develop seeds.

Method — To make this work of the greatest use and interest, each pupil should make a portfolio of the violets of the locality. This may be in the form of pressed and mounted specimens, or of water-color drawings. In either case, the leaf, leafstalk, flower, flowerstalk, and rootstock should be shown, and each blossom should be neatly labeled with name, locality, and date. From the nature-study standpoint, a portfolio of drawings is the more desirable, since from making the drawings the pupils become more observant of the differences in structure and color which distinguish the species. Such a portfolio may be a most beautiful object; the cover of thick cardboard may have an original, conventionalized design made from the flowers and leaves of the violets. Each drawing may be followed by a page containing notes by the pupil and some appropriate quotation from botany, poetry, or other literature.

Verne Morton

The Canada white violet, a leafy-stemmed species

OBSERVATIONS — 1. Describe the locality and general nature of the soil where the violet was found. That is, was it in the woods, dry fields, or near a stream?

2. Sketch or describe the shape of the leaf, paying particular attention to its margin and noting whether it is rolled toward the stem at its base. Is the petiole longer or shorter than the leaf? Are there stipules where the leaf joins the main stem? If so, are they toothed on the edge?

3. What is the color of the leaf above? Are the leaves and stems downy and velvety, or smooth and glossy?

4. Does the flowerstalk come from the rootstock of the plant, or does it grow from the main stem at the axil of the leaf? Are the flowerstalks long enough to lift the flowers above the foliage of the plant?

5. How many sepals has the violet? Are they long or short, pointed or rounded? How many petals has the violet? How are they arranged? Is the lower petal shaped like the others? What is the use of this broad lower petal? Are there any marks upon it? If you should follow one of these lines, where would it lead?

6. Look at the spur at the back of the flower. Of which petal is it a part? How long is it, compared with the whole flower? What is the use of this spur?

7. Find the opening that leads to the nectar-spur and note what the tongue of the bee or butterfly would brush against when reaching for the nectar. Are the side petals which form the arch over the opening that leads to the nectar fringed at their bases?

8. What colors are the petals? Are they the same on both sides? How are they marked and veined? Are the flowers fragrant?

Leonard K. Beyer

Bird's-foot violet

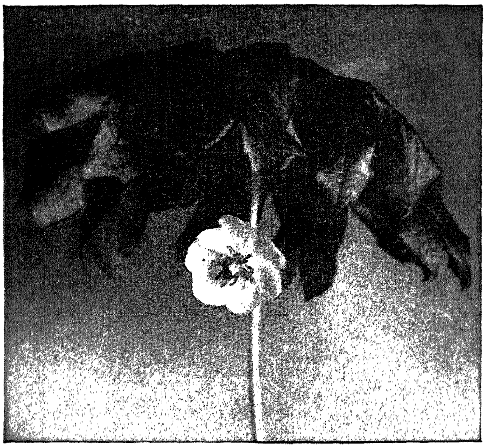
9. What color are the anthers? What color is the stigma? Examine a fading violet, and describe how the seed is developed from the flower.

10. Find the seed-pods of the violet. How are the seeds arranged within them? How do the pods open? How are the seeds scattered?

11. Look at the base of the violet and find the little flowers there which never open. Examine one of these flowers and find if it has sepals, petals, anthers, and pistil. Are these closed flowers on upright stems or do the stems lie flat on the earth? Of what use to the plant are these little closed flowers?

THE MAY APPLE OR MANDRAKE

This is a study of parasols and, therefore, of perennial interest to the little girls who use the small ones for their dolls, and with many airs and graces hold the large ones above their own heads. And when this diversion palls, they make mandarin dolls of these fascinating plants. This is easily done by taking one of the small plant umbrellas and tying with a grass sash all but two of the lobes closely around the stem, thus making a dress, the lobes left out being cut in proper shape for flowing sleeves; then for a head some other flower is robbed of its flower bud, which is put



Verne Morton

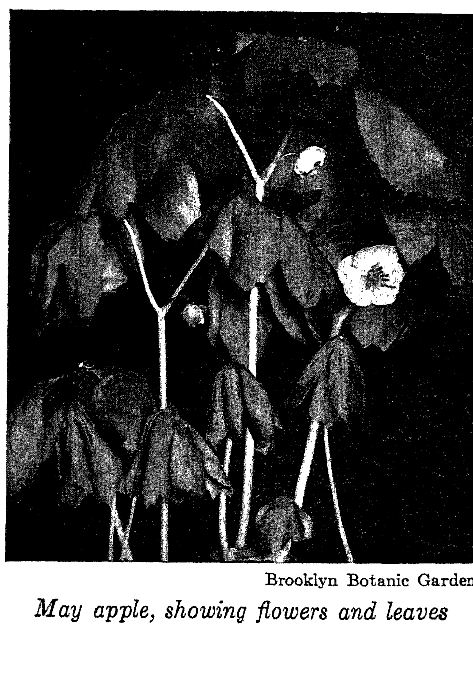
May apple or mandrake

into place and surmounted with a clover leaflet hat. Then a pin is thrust through hat, head, and neck into the stem of the dressed plant, and the whole is properly finished by placing a small umbrella above the little green mandarin.

The mandrakes grow in open places where there is sun, and yet not too much of it; they like plenty of moisture, and grow luxuriantly in open glades or in meadows or pastures bordering woodlands, and in the fence-corners, along roadsides. The first lesson of all should be to notice how nature has folded these little umbrellas. Study the plants when they first put their heads above ground, each like a parasol wrapped in its case, and note how similarly to a real umbrella it is folded around its stem. Later, after the umbrellas are fairly spread, they afford a most interesting study in varieties of form and size. Some of the leaves have only four lobes while others have many more. I have found them with as many as nine, although the botanies declare seven to be the normal number. One of the special joys afforded by nature-study is finding things different from the descriptions of them in the books.

One of these little parasols is a worthy object for careful observation. Its stem is stout and solid, and at its base may be seen the umbrella-case, now discarded like other umbrella-cases; the stem is pink wherever the sun touches it, but close up under the leaves it is likely to be green; it ends at the middle of the parasol by sending out strong, pale green, fuzzy ribs into each lobe. The lobes are narrow toward the stem but broad at the outer edge, each lobe being sparsely toothed on its outer margins and with a deep, smooth notch at the center. From the ribs of each lobe extend other ribs, an arrangement quite different from that which we find in cloth umbrellas. The lobes of the mandrake leaf or parasol are divided almost to the center. The parasol is a beautiful shining green on the upper side, and has a pale green lining that feels somewhat woolly.

In examining any patch of May apples, we find that many of the leaves are double; one of these twin leaves is always larger than the other and evidently belongs to the main stem, since its stem is stouter, and it is likely to have seven lobes while the smaller one may have but five. However, the number of lobes varies. Neither of these double leaf-parasols has its ribs extending out toward the other; instead they are at the side next each other, exactly as if the original single stem had been split and the whole parasol had been torn in twain.

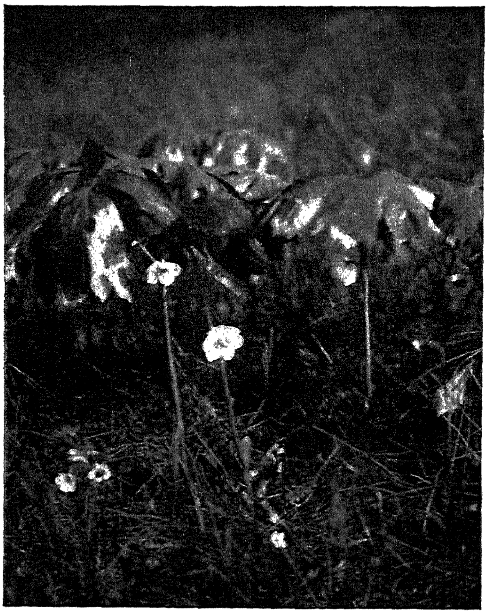


Brooklyn Botanic Garden

May apple, showing flowers and leaves

But of greatest interest is the bud carried under this double parasol. At first it is a little, elongate, green ball on a rather stiff little stalk, which arises just where the two branches fork. One of the strange things about this bud is, that when the plant is just coming from the ground, the bud pushes its head out from between the two folded parasols, and takes a look at the world before it is covered by its green sunshade. As the bud unfolds, it looks as if it had three green sepals, each keeping its cup form and soon falling off, as a little girl drops her hood on a warm day; but each of these sepals, if examined, will be found to be two instead of one: the outer is the outside of the green hood while the inner is a soft, whitish membrane. As the greenish white petals spread out, they disclose a triangular mass of yellow stamens grouped about the big seed box, each side of the triangle being opposite one of the inner petals. After the flower is fully open, the stamens spread and each anther is easily seen to be grooved, and each edge of the groove opens for the whole of its length; but because of its shape and position, it lets the pollen fall away from the pistil instead of toward it; nor do the tips of the anthers reach the waxy, white, ruffled stigma. There is no nectar in this flower; but the big queen bumblebee collects the pollen for her new nest, and " bumbles " around in the flower while getting her load, so that she becomes well dusted with the pollen, and thus carries it from flower to flower. But the whole story of the pollen carriers of the May apple is, as yet, untold; and any child who is willing to give time and attention to discovering the different insects which visit this flower may give to the world valuable and as yet unknown facts. It is said that a white moth is often found hanging to the flowers, but it is difficult to understand why the moth should be there if the flower does not have any nectar.

The seed vessel at the center of the flower is large and chunky, and, although crowned with its ruffled stigma, looks as if it were surely going to " grow up " into a May apple. There are usually six wide, white, rounded petals, three on the outside and three on the inside; but sometimes there are as many as nine. There are usually twice as many stamens as petals, but I have often found thirteen stamens, which is not twice any possible number of petals. The petals soon fall, and the green fruit — which is a berry instead of an apple — has nothing to do but grow, until in July it is as juicy and luscious to the thirsty child as if it were the fruit of the gods. It is about two inches long, a rich yellow in color, and is sometimes called the " wild lemon," although it is not sour. It is also called the hog-apple because the clever swine of the South know how to find it. Riley thus celebrates this fruit:



May apples as they grow

And will any poet sing of a lusher, richer thing,
Than a ripe May apple, rolled like a pulpy lump of gold
Under thumb and finger tips; and poured molten through the lips?

While the May apple itself is edible, certainly its root is not, except when given by physicians as a medicine, for it is quite poisonous when eaten. When we see plants growing in colonies or patches, it usually means that very interesting things are going on underground beneath them, and the mandrake is no exception to this. Each plant has a running underground stem, straight and brown and fairly smooth; at intervals of a few inches, there are attached to it rosettes of stout, white roots, which divide into tiny, crooked rootlets. There is a large rosette of these roots under the plant we are studying, and we can always find a rosette of them under the place where the plant stood last year. Beneath the present plant we can find the bud from which will grow the rootstock for the coming year. The working out of the branching and the peculiarities of these rootstocks is an excellent lesson in this peculiar and interesting kind of plant reproduction.

LESSON 124

The Mandrake

Leading Thought — These interesting plants grow in colonies because of the spreading of their underground stems. Their fruit is well hidden by its green parasol until it is ripe.

Method — Begin the study just as the mandrakes are thrusting their heads up through the soil in April, and continue the work at intervals until the fruit is ripe.

Observations — 1. How do the mandrakes look when they first appear above the ground? How are the little umbrellas folded in their cases? What do the cases look like? How can you tell from the first the plants which are to bear the flowers and fruit?

2. Study a patch of mandrakes, and see how many varieties of leaves or parasols you can find. Do they all have the same number of main ribs and lobes? How many lobes do most of them have? Are there more single or double leaves in the patch?

3. Take a simple plant and study it carefully. What sort of stem has it? Can you find at its base the old umbrella case? How high is the stem? What is its color at the bottom and at the top? How many ribs does it divide into at the top? Are these ribs as smooth as the stem? How does the parasol lining differ from its outside in color and feeling?

4. Study the leaf lobes. What is their general shape? Are they all notched at the wide end? How close to the stem does the division between them extend?

5. Take a plant with two leaves. Where is the flower bud to be found? How is it protected from the sun? Does the stem divide equally on each side of it or is one part larger than the other? Are the twin leaves of the same size? How many lobes has each? What are the chief differences in shape between one of these twin leaves and one which has no flower bud?

6. How does the flower bud look? What happens to the green hood or sepals when the flower opens? Can you find six sepals in the hood?

7. Does the open flower bow downward? As the flower opens, what is the shape of the group of stamens at the center? Are there the same number of white, waxy petals in all the flowers? Are there always about twice as many stamens as petals? How do the anthers open to shed the pollen? Do they let the pollen fall away from the ruffled stigma of the " fat " little seed box at the center of the flower?

8. Does the flower have a strong odor? Does not the plant itself give off this odor? Do you think it is pleasant? Do the cattle eat the mandrake when it is in pastures?

9. What insects do you find visiting the mandrake flowers?

10. Do you like the May apple? When is it ripe? Cut a fruit across and see how the seeds are arranged.

11. Where are mandrakes found? Do they always grow in patches?

12. Why must we not taste of the mandrake root?

13. In late July, visit the mandrake patch again. Are there any leaves now? What is left of the plants?

THE BLUETS

During April, great patches of blue appear in certain meadows, seeming almost like reflections from the sky; and yet when we look closely at the flowers which give this azure hue to the fields, we find that they are more lavender than blue. The corolla of the bluet is a tube, spreading out into four long, lavender, petal-like lobes; each lobe is paler toward its base and the opening of the tube has a ring of vivid yellow about it, the tube itself being yellow even to its very base, where the four delicate sepals clasp it fast to the ovary. After the corolla has fallen the sepals remain.

If we look carefully at the bluets we find two forms of flowers: a, those with a two-lobed stigma protuding from the opening of the flower-tube; *b*, those where the throat of the tube seems closed by four anthers which join like four finger-tips pressed together. In opening the flower, we observe that those which have the stigmas protruding from the tube have four anthers fastened to the sides of the tube about half-way down; while those that have the four anthers near the opening of the tube have a pistil with a short style which brings the stigmas about half-way up the tube. An insect visiting the flower a gets her tongue dusted with pollen from the anthers at the middle of the tube; and this pollen is ready to be brushed off against the stigmas of a flower of the *b* form. A bee visiting a bluet of the *b* form receives the pollen at the base of her tongue; from here it can be brushed off by the protruding stigmas of the flowers of the *a* form.

This arrangement in flowers for the reciprocal exchange of pollen also characterizes members of the primrose family; it is certainly a very clever arrangement for securing cross-pollination.

LESSON 125

The Bluets

Leading Thought — The bluets have two forms of flowers, the anthers and stigmas being placed in different positions in the two.

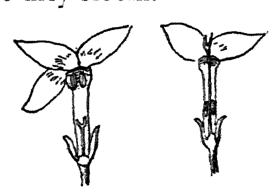
Method — Ask the children to bring in several bits of sod covered with bluets. Let the pupils, with the aid of a lens if necessary, find the two different forms of

Cyrus Crosby

Bluets

flowers. Later, let each see a flower of each form with the tube opened lengthwise.

Observations — 1. Where do the bluets grow? Do they grow singly or in masses? On what kind of soil do they grow, in woods or meadows? At what time of year do they bloom?



b, Section of a bluet blossom that has the anthers at the throat of the tube and the stigmas below. a, Section of a bluet with the stigmas protruding and the anthers below

2. Describe the bluet flower, its color, the shape of its sepals, the form of the corolla, the color of the corolla-tube and lobes.

3. Where is the nectar in the bluet?

4. Look directly into the flowers. Do you see any with the stigmas thrust out of the corolla-tube? Is there more than one style? Has it one or two stigmas?

Open this flower-tube and describe where the anthers are situated in it. How many anthers are there?

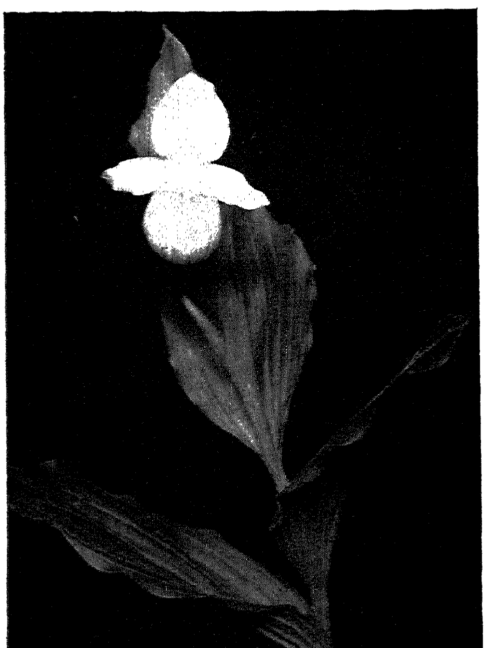
5. Look for a flower where the stigmas do not protrude and the anthers close the throat of the tube. Where are the stigmas in this flower, below or above the anthers? Where are the anthers attached?

6. Work out this problem: How do the insects gathering nectar from one form of the bluets become dusted with pollen in such a way as to leave it upon the stigma of the other form of the bluet flower?

7. How many sepals has the flower of the bluet? Do these sepals fall off when the corolla falls?

THE YELLOW LADY'S-SLIPPER

Graceful and tall the slender drooping stem,
With two broad leaves below,
Shapely the flower so lightly poised between,
And warm its rosy glow. — Elaine Goodale



Brooklyn Botanic Garden

Showy lady's-slipper

These showy flowers look so strange in our woodlands that we gaze at them as curiously as we might upon a veiled lady from the Orient who had settled in our midst. There is something abnormal and mysterious in the shape of this flower, and though it be called the lady's-slipper, yet it would be a strange foot that could fit such a slipper; and if it is strange at the first glance, it is still more so as we try to compare it with other flowers. There are two long sepals that extend up and down, the lower one being made up of two grown together. The sepals are yellow, and are wider than the two long streamers that extend out at right angles to them, which are petals; the brighter color of the latter, their markings of reddish dots, the hairs near their bases, all go to show that these petals, although so different in shape, belong to the same series as the big lower petal which is puffed out into a sac, shaped like a deep, long bowl, with its upper edges incurved. If we look carefully at this bowl, we find two openings besides the main one; these two are near the stem, and their edges are not incurved. Extending out into each of these openings is a strange little round object, which is an anther; but if we try to get pollen from this anther with a pencil or a knife we get, instead of powdery pollen, a smear that sticks to what it touches, like melted rubber or gum. The secret of this is that the lower side of the anther is gummy, and, adhering to whatever touches it, brings with it, when pulled away, the mealy pollen which lies loose above it. Another strange thing is that, if this lower part of the anther is not carried away, it seems to partially harden and opens downward, letting the pollen escape in a way usual with other flowers. We have to remove a side of the bowl to see the stigma; it is fan-shaped, and is bent at right angles to the flower stem; and above it, as if to protect it, is a stiff triangular piece which is really a strangely modified stamen. I think one reason why the lady's-slipper always is called " she " is because of this tendency on her part to divert an object from its natural use. Surely a hairpin used for a paper knife or a monkey wrench for a hammer is not nearly so feminine a diversion as a stamen grown wide and long to make an awning above a stigma.

The general color of the flower is yellow, and there are some dark red spots on the stamen-awning and along the folded-in surface of the petal sac. The little bee alights on the flower and crawls into the well at the center, the recurved edges preventing it from returning by the same opening. At the bottom of the sac there are vegetable hairs to be browsed upon;

Buffalo Museum of Science

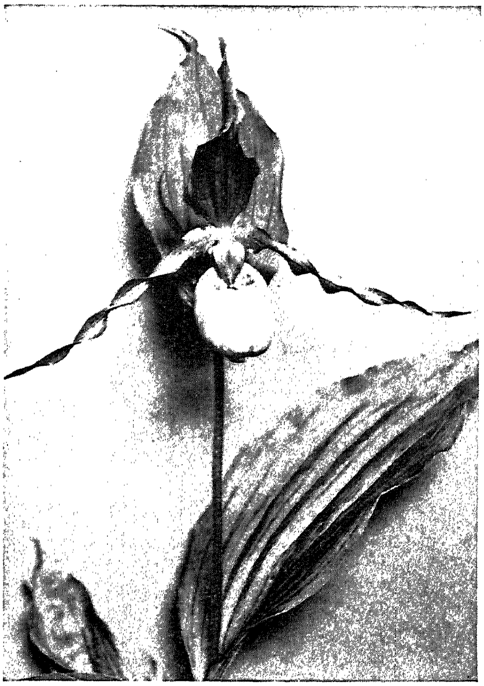
Smaller yellow lady's-slipper

Leonard K. Beyer

Lesser purple-fringed orchis

if there is nectar, I have never been able to detect it with my coarse organs of taste; and Mr. Eugene Barker, who has examined hundreds of the flowers, has not been able to detect the presence of nectar in them at any stage; but he made no histological study of the glands.

After a satisfying meal the bee, which is a lively crawler, seeks to get out to the light again through one of the openings near to the stem. In doing this, she presses her head and back, first against the projecting stigma and then against the sticky anther, which smears her with a queer kind of plaster; and it sticks there until she brushes it off on the stigma of another flower, when crowding past it; and there she again becomes smeared with pollen plaster from this flower's anthers. Mr. Barker, who has especially studied these flowers, has found that the little mining bees of the genus *Andrena* were the most frequent visitors; he also found honeybees and one stray young grasshopper in the sacs. The mining bees which he sent to me had their backs plastered with the pollen. Mr. Barker states that the flowers are not visited frequently by insects, and adds feelingly: " My long waiting was rewarded with little insect activity aside from the mosquitoes which furnished plenty of entertainment."



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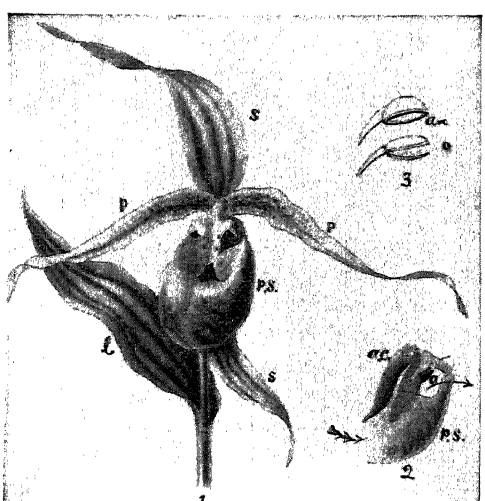
Larger yellow lady's-slipper

The ovary looks like a widened and ribbed portion of the flowerstalk, and is hairy outside; its walls are thick and obscurely three-angled; seen in cross section



Detail of yellow lady's-slipper

1, l, leaf; s,s, sepals; p,p, petals; p.,s., petal sac. 2, Side view: a.c., anther cover; p.s., petal sac; a, anther. 3, an, anther closed; o, anther open

the seeds are arranged in a triangular fashion which is very pretty.

The leaves of the yellow lady's-slipper are oval or elliptic, with smooth edges and parallel veins; they often have narrow veins between each two heavier ones. The leaves are of vivid yellowish green and are scattered, in a picturesque manner, alternately along the stem, which their bases completely clasp. The stem is somewhat rough and ribbed and is likely to

Brooklyn Botanic Garden

Pink moccasin flower or stemless lady's-slipper

grow crooked; it grows from one to two feet in height. The roots are a mass of small rootlets. This species is found in woods and in thickets.

The pink moccasin flower, also called the stemless lady's-slipper (*C. acaule*), is perhaps prettier than the yellow species, and differs from it in several particulars. The sac opens by the merest crevice, and there are dark-pink lines which lead to the little opening of the well. The downward-folded edges prevent the visiting insect from getting out by this opening even more surely than in the other species. The side petals are not so long as in the yellow species, and they extend forward as if to guide the insect to the well in the lower petal. The sepals are greenish purple, and are likewise shorter; and the lower one is wide, indicating that it is made up of two grown together. At the base of the ovary there is a pointed green bract or leaf, which lifts up and bends above the flower. There are but two leaves on the stemless lady's-slipper; they arise from the base of the flowerstalk. They are broadly ovate, and from six to seven inches long. This species grows in sandy or rocky woods.

Another species more beautiful than these is the showy lady's-slipper, which is white with a pink entrance to the petal sac. This grows by preference in peaty bogs, and is not so common as the others.

The interesting points for observation in these flowers are the careful noting of the kinds of insects which visit them, and how they enter and leave the "slipper," or sac.

Buffalo Museum of Science

Showy lady's-slipper. In this native habitat it is surrounded by such plants as horsetail, Indian cucumber, and ferns

LESSON 126

The Yellow Lady's-Slipper

Leading Thought — The moccasin flower belongs to that family of flowers known as orchids which especially depend upon insects for bringing and carrying pollen, and which have developed many strange devices to secure insect aid in pollination.

Method — A trip may be taken to see these plants where they grow.

Observations — 1. Where does the yellow lady's-slipper grow? Look carefully at its leaves and describe them. How do they join the stem? Are they opposite or alternate?

2. What is there peculiar about the sepals? How many are there?

3. Describe the three petals and the difference and likeness in their form and color. What is the shape of the lower petal? Is there a hole in this sac? What is the color of the sac? Is there anything about it to attract insects? If an insect should enter the mouth of the well in the lower petal could it easily come out by the same opening? Why not? Where do you think it would emerge?

4. Note the two roundish objects projecting into the two openings of the sac near the stem. Thrust a pencil against the under side of one of these. What happens? How does this pollen differ from the pollen of ordinary flowers?

5. Explain how a bee visiting these flowers, one after another, must carry the pollen from one to another and deposit it on the waiting stigmas.

6. How is the insect attracted? How is it trapped?

7. Look at the seed capsule and describe it from the outside.

8. How many species of lady's-slippers do you know? Do you know the pink, or stemless species? How does it differ from the yellow species?

THE EVENING PRIMROSE

Children came
To watch the primrose blow. Silent they stood,
Hand clasped in hand, in breathless hush around,
And saw her shyly doff her soft green hood
And blossom — with a silken burst of sound.
— MARGARET DELAND

To the one who has seen the evening primrose unfold, life is richer by a beautiful, mysterious experience. Although it may be no more wonderful than the unfolding of any other flower, yet the suddenness of it makes it seem more marvelous. For two or three days it may have been getting ready; the long tube which looks like the flowerstalk has been turning yellow; pushing up between two of the sepals, which clasp tips beyond it, there appears a row of petals. Then some warm evening, usually about sunset, but varying from four o'clock in the afternoon to nine or ten in the evening, the petals begin to unfurl; they are wrapped around each other in the bud as an umbrella is folded, and thus one edge of each petal becomes free first. The petal first in freeing its edge seems to be doing all the work, but we may be sure that all the others are opening too; little by little the sepals are pushed downward, until their tips, still clasped, are left beneath; and the petals now free suddenly flare open before our delighted eyes, with a movement so rapid that it is difficult for us not to attribute to them consciousness of action. Three or four of these flowers may open on a plant the same evening; and they, with their fellows on the neighboring plants, form constellations of starry bloom that invite attention, and night-flying insects are often seen on them. There is a difference in the time required for a primrose flower to unfold, probably depending upon its vigor; once I watched for half an hour to see it accomplished, and again I have seen it done in two or three minutes. The garden species seems to unfold more rapidly than the wild species, and is much more fragrant. The rapidity of the opening of the blossom depends upon the petals getting free from the sepals, which seem to try to repress them. The bud is long, conical, obscurely four-sided, and is completely covered by the four sepals, the tips of which are cylindrical and twisted together; this is an interesting habit, and one wonders if they hold the petals back until the latter are obliged to burst out with the force of repressed energy; after they let go of the petals, they drop below the flower angularly, and finally their tips open and each

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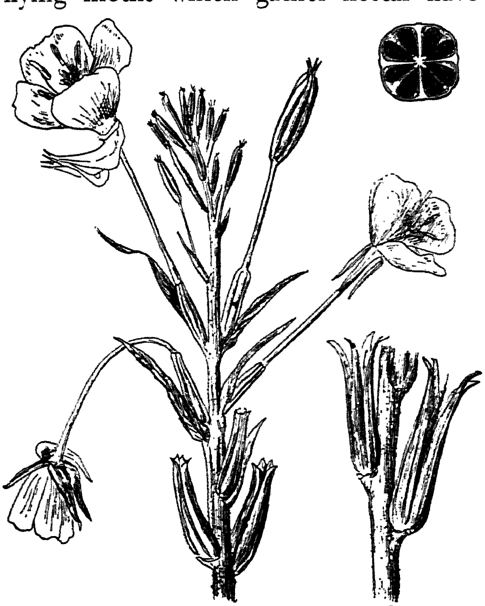
Evening primrose in flower

sepal turns back lengthwise along the seed-tube.

The four lemon-yellow petals are broad, with the outer margin notched. The eight stamens are stout, and set one at the middle of each petal and one between each two petals. The long, pale yellow anthers discharge their pollen in cobwebby strings. When the flower first opens, the stigma is egg-shaped and lies below the anthers; later, it opens into a cross and usually hangs off at one side of the anthers. If we try to trace the style back to the ovary, we find that it extends down into what seems to be the very base of the flowerstalk, where it joins the main stem. This base is enlarged and ribbed and is the seed box, or ovary. The tube is rich in nectar, but only the long sucking-tubes of moths can reach it, although I have sometimes seen the ubiquitous bees attempting it. The butterflies may take the nectar in the daytime, for the blossoms of the wild species remain open, or partially open, for a day or two. But the night-flying moths which gather nectar have



1, *Evening primrose showing buds, one ready to open, a flower just opened above at the left, an older flower at the right, a fading flower and seed capsules below.* 2, *seed capsules. Cross section of seed capsule with seeds above*

Verne Morton

Winter rosette of evening primrose

the first chance, and it is they who carry the flower's pollen.

There are times when we may find the primrose blossoms with holes in the petals, which make them look very ragged. If we look at such plants carefully, we may find the culprit in the form of a green caterpillar very much resembling the green tube of the bud; and we may conclude, as Dr. Asa Fitch did, that this caterpillar is a rascal, because it crawls out on the bud-ends and nibbles into them, thus damaging several flowers. But this is only half the story. Later this caterpillar descends to the ground, digs down into it and there changes to a pupa; it remains there until the next summer and then, from this winter cell, emerges an exquisitely beautiful moth called the *Alaria florida;* its wings expand about an inch, and all except the outer edges of the front wings are rose-pink, slightly mottled with lemon-yellow, which latter color decorates the outer margins for about one-quarter of their length; the body and hind-wings are whitish and silky, the face and antennæ are pinkish. Coiled up beneath the head is a long sucking-tube which may be unfolded. This moth is the special pollen-carrier of the evening primrose; it flies about during the evening, and thrusts its long, tubular mouth into the flower to suck the nectar, meanwhile gathering strings of pollen upon the front part of its body. During the day, it hides within the partially closed flower, thus carrying the pollen to the ripened stigmas, its colors meanwhile protecting it almost completely from observation. The fading petals of the primrose turn pinkish, and the pink color of the moth renders it invisible when in the old flowers, while the lemon-yellow tips of its wings, protruding from a flower still fresh and yellow, form an equally perfect protection from observation.

The evening primrose is an ornamental plant in both summer and winter. It is straight, and is ordinarily three or four feet tall, although it sometimes reaches twice that height. It is branched somewhat, the lower portion being covered with leaves and the upper portion bearing the flowers. The leaves are pointed and lanceolate, with few whitish veins. The leaf edges are somewhat ruffled and obscurely toothed, especially in the lower leaves. The leaves stand up in a peculiar way, having a short, pink petiole, which is swollen and joins the stalk like a bracket. The upper leaves are narrower; the leafy bracts at the base of the flower grow from the merest slender leaflet at the base of the bud to a leaf as long as the seed pod, when the flower blooms.

The seed capsules are four-sided, long, and dark green. In winter they are crowded in purplish-brown masses on the dry stalks, each one a graceful vase with four flaring tips. At the center of each there projects a needlelike point; and within the flaring, pale, satin-lined divisions of these urns we may see the brown seeds, which are tossed by the winter winds far and near. The young plants develop into vigorous rosettes during the late summer and autumn, and thus pass the winter under the snow coverlet.

Suggested Reading — *Holiday Hill*, by Edith M. Patch; also, readings on page 461.

LESSON 127

The Evening Primrose

Leading Thought — The pollen of the evening primrose is carried by night-flying insects. The evening primrose's flowers open in the evening; their pale yellow color makes them noticeable objects in the twilight, and even in the dark.

Method — The form of the evening primrose may be studied from plants brought to the schoolroom; but its special interest lies in the way its petals expand in the evening, so the study should be continued by the pupils individually in the field. This is one of the plants which is an especially fit subject for the summer notebook; but since it blossoms very late and the plants are available even in October, it is also a convenient plant to study during the school year. The garden species is well adapted for this lesson.

Observations — 1. Look at the plant as a whole. How tall is it? Is the stem stiff and straight? Where do you find it growing? Does it grow in the woods?

2. Are the leaves near the base the same shape as those at the top of the plant? What is their shape? Are the edges toothed? What is there peculiar about the veins? How do the leaves join the stem? How do the leaves which are at the base of the flowerstalk look? Those at the base of the buds?

3. Where on the plant do the flowers grow? Which flowers blossom first, those above or below? Take a bud nearly ready to open; what is there peculiar in the appearance of the budstalk? What is the general shape of the bud? Describe the sepals. Look at their tips carefully, and see how they hold together. Cut a bud across and see how the petals are folded within it.

4. Take an open flower; where are the sepals now? Describe the open petals, their shape and color.

5. How many stamens are there? How are they placed? What is the shape of the anthers? How does the pollen look?

6. What is the shape and the position of the stigma in the freshly opened flower? Later? Open the flower-tube and find how far down the style extends. Where is the ovary? How does the ovary look on the outside? Taste the opened tube; can you detect the nectar? What sort of tongue must an insect have to reach this nectar?

How do the fading flowers look and act?

7. Describe the seed pod. Cut it across, and see how many compartments there are within it. How are the seeds arranged in it? How do the pods open and how are the seeds scattered?

8. Watch the flower of the evening primrose open, and describe the process carefully. At what hour did it open? What was the movement of the petals? Can you see how they unfold in relation one to another? How do they get free from the sepals? How many minutes are required for the whole process of the opening of the flower? How many flowers on a plant expand during the same evening? Look at the open blossoms in the dark; can you see them? How do they look? What insects do you find visiting these flowers?

9. How long does the primrose blossom remain open? How do the young plants of the evening primrose pass the winter?

THE MILKWEED

Little weavers of the summer, with sunbeam shuttle bright,
And loom unseen by mortals, you are busy day and night,
Weaving fairy threads as filmy, and soft as cloud swans, seen
In broad blue sky-land rivers, above earth's fields of green.

— Ray Laurance

Is there any other young plant that shows off its baby clothes as does the young milkweed! When it comes up through the soil, each leaf is folded lengthwise around the stem, flannel side out, and it is entirely soft and white and infantile. The most striking peculiarity of the milkweed plant is its white juice, which is a kind of rubber. Let a drop of it dry on the back of the hand, and when we try to remove it we find it quite elastic and possessed of all the qualities of crude rubber. At the first trial it seems quite impossible to tell from which part of the stem this white juice comes, but by blotting the cut end once or twice, we can see that the hollow of the center of the stem has around it a dark green ring, and that outside this is a light green ring. It is from the dark green ring encircling the stem cavity that the milk exudes. This milk is not the sap of the plant any more than resin is the sap of the pine; it is a special secretion, and is very acrid to the taste. Milkweed is seldom eaten by grazing animals. If a milkweed stem be broken or gashed, this juice soon heals the wound. If cut across, every vein in every leaf produces " milk," and so does every small flower pedicel. When the " milk " is by chance smeared on cloth and allowed to dry, soap and water will not remove it, but it yields readily to chloroform, which is a solvent of rubber.

Verne Morton

Milkweed in blossom

The milkweed leaves are in stately conventional pairs; if one pair points east and west, the pair above and the pair below point north and south. The leaf is beautiful in every particular; it has a dark green upper surface, with veins that join in scallops near the border; it is soft to the touch on the upper surface, and is velvety below.

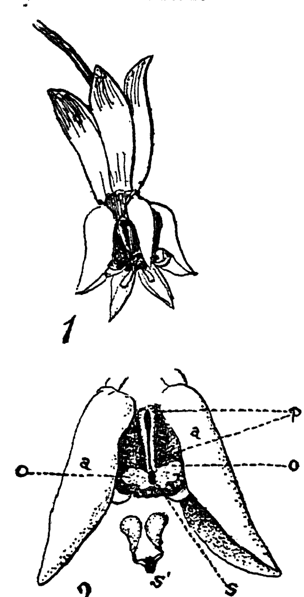
Leonard K. Beyer

Milkweed in natural surroundings

The lens reveals that the white under surface, or the nap of the velvet, is a cover of fine white hairs.

The flower of the milkweed is too complicated for little folks even to try to understand; but for the pupils of the seventh and eighth grades it will prove an interesting subject for investigation, if they study it with the help of a lens. In examining the globular bud, we see the five hairy sepals, which are later hidden by the five long, pinkish green petals that bend back around the stem. When we look into the flower, we see five little cornucopias — which are really horns of plenty, since they are filled with nectar; in the center of each is a little, fleshy tongue, with its curved point resting on the disk at the center of the flower. Between each two of these nectar-horns can be seen the white bordered opening of a long pocket — like a dress pocket — at the upper end of the opening of which is a black dot. Slip a needle into the pocket opening until it pushes against the black dot, and out pops a pair of yellow saddle-bags, each attached to the black dot which joins them. These are the pollen-bags, and each was borne in a sac, shaped like a vest-pocket, one lying either side of the upper end of the long pocket. These pollen-bags are sticky, and they contract so as to close over the feet of the visiting bee.

Since the stalk of the flower cluster droops and each flower pedicel droops, the bee is obliged to cling, hanging back down, while getting the nectar, and has to turn about as if on a pivot in order to thrust her tongue into the five cornucopias in succession; she is then certain to thrust her claws into a long pocket, and it proceeds to close upon them, its edges being like the jaws of a trap. The bee, in trying to extricate her feet, leaves whatever pollen-bags she had inadvertently gathered in this trap-pocket, which gives them passage to the stigma. But the milkweed flower, like some folks, is likely to overdo matters, and sometimes these pockets grasp too firmly the legs of the bee and hold her a prisoner. We often find insects thus caught and dead. Sometimes bees become so covered with these pollen-bags, which they are unable to scrape off, that they die because of the clogging. But for one bee that suffers there are thousands that carry off the nectar.



1, *Milkweed flower, enlarged.* 2, *Same, more enlarged*

a, a, nectar-horns; p, pocket; o, openings to pocket; s, pollen-bags in place; s′ pollen-bags removed

The milkweed pod has been the admiration of nature students from the beginning, and surely there are few plant structures that so interest the child as this house in which the milkweed carries its seeds. When we look at a green pod, we first admire its beautiful shape; on either side of the seam, which will sometime open, are three or four rows of projecting points rising from the felty surface of the pod in a way that suggests embossed embroidery. We open the pod by pulling it apart along the seam; and this is not a seam with a raw edge but is finished with a most perfect selvage. When we were children we were wont to dispossess these large green pods of their natural contents, and because they snapped shut so easily, we imprisoned therein bumblebees "to hear them sing," but we always let them go again. We now know that there is nothing so interesting as to study the contents of the pod just as it is. Below the opening is a line of white velvet; at one end, and with their "heads all in one direction," are the beautiful, pale-rimmed, brown, overlapping seeds; and at the other end we see the exquisite milkweed silk with the skein so polished that no human reel could give us a skein of such luster. If we remove the contents of the pod as a whole, we see that the velvety portion is really the seed-support and that it joins the pod at either end. It is like a hammock full of babies, except that the milkweed babies are fastened on the outside of the hammock.

No sooner is our treasure open to the air than the shining silk begins to separate into floss of fairy texture. But before one seed comes off, let us look at the beautiful pattern formed by the seeds overlapping — such patterns we may see in the mosaics of mosques.

Pull off a seed, and with it comes its own skein of floss, shining like a pearl; but if we hold the seed in the hand a moment the skein unwinds itself into a fluff of shining threads as fine as spiders' silk, and each individual thread thrusts itself out and rests upon the air; and altogether there are enough of the threads

Milkweed seed balloons just leaving the sheltering pod

to float the seed, a balloon of the safest sort. If we wreck the balloon by rubbing the floss through our fingers, we shall feel one of the softest textile fibers spun by Mother Nature.

If we look closely at our seed we see a margin all around it. Well, what if the balloon should be driven over a stream or lake, and the seed dropped upon the water? It must then sink unless it has a life preserver; this margin that we have noted keeps it afloat; if you do not believe it, try it.

If we pull off all the seeds, we can see that the velvety support is flat and that all of the seeds are attached to it, but before we stop our admiring study we should look carefully again at the inside of the pod, for never was there a seed cradle with a lining more soft and satiny.

LESSON 128

The Milkweed

Leading Thought — The milkweed when wounded secretes a milky juice which is of a rubber-like composition; it flows out of the wounded plant and soon hardens, thus protecting the wound. Milkweed flowers depend entirely upon insects for pollination; the pollen is not a free, yellow powder, but it is contained in paired sacs, which are joined in V-shape.

Milkweeds sending forth their seed balloons

The seeds are carried by balloons, and they can float on water as well.

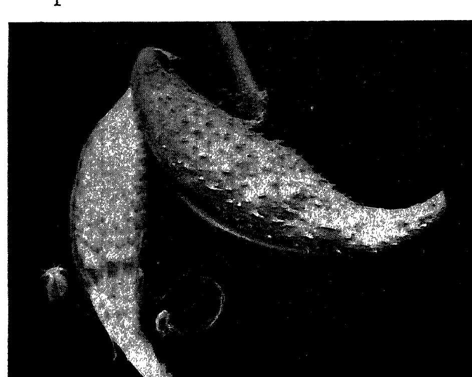
METHOD — Begin the study of the plant when it first appears above ground in April or May. Give the pupils the questions about the blossom for a vacation study, and ask that their observations be kept in their notebooks. The study of the pods and seeds may be made in September or October. When studying the milky juice, add a geography lesson on rubber trees and the way that rubber is made.

OBSERVATIONS — 1. *The plant.* How does the milkweed look as it appears above ground in the spring? How are its leaves folded when it first puts its head up? Cut off a fully expanded plant a few inches above the ground. What flows out of the stem? Blot off the " milk " and study the cross-section of the stem. What is at the center? How many layers do you see around this center? Can you see from which the milkweed juice comes? How does the juice feel as it dries on your fingers? How does it look when dry? Place a few drops on a piece of paper and when it is dry pull it off and see if it is elastic. Break the edge of the leaf. Does the milky juice flow from it? Does it come from the veins? Do you think that this is the sap of the milkweed? Cut a gash in the milkweed stem and see how the " milk " fills the wound. How does this help the plant? Do cattle feed upon the milkweed when it grows in pastures? Why not?

2. How are the leaves arranged on the stem? How do the upper and under sides of the leaves differ? Examine with a lens, and see what makes the nap of the velvet. What gives the light color to the under side? Sketch a leaf showing its shape and venation, noting especially the direction of the veins as they approach the edge of the leaf.

3. *The flower.* Where do the flower clusters come off the stems in relation to the leaves? Does the stalk of the flower cluster stand stiff or droop? Take a good-sized flower cluster and count the flowers in it. What would happen if all these flowers should develop into pods? How many flower clusters do you find in one plant? Which of these clusters opens first? Last?

4. Take off a single bud with its stalk or pedicel. Does the milky juice come at the break? Is the bud stalk stiff or drooping? What is its color and how does it feel? What is the shape of the bud? How many sepals has it? Look at the stalk, sepals, and bud with a lens and describe their covering. Look for a flower just opening where the petals stand out around it like a five-



Milkweed pod

pointed star. What is their color? What happens to the petals when the flower is fully expanded? Can you see the sepals then? Look straight into the flower. Do you see the five nectar-horns? Look at them with a lens and describe them. Where does the tip of the tongue rest? With a lens, look between two of the nectar-horns; can you see a little slit or pocket, with white protruding edges? Note just above the pocket a black dot; thrust a needle into this pocket near its base and lift it toward the crown of the flower, touching the black dot. What happens?

5. Describe the little branched object that came out when you touched it with a needle. These are the pollen saddlebags and each bag comes from a pocket at one side of, and above the long pocket. Do these saddlebags cling to the needle? Look with a lens at some of the older flowers, and see if you can find the pollen-bags protruding from the long pocket. See if you can find how the long pocket is a passageway to the stigma. To see how the little saddlebags were transported, watch a bee gathering nectar. Describe what happens.

6. Since the flowers bend over, how must the bee hold on to the flower while she gathers nectar from the horns? As she turns around, would she naturally pull out some of the saddlebags? Catch a bee in a collecting tube and see if her feet have upon them these pollen-sacs. After these pollen-sacs have been gathered upon her feet, what happens to them when she visits the next flower? Is the opening of the long pocket like a trap? Can you find on milkweed flowers any bees or other insects that have been entangled in these little traps and have thus perished? Try the experiment of drawing a thread into one of these traps and with your lens see if the opening closes over it.

7. How many kinds of insects do you find visiting the milkweed flowers? Can you detect the strong odor of the flowers? How does the milkweed benefit by having so many flowers and by offering such an abundance of nectar?

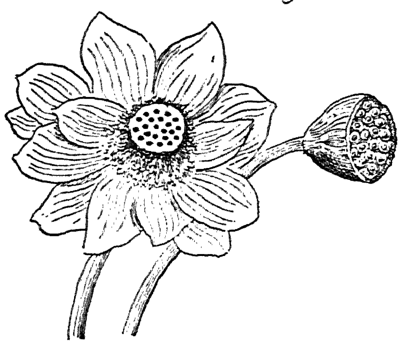
Verne Morton

THE WHITE WATER LILY

Whence O fragrant form of light,
Hast thou drifted through the night
Swanlike, to a leafy nest,
On the restless waves at rest.

Thus asks Father Tabb, and if the lily could answer it would have to say: "Through ages untold have the waves upheld me until my leaves and my flowers have changed into boats, my root to an anchor, and my stems to anchor-ropes."

There is no better example for teaching the relation between geography and plant life than the water lily. Here is a plant that has dwelt so long in a certain

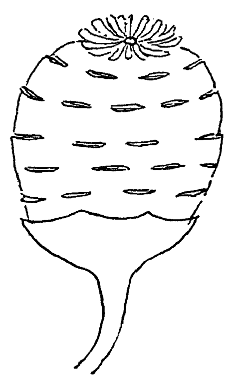


Egyptian lotus flower and seed vessel

situation that it cannot live elsewhere. The conditions which it demands are quiet water, not too deep, and with silt bottom. Every part of the plant relies upon these conditions. The rootstock has but few rootlets; and it lies buried in the silt, where it acts as an anchor. Rising from the rootstock is a stalk as pliable as if made of rubber, and yet it is strong; its strength and flexibility are gained by having at its center four hollow tubular channels, and smaller channels near the outside. These tubes extend the whole length of the stem, making it light so that it will float, and at the same time giving it strength as well as flexibility. At the upper end of the stalk is a leaf or flower, which is fashioned as a boat. The circular leaf is leathery and often bronze-red below, with prominent veins, making an excellent bottom to the boat; above, it is green with a polished surface, and here are situated its air-pores, although the leaves of most plants have these stomata in the lower surface. But how could the water lily leaf secure air, if its stomata opened in the water? The leaf is large, circular, and quite heavy; it would require a very strong, stiff stem to hold it aloft, but by its form and structure it is fitted to float upon the water, a little green dory, varnished inside, and waterproof outside.

The bud is a little, egg-shaped buoy protected by its four pinkish brown, leathery sepals; as it opens, we can see four rows of petals, each overlapping the space between the next inner ones; at the center there is a fine display of brilliant yellow anthers. Those hanging over the greenish yellow pit, which has the stigma at its center, are merely golden hooks. When the flower is quite open, the four sepals, each a canoe in form, lie under the lily and float it; although the sepals are brownish outside, they are soft white on the inside next the flower. Between each two sepals stands a large petal, also canoe-shaped, and perhaps pinkish on the outside; these help the sepals in floating the flower. Inside of these there is a row of large creamy white petals which stand upright; the succeeding rows of petals are smaller toward the center and grade into the outer rows of stamens, which are petal-like at the base and pointed at the tip. The inner rows of stamens make a fine golden fringe around the cup-shaped pistil.

It has been stated that pond lilies, in the state of nature, have an interesting way of opening in the early morning, closing at noon, and opening again toward evening. If we knew better the habits of



Seed vessel of white pond lily

the insects which pollinate these flowers, we should possibly have the key to this action. In our ponds in parks and grounds we find that each species of pond lily opens and closes at its own particular time each day. Each flower opens usually for several consecutive days, and the first day of its blooming it opens about an hour later and closes an hour earlier than on the days following. After the lilies have blossomed, the flower stem coils in a spiral and brings the ripening seeds below the surface of the water. After about two months the pod bursts, letting the seeds out in the water. Each seed is in a little bag, which the botanists call an aril, and which serves to float the seed off for some distance from the parent plant. The aril finally decays and the seed falls to the bottom where, if the conditions are favorable, it develops into a new plant.

To emphasize the fact that the water lily is dependent upon certain geographical conditions, ask the pupils to imagine a water lily planted upon a hillside. How could its roots, furnished with such insufficient rootlets, get nourishment there? How could its soft, flexible stems hold aloft the heavy leaves and blossoms to the sunlight? In such a situation it would be a mere drooping mass. Moreover, if the pupils understand the conditions in which the water lilies grow in their own neighborhood, they can understand the conditions under which the plant grows in other countries. Thus, when they read about the great *Victoria regia* of the Amazon — that water lily whose leaves are large enough to support a man — they would have visions of broad stretches of still water and they should realize that the bottom must be silt. If they read about the lotus of Egypt, then they should see the Nile as a river with borders of still water and with bottom of silt. Thus, from the conditions near at hand, we may cultivate in the child an intelligent geographical imagination.

Suggested Reading — *Science Stories*, by Wilbur L. Beauchamp and Co-authors, Book 3; also, readings on page 461.

LESSON 129

The Water Lily

Leading Thought — The water lily has become dependent upon certain conditions in pond or stream, and has become unfitted in form to live elsewhere. It must have quiet waters, not too deep, and with silt bottom.

Method — The study should be made first with the water lilies in a stream or pond, to discover just how they grow. For the special structure, the leaves and flowers may be brought to the schoolroom and floated in a pan of water. The lesson may easily be modified to fit the yellow water lily, which is in many ways even more interesting, since in shallow water it holds its leaves erect while in deeper water its leaves float.

Observations — 1. Where is the water lily found? If in a pond, how deep is the water? If in a stream, is it in the current? What kind of bottom is there to the stream or pond? Do you find lilies in the water of a limestone region? Why?

2. What is the shape of the leaf? What is the color above and below? What is the texture? How is it especially fitted to float? How does it look when very young?

3. Examine the petiole. How long is it? Is it stiff enough to hold up the leaf? Why does it not need to hold up the leaf? How does it serve as an anchor? Cut a petiole across and describe its inside structure. How does this structure help it float?

4. Examine the open flower. How many sepals? How many rows of petals? How do the stamens resemble the petals? How are the sepals fitted to keep the flower afloat? At what times of the day does the lily open? At what hours does it close?

5. Describe the pistil. When the lily first opens, how are the stamens placed around the pistil? What happens to the seed box after the blossoms have faded? Does the seed pod float upon the water as did the flower? What sort of stalk has the flower? How does this stalk hold the seed pod below the water?

6. What sort of seed has the water lily? Sketch the seed pod. How does the seed escape from it? How is it scattered and planted?

7. What sort of root has the water lily? Are there many fine rootlets upon it? Why? How does this rootstock serve the plant aside from getting moisture?

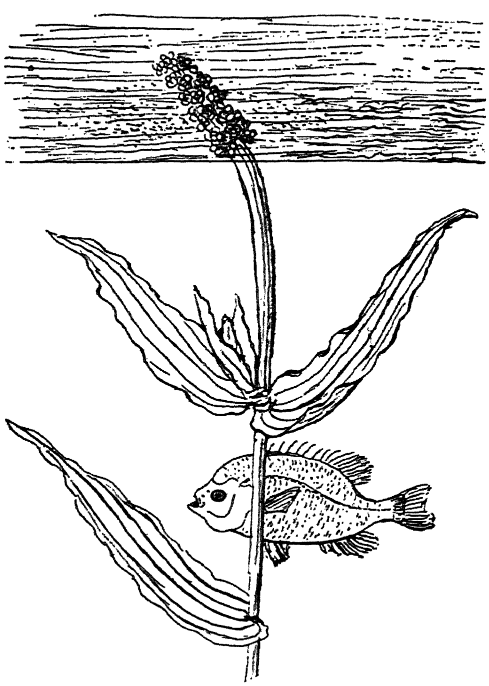
8. Imagine a water lily set on a dry hillside. Could the stalks uphold the

flowers or leaves? Is the petiole large enough to hold out such a thick, heavy leaf?

9. Judging from what you know of the places where water lilies grow and the condition of the water there, describe the Nile where the lotus grows. Describe the Amazon where the *Victoria regia* grows.

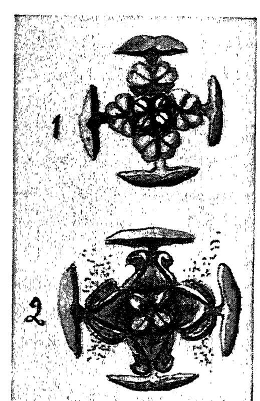
PONDWEED

The study of any plant which has obvious limitations as to where it may grow should be made a help in the study of geography. Pondweed is an excellent subject to illustrate this principle; it grows only in quiet beds of sluggish streams or in ponds, or in the shallow protected portions of lakes. It has tremendous powers of stretching up, which render it able to grow at greater depth than one would suppose possible; it often flourishes where the water is from ten to twenty feet deep. Often, when the sun is shining, it may be seen like a bed of seaweed on the bottom. Its roots, like those of most water plants, have less to do with the matter of absorbing water than do the roots of land plants, one of their chief functions being to anchor the plant fast; they have a firm grip on the bottom, and if pondweed is cut loose, it at once comes to the surface, floats, and soon dies.



Pondweed

The stem is very soft and pliable and the plant is supported and held upright by the water. A cross-section of the stem shows that its substance is spongy, the larger open cells being near the outer edge, and thus helping it to float. The leaves are two or three inches long, their broad bases encircling the stem, their tips tapering to slender points. They have parallel veins and ruffled edges. They are dull olive green in color, much darker than the stems; in texture they are very thin, papery, and so shining as to give the impression of being varnished. No land plants have such leaves; they remind us at once of kelp or other seaweeds. The leaves are scattered along the stems, by no means thickly, for water plants do not seem to need profuse foliage.



1, *Flower of a pondweed enlarged, early stage.* 2, *Same at later stage*

In blossom time the pondweed shows its real beauty. The stems grow and grow, like Jack's beanstalk, and what was a bed of leaves on the pond bottom suddenly changes into a forest of high plants, each one standing tall and straight and with every leaf extended, as if its stems were as strong and stiff as ironwood; but if a wave disturbs the water the graceful undulations of the plant tell the true story of the pliant stems. There is something that arouses our admiration when we see one of these pondweeds grown so straight and tall, often three or four yards high, with its little, greenish brown flower-head above the water's surface. We have spent hours looking down into such a submerged forest, dreaming and wondering about the real meaning of such adaptations.

Although the stem is flexible, the somewhat curved, enlarged stalk just below the flower-head is rigid; it is also more spongy than the lower part of the stem and is thus fitted to float the flower. The flower itself is one of the prettiest sights that nature has to show us through a lens. It is a Maltese cross, the four reddish stigmas arranged in a solid square at the center; at each side of this central square is a double-barrelled anther, and outside of each anther is a queer, little, dipper-shaped, green flap. When the anthers open, they push away from the stigmas and throw their pollen toward the outside. There may be thirty or more of these tiny, cross-shaped flowers in one flower-head. In the bud, the cup-shaped flaps shut down closely, exposing the stigmas first, which would indicate that they ripen before the pollen is shed. The pollen is white, and is floated from plant to plant on the surface of the water; often the water for yards will be covered with this living dust.

SUGGESTED READING — *Field Book of Ponds and Streams*, by Ann H. Morgan; also, readings on page 461.

LESSON 130

PONDWEED

LEADING THOUGHT — The pondweed lives entirely below the water; at blossom time, however, it sends up its flowerstalks to the surface of the water, and there sheds its pollen, thus securing cross-pollination.

METHOD — As this is primarily a lesson that relates to geography, the pondweed should be studied where it is growing. It may be studied in the spring or fall, and the pupils asked to observe the blossoming, which occurs in late July. After the pupils have seen where it grows, the plants themselves may be studied in an aquarium, or by placing them in a pail or basin of water. There are confusing numbers of pondweeds but any of them will do for this lesson. The one described above is *P. perfoliatus*.

OBSERVATIONS — 1. Where is the pondweed found? Does it ever grow out of water? Does it ever grow in very deep water? Does it ever grow in swiftly flowing water?

2. Has the pondweed a root? Does the pondweed need to have water carried to its leaves, as it would if it were living in the air? What is one of the chief uses of the roots to the pondweed? Break off a plant; does it float? Do you think it would float off and die, if it were not held by its root?

3. Compare the stem of pondweed with that of any land plant standing straight. What is the chief difference? Why does the pondweed not need a stiff stem to hold it up? Cut the stem across, and see if you can observe why it floats.

4. Examine the leaves. Are all of them below the surface of the water? If some float, how do they differ in texture and form from those submerged? How are they arranged on the stem? Are they set close together? What is the difference in texture between its leaves and those of the jewelweed, dock, or any other land plant? If any leaves project out of the water are they different in form and texture from those submerged? Sketch the leaf, showing its shape, its edges, and the way it joins the stem.

5. How far below the surface of the water does the pondweed usually lie? Does it ever rise up to the water's surface? When? Have you ever noticed the pondweed in blossom? How does the blossom look on the water? Can you see the white pollen floating on the surface of the water? Look down into the water and see

the way the pondweed stands when in blossom.

6. Study the blossom. Note the stalk that bears it. Is the part that bears the flower enlarged and stiffer than the stem below? Do you think that this enlarged part of the stalk acts like the bob on a fish-line? Examine a flower cluster with a lens. How many flowers upon it? Study one flower carefully. Describe the four stigmas at the center. Describe the anthers arranged around them. Describe the flap which protects each anther. When the anthers open do they discharge the pollen toward or away from the stigmas?

7. What happens after the flowers are pollinated? Do they still float? What sort of seed capsule has the pondweed? Do the seeds break away and float?

Again the wild cow-lily floats
Her golden-freighted, tented boats,
In thy cool caves of softened gloom,
O'ershadowed by the whispering reed,
And purple plumes of pickerel weed,
And meadow-sweet in tangled bloom.

The startled minnows dart in flocks,
Beneath thy glimmering amber rocks,
If but a zephyr stirs the brake;
The silent swallow swoops, a flash
Of light, and leaves with dainty plash,
A ring of ripples in her wake.

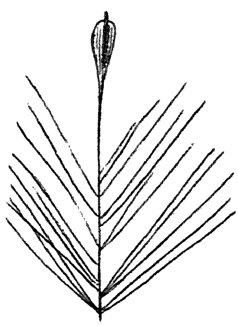
— "BIRCH STREAM,"
ANNA BOYNTON AVERILL

Verne Morton

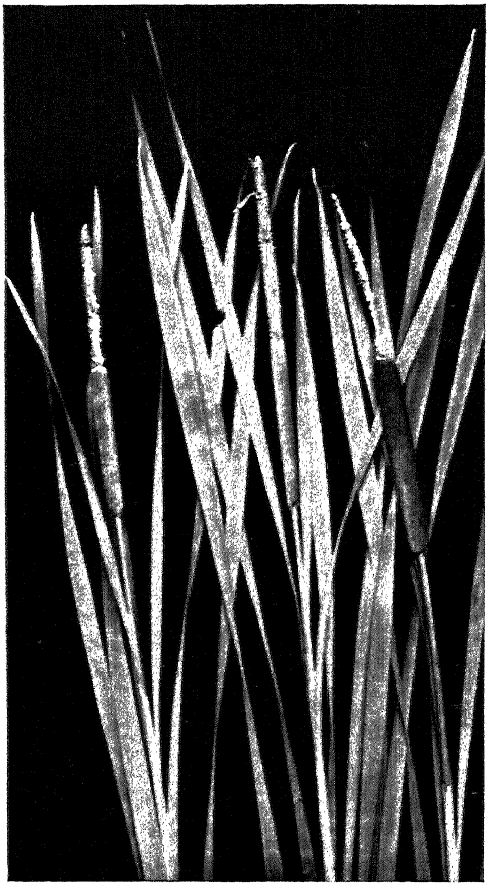
Cattails sending off their seed and balloons

THE CATTAIL

In June and early July, if the cattail be closely observed, it will be seen to have the upper half of the cat's tail much narrower and different in shape from the lower half — as if it were covered with a quite different fur. It seems to be clothed with a fine drooping fringe of olive yellow. With the aid of a lens, we can see that this fringe is a mass of crowded anthers, two or three of them being attached to the same stalk by a short filament. These anthers are packed full of pollen, which is sifted down upon the pistillate flowers below by every breeze; and with every puff of stronger wind, the pollen is showered over all neighboring flowers to the leeward. There is not much use in trying to find the pistillate flowers in the plush of the cattail. They have no sepals or petals, and are so imbedded in thick plush that the search is hardly worth while for nature-study, unless a microscope is used. The ovary is rather long, the style slender, and the stigma reaches out to the cut-plush surface of the cattail. The pupils can find what these flowers are by studying the fruit; in fact, the fruit does not differ very much from the flower, except that it is mature and is browner in color.



A cattail fruit with its balloon



Brooklyn Botanic Garden

Cattail in blossom. The staminate flowers are massed at the tip, and the pistillate flowers which form the "cattail" are massed lower on the stalk

It is an interesting process to take apart a cattail plant; the lower, shorter leaves surround the base of the plant, giving it size and strength. All the leaves have the same general shape, but vary in length. Each leaf consists of two parts: the free portion, which is long and narrow and flat toward its tapering tip but is bent into a trough as it nears the plant, and the lower portion, which clasps the plant entirely or partially, depending upon whether it is an outer or inner leaf. This clasping of the stalk by the leaf adds to its strength. We almost feel as if these alternate leaves were consciously doing their best to protect the slender flower stem. The free part of the leaves is strengthened by lengthwise veins, and they form edges that never tear or break. They are very flexible, and therefore yield to the wind rather than defy it. If we look at a leaf in cross section, we can see the two thick walls strengthened by the framework of stiff veins which divide the interior into long cells. If we cut the leaf lengthwise we can see that these long cells are supported by stiff, coarse partitions.

Where the leaf clasps the stem, it is very stiff and will break rather than bend. The texture of the leaf is soft and smooth, and its shade of green is attractive. The length of the leaves is often greater than that of the blossom stalk, and their graceful curves contrast pleasantly with its ramrod-like stiffness. It is no wonder that artists and decorators have used the cattail lavishly as a model. It is interesting to note that the only portion of the leaves injured by the wind is the extreme tip.

The cattail is adapted for living in swamps where the soil is wet but not under water all the time. When the land is drained, or when it is flooded for a considerable time, the cattails die out and disappear. They usually occur in marshy zones along lakes or streams; and such a zone is always sharply defined by dry land on one side and water on the other. The cattail roots are fine and fibrous and are especially fitted, like the roots of the tamarack, to thread the mud of marshy ground and thus gain a foothold. The cattails form one of the cohorts in the phalanx of encroaching plants, like the reeds and rushes, which surround and, by a slow march of years, finally conquer and dry up ponds. But in this they overdo the matter, since after a time the soil becomes too dry for them and they disappear, giving place to other plants which find there a congenial environment. The place where I studied the cattails as a child is now a garden of joe pye weed and wild sunflowers.

Suggested Reading — *The Pond Book*, by Walter P. Porter and Einar A. Hansen; also, readings on page 461.

The Cattail

Leading Thought — The cattail is adapted to places where the soil is wet but not under water; its pollen is scattered by the wind, and its seeds are scattered by wind and water. Its leaves and stalks are not injured or broken by the wind.

Method — As this is primarily a geography lesson, it should be given in the field if possible; otherwise the pupils must explore for themselves to discover the facts. The plant itself can be brought into the schoolroom for study. When studying the seeds, it is well to be careful, or the schoolroom and the pupils will be clothed with the " down " for weeks.

Observations — 1. Where are the cattails found? Is the land on which they grow under water all the year? At any part of the year? Is it dry land all the year? What happens to the cattails if the land on which they grow is flooded for a season? What happens to them if the land is drained?

2. How wide a strip do the cattails cover, where you have found them? Are they near a pond or brook or stream? Do they grow out in the stream? Why do they not extend further inland? What is the character of the soil on which they grow?

3. What sort of root has the cattail? Why is this root especially adapted to the soil where cattails grow? Describe the rootstock.

4. *The cattail plant.* Are the leaves arranged opposite or alternate? Tear off a few of the leaves and describe the difference between the lower and the upper end of a leaf as follows: How do they differ in shape? Texture? Pliability? Color? Width? Does each leaf completely encircle the stalk at its base? Of what use is this to the plant? Of what use is it to have the plant stiffer where the leaves clasp the stalk? What would happen in a wind storm if this top-heavy, slender seedstalk were bare and not supported by the leaves?

5. Take a single leaf, cut it across near where it joins the main stalk and also near its tip. Look at the cross section and see how the leaf is veined. What do its long veins or ribs do for the leaf? Split the leaf lengthwise and see what other supports it has. Does the cattail leaf break or tear along its edges easily? Does the wind injure any part of the leaf?

6. Study the cattail flowers the last half of June. Note the part that will develop into the cat's tail. Describe the part above it. Can you see where the pollen comes from? The pistillate flowers which are in the plush of the cattail have no sepals, petals, odor, or nectar. Do you think that their pollen is carried to them by the bees? How is it carried?

7. Examine the cattail in fall or winter. What has happened to that part of the stalk above the cattail where the anthers grew? Study two or three of the fruits, and see how they are provided for traveling. What scatters them? Will the

cattail balloons float? Would the wind or the water be more likely to carry the cattail seeds to a place where they would grow? Describe the difference between the cattail balloon and the thistle balloon.

8. How crowded do the cattail plants grow? How are they arranged to keep from shading each other? In how many ways is the wind a friend of the cattails?

9. How do the cattails help to build up land and make narrower ponds and streams?

LESSON 131

A Type Lesson for a Composite Flower

Leading Thought — Many plants have their flowers set close together and thus make a mass of color, like the geraniums or the clovers. But there are other plants where there are different kinds of flowers in one head, those at the center doing a certain kind of work for the production of seed, and those around the edges doing another kind of work. The sunflower, goldenrod, asters, daisies, coneflower, thistle, dandelion, burdock, everlasting, and many other common flowers have their blossoms arranged in this way. Before any of the wild flower members of this family are studied, the lesson on the garden sunflower should be given. (See Lesson 159.)

Method — These flowers may be studied in the schoolroom with suggestions for field observations. A lens is almost necessary for the study of most of these flowers.

Observations — 1. Can you see that what you call the flower consists of many flowers set together like a beautiful mosaic? Those at the center are called disc flowers; those around the edges ray flowers.

2. Note that the flowers around the edges have differently shaped corollas than

Daisies and grasses

those at the center. How do they differ? Why could these be called the banner flowers? Why are they called the ray flowers? How many ray flowers are there in the flower-head you are studying? Cut off or pull out all the ray flowers and see how the flower-head looks. Why do you think the ray flowers hold out their banners? Has the ray flower any stigma or stamens?

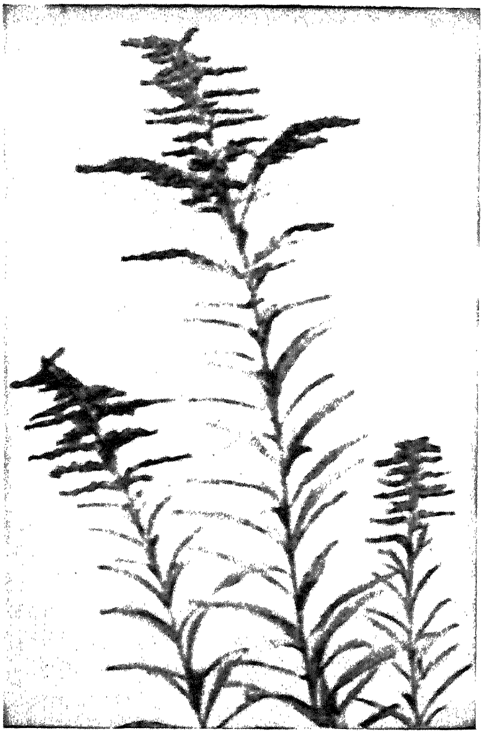
3. Study the flowers at the center. Are they open, or are they unfolded buds? Can you make a sketch of how they are arranged? Are any of the florets open? What is the shape and the color of the corolla? Can you see the stamen-tubes pushing out from some? What color are the stamen-tubes? Can you see the two-parted stigmas in others? What color is the pollen? Do the florets at the center or at the outside of the disc open first? When they first open, do you see the stamen-tube or the stigma?

4. The flower-heads are protected before they open with overlapping bracts. As the flower-head opens, these bracts are pushed back beneath it. Describe the shape of these bracts. Are they set in regular, overlapping rows? Are they rough or smooth? Do they end bluntly, with a short point, with a long point, with a spine, or with a hook? How do the bracts act when the flower-head goes to sleep? Do they remain after the seeds are ripened?

5. Study the ripe fruits. How are they scattered? Do they have balloons? Is the balloon close to the seed? Is it fastened to all parts of it?

THE GOLDENROD

Once I was called upon to take some children into the field to study autumn flowers. The day we studied goldenrod, I told them the following story on the way, and I found that they were pleased with the fancy and through it were led

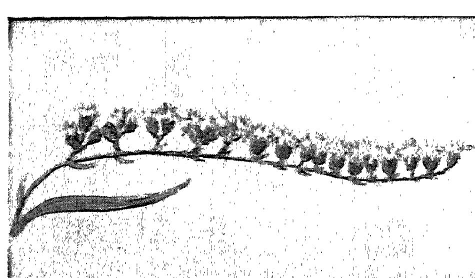


Goldenrod

to see the true purpose of the goldenrod's blossoming:

"There are flowers which live in villages and cities, but people who also live in villages and cities are so stupid that they hardly know a flower city when they see it. This morning we are going to visit a golden city where the people are all dressed in yellow, and where they live together in families; and the families all live on top of their little, green, shingled houses, which are set in even rows along the street. In each of these families, there are some flowers whose business it is to furnish nectar and pollen and to produce fruits which have fuzzy balloons; while there are other flowers in each family which wave yellow banners to all the insects that pass by and signal them with a code of their own, thus: 'Here, right this way is a flower family that needs a bee or a beetle or an insect of some sort to bring it pollen from abroad, so that it can ripen its seed; and it will give nectar and plenty of pollen in exchange.' Of course, if the flowers could walk around like people, or fly like insects, they could fetch and carry their own pollen, but as it is, they have to depend upon insect messengers to do this for them. Let us see who of us will be the first to guess what the name of this golden city is, and who will be the first to find it."

The children were delighted with this riddle and soon found the goldenrod city. We examined each little house with its ornate, green "shingles." These little houses, looking like cups, were arranged on the street stem, right side up, in an orderly manner and very close together; and where each joined the stem, there was a little green bract for a doorstep. Living on these houses we found the flower families, each consisting of a few tubular disc flowers opening out like bells, and coming from their centers were the long pollen-tubes or the yellow, two-parted stigmas. The ray flowers had short but brilliant banners; and they, as well as the disc flowers, had young fruits with pretty fringed pappus developing upon them. The ray flowers were not set so regularly around the edges as in the asters; but the families were such close neighbors that the banners reached from one house to another. And all of the families on all of the little, green streets were signaling to insects, and one boy said, "They must be making a very loud yellow noise." We found that very many insects had responded to this call — honeybees, bumblebees, mining and carpenter bees, blue-black blister beetles with short wings and awkward bodies, beautiful golden-green chalcid flies, soldier beetles, and many

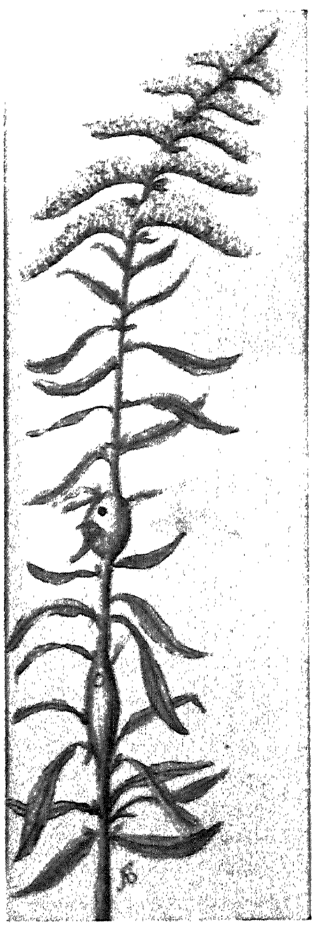


A street in goldenrod city

others; and we found the spherical gall and the spindle-shaped gall in the stems, and the strange gall up near the top which grew among the leaves.

Unless one is a trained botanist it is wasted energy to try to distinguish any but the well-marked species of goldenrod; for, according to Gray, we have fifty-six species, the account of which makes twelve pages of most uninteresting reading in the *Manual*. The goldenrod family is not in the least cliquish; the species have a habit of interbreeding, to the confusion of the systematic botanist.

Suggested Reading — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits*; also, readings on page 461.

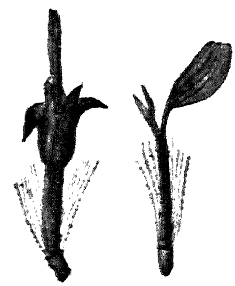


Insect galls on goldenrod. The upper one is deserted, the lower inhabited

LESSON 132

The Goldenrod

Leading Thought — In the goldenrod the flower-heads are very small. They attract the attention of the insects because



Disc flower and ray flower of goldenrod

they are set closely together along the stem, thus producing a mass of color.

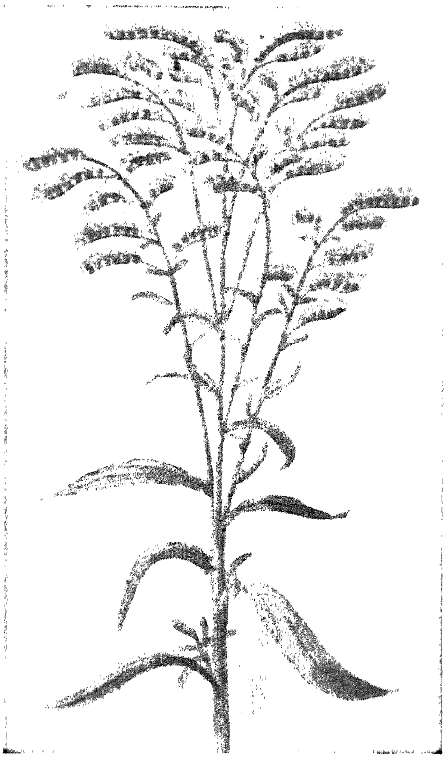
Method — There should be a field excursion to get as many kinds of goldenrod as possible. Bring to the schoolroom any kind of goldenrod, and give further lessons on the flowers there. The following observations will bring out differences in well-marked species.

Observations — 1. Use Lesson 131 to study the flower. How many ray flowers in the head? How many disc flowers? Are the rays arranged as regularly around the edges as in the asters and daisies? How are the flower-heads set upon the stems? Which flower-heads open first — those at the base or at the tip of the stem? Do the upper stems of the plant blossom before those lower down?

2. Do the stems bearing flowers come from the axils of the leaves? What is the general shape of the flower branches? Do they come off evenly at each side, or more at one side? Are the flower branches long or short? Make a sketch of the general shape of the goldenrod you are studying.

3. Is the stem smooth, downy, or covered with bloom? What is its color? In cross-section, is it circular or angular?

4. What is the shape and form of the edges of the lower leaves? The upper ones? Are they set with or without petioles on the stem? Do they have a



Goldenrod in bloom

heart-shaped base? Are the leaves smooth or downy? Are they light or dark green?

5. *Field notes.* Where do you find the goldenrod growing? Do you find one kind growing alone or several kinds growing together? Do you find any growing in the woods? If so, how do they differ in shape from those in the field?

6. How many kinds of insects do you find visiting goldenrod flowers? How many kinds of galls do you find on the goldenrod stems and leaves?

7. Study the goldenrods in November. Describe their fruits and how they are scattered.

I am alone with nature,
With the soft September day;
The lifting hills above me,
With goldenrod are gay.
Across the fields of ether
Flit butterflies at play;
And cones of garnet sumac
Glow down the country way.

The autumn dandelion
Beside the roadway burns;
Above the lichened boulders
Quiver the plumèd ferns.
The cream-white silk of the milkweed
Floats from its sea-green pod;
From out the mossy rock-seams
Flashes the goldenrod.

— Mary Clemmer Ames

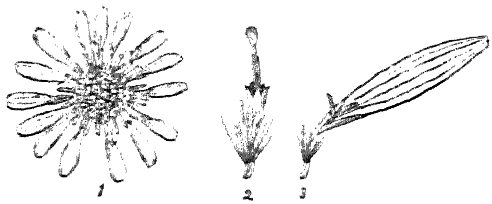
THE ASTERS

Let us believe that the scientist who gave to the asters their Latin name was inspired. Aster means *star*, and these, of all flowers, are most starlike; and in beautiful constellations they border our fields and woodsides. The aster combination of colors is often exquisite. The ray flowers of many asters are lavender, oar-shaped, and are set like the rays of a star around the yellow disc flowers; these latter send out long, yellow anther tubes, overflowing with yellow pollen, and add to the stellar appearance of the flower-head.

And asters by the brookside make asters in the brook.

Thus sang H. H. of these beautiful masses of autumn flowers. But if H. H. had attempted to distinguish the species, she would have said rather that asters by the brookside make more asters in the book; for Gray's *Manual* assures us that we have 77 species including widely different forms, varying in size, color, and also as to the environment in which they will grow. They range from woodland species, which have a few whitish ray flowers hanging shabbily about the yellow disc and great, coarse leaves on long, gawky petioles along the zigzag stem, to the beautiful and dignified New England aster, which brings the glorious purple and orange of its great flower-heads to decorate our hills in September and October.

Luckily, there are a few species which are fairly well marked, and still more luckily, it is not of any consequence whether we know the species or not, so far as our enjoyment of the flowers themselves is concerned. The outline of this lesson will call the attention of the pupils to the chief points of difference and likeness in the aster species, and they will thus learn to discriminate in a general way. The asters, like the goldenrods, begin to bloom at the tip of the branches, the flower-heads nearest the central stem blooming last. All of the asters are very sensitive, and the flower-heads usually close as soon as they are gathered. The ray flowers are pistillate, and therefore develop akenes. The akene has attached to its rim a ring of pappus, and is ballooned to its final destination. In late autumn the



1, An aster flower-head enlarged; 2, a disc flower; 3, a ray flower

matured flower-heads are fuzzy, with seeds ready for invitations from any passing wind to fly whither it listeth.

Asters

LESSON 133

The Asters

Leading Thought — There are very many different kinds of asters, and they all have their flowers arranged similarly to those of the sunflower.

Method — Have the pupils collect as many kinds of asters as possible, being careful to get the basal leaves and to take notes on where each kind was found — that is, whether in the woodlands, by the brooksides or in the open fields. This lesson should follow that on the sunflower.

Observations — 1. What was the character of the soil and surroundings where this aster grew? Were there large numbers of this kind growing together? Were the flowers wide open when you gathered them? How soon did they close?

2. How high did the plants stand when growing? Were there many flowers, or few, on each plant?

3. Study the lower and the upper leaves. Describe each as follows: the shape, the size, the edges, the way it was joined to the stem.

4. Is the stem many-branched or few? Do the branches bearing flowers extend in all directions? Are the stems hairy or smooth, and what is their color?

5. What is the diameter of the single flower-head? What is the color of the ray flowers? How many ray flowers are there? What is the shape of a single ray as com-

pared with that of a sunflower? What are the colors of the disc flowers? Of the pollen? Do the disc flowers change color after blossoming?

6. Look at the bracts below the flower-head. Are they all the same shape? What is their color? Do they have recurved tips or do they overlap closely? Are they sticky?

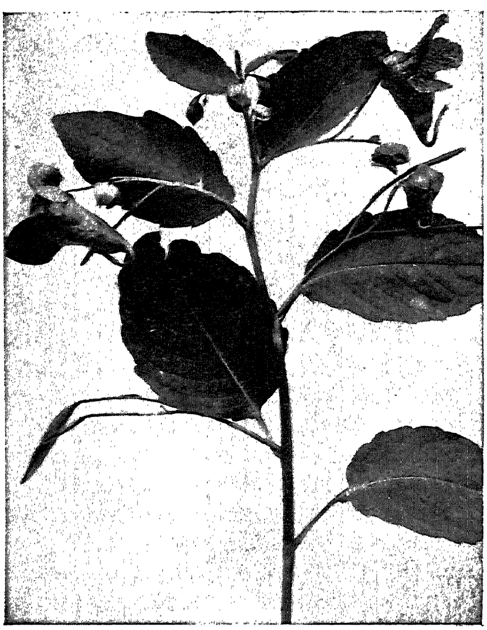
7. Take the aster flower-head apart and look at it with a lens. In a disc flower, note the young fruit, the pappus, the tubular five-parted corolla, the anther-tube, and the stigmas. In the ray flower, find the young fruit, the pappus, and the stigma.

8. Watch the bees working on asters, and find where they thrust their tongues to reach the nectar.

9. Study an aster plant in late autumn; describe the akenes and how they are scattered.

THE JEWELWEED OR TOUCH-ME-NOT

Jewels for the asking at the brookside, pendant jewels of pale gold or red-gold and of strange design! And the pale and the red are different in design, although of the same general pattern. The pale ones seem more simple and open, and we may study them first. If the flowers of the jewelweed have been likened to ladies' earrings, then the bud must be likened to the old-fashioned earbob; for it is done up in the neatest little triangular knob imaginable, with a little curly pigtail appendage at one side, and protected above by two cup-shaped sepals, their pale green seeming like enamel on the pale gold of the bud. It is worth while to give a glance at the stalk from which this jewel hangs; it is so delicate and so gracefully curved; and just above the twin sepals is a tiny green bract, elongate, and following the curve of the stem as if it were just a last artistic touch; and though the flowers fall, this little bract remains.



Jewelweed

It would take a Yankee, very good at guessing, to make out the parts of this flower, so strange are they in form. We had best begin by looking at the blossom from the back. The two little, greenish sepals are lifted back like butterfly wings, and we may guess from their position that there are two more sepals, making four in all. These latter are yellow; one is notched at the tip and is lifted above the flower; the other is below and is made into a wide-mouthed triangular sac, ending in a quirl at the bottom, which, if we test it, we shall find is the nectary, very full of sweetness. Now, if we look the flower in the face, perhaps we can find the petals; there are two of them "holding arms" around the mouth of the nectar sac. And stiff arms they are too, two on a side, for each petal is two-lobed, the front lobe being very short and the posterior lobe widening out below into a long frill, very convenient for the bee to cling to, if she has learned the trick, when prospecting the nectar sac behind for its treasure. The way this treasure sac swings backward from its point of attachment above when the insect is probing it, must make the bee feel that the joys of life are elusive. Meanwhile, what is the knob projecting down above the entrance to the nectar sac, as if it were a chandelier in a vestibule? If we look at it with a lens, we can see that it is made up of five chubby anthers, two in front, one at each side and one behind; their short, stout little filaments are crooked, bringing the anthers together like five closed fingers holding a fist full of pollen-dust, just ready to sift it on the first one that chances to pass below. Thus it is that the bumblebee gets its back well dusted with the creamy-white pollen and does a great business for the jewelweed in transferring it. But after the pollen is shed, some day the bumblebee pushes up too hard against the anthers and they break loose, all in a bunch, looking like a crook-legged table; and there in their stead, thus left bare and ready for pollen, is the long green pistil with its pointed stigma ready to rake the pollen out of the fur of any bumblebee that calls.

The red-gold jewelweed is quite different in shape from the pale species. The sepal sac is not nearly so flaring at the mouth, and the nectar-spur is half as long as the sac and curves and curls beneath the flower. The shape of the nectar-spur suggests that an insect with a long, flexible sucking-tube that could curl around and probe it to the bottom would be most successful in securing the nectar; and some butterflies do avail themselves of the contents of this bronze pitcher. Mr. Mathews mentions the black swallowtail butterfly and I have seen the yellow roadside butterfly partaking of the nectar. But I am sure that the flowers which I have had under observation are the special partners of a small species of bumblebee, which visits these flowers with avidity, celerity, and certainty, plunging into the nectar sac "like a shot," and out again and in again so rapidly that the eye can hardly follow. One day, one of them accommodatingly alighted on a leaf near me, while she combed from her fur a creamy-white mass of pollen, which matched in color the fuzz on her back, heaping it on her leg baskets. It was comical to see her contortions to get the pollen off her back. The action of these bumblebees in these flowers is in marked contrast to that of the large bumblebees and the honeybees. One medium-sized species of bumblebee has learned the trick of embracing with the front legs the narrow, stiff portion of the petals which encircles the opening to the sac, thus holding the flower firm while thrusting the head into the sac. The huge species — black with very yellow plush — does not attempt to get the nectar in a legitimate manner, but systematically alights, back downward, below the sac of the flower, with head toward the curved spur, and cuts open the sac for the nectar. A nectar-robber of the most pronounced type! The honeybees, Italian hybrids, are the most awkward in their attempts to get nectar from these flowers; they attempt to alight on the expanded portion of the petals and almost invariably slide off between the two petals. They then circle around and finally succeed, as a rule, in gaining a foothold and securing the nectar. But the midget bumblebees in probing the orange jewelweed show a *savoir faire* that is convincing; they are so small that they are quite out of sight when in the nectar sacs.

The jewelweed flowers of the pale species and the pale flowers of the orange species — for this latter has sometimes pale yellow flowers — are not invariably marked with freckles in the nectar sac. But the most common forms are thus speckled. The orange jewelweed flower is a model for an artist in its strange, graceful form and its color combination of yellow spotted and marbled with red.

Gray's *Manual* states that in the jewelweeds are often flowers of two sorts: "The large ones which seldom ripen seeds, and very small ones which are fertilized early in the bud, their floral envelopes never expanding but forced off by the growing pod and carried upward on its apex." My jewelweed patch has not given me the pleasure of observing these two kinds of flowers; my plants blossom luxuriously and profusely, and a large proportion

Jewelweed, showing blossoms, and pods discharging seeds

of the flowers develop seed. The little, straight, elongated seed pods are striped prettily and become quite plump from the large seeds within them. Impatient? We should say so! This pod which looks so smug and straight-laced that we should never suspect it of being so touchy, at the slightest jar when it is ripe, splits lengthwise into five ribbon-like parts, all of which tear loose at the lower end and fly up in spirals around what was once the tip of the pod, but which now looks like a crazy little turbine wheel with five arms. And meanwhile, through this act the fat, wrinkled seeds have been flung, maybe several feet away from the parent plant, and perhaps to some congenial place for growth the following spring. This surprising method of throwing its seeds is the origin of the popular name touch-me-not, and the scientific name *Impatiens* by which these plants are known.

The jewelweed has other names — celandine and silver-leaf, and ladies'-eardrop. It is an annual with a slight and surface-spreading growth of roots, seeming scarcely strong enough to anchor the branching stems, did not the plants have the habit of growing in a community, each helping to support its neighbor. The stem is round, hollow, and much swollen at the joint; it is translucent, filled with moisture, and its outer covering is a smooth silken skin, which may be readily stripped off. Both species of jewelweed vary in the color of their stems, some being green, others red, and some dark purple; and all the differing colors may be found within a few yards of each other.

The leaves are alternate, dark green above and a lighter shade below, ovate in form with scalloped edges, with midrib and veins very prominent beneath and depressed on the upper side; they are smooth on both sides to the unaided eye, but with a lens a film of fine, short hairs may be seen, particularly on the under side. When plunged beneath clear water, they immediately take on the appearance of burnished silver; when removed, no drop remains on their surface.

The flowerstalks spring from the axils of the leaves and are very slender and threadlike, and the flowers nod and swing with every breeze. They grow in open, drooping clusters, few blossoms open at a time, and with buds and seed capsules present in various stages of growth.

The jewelweed is involuntarily most hospitable, and always houses many guests. Galls are formed on the leaves and flowers; the hollow stems are inhabited by stalk-borers; leaf-miners live between the upper and under surfaces of the leaves, making curious arabesque patterns and initials as if embroidering milady's green gown.

LESSON 134

The Jewelweed or Touch-me-not

Leading Thought — The jewelweed may be found by the brookside, in swamps, or in any damp and well-shaded area. It is provided with a remarkable contrivance for scattering its seeds far afield. It has no liking for open sunny places, unless they are very damp. There are two kinds, often found growing together, though the spotted touch-me-not (*Impatiens biflora*) is said to be more widely distributed than its relative — the golden or pale touch-me-not (*Impatiens pallida*).

METHOD — The jewelweed should be studied where they are growing; but if this is impracticable, a bouquet of both kinds (if possible), bearing buds, blossoms, and seed capsules, and one or two plants with roots, may be brought to the schoolroom.

In the fields the children may see how well the plant is provided with means to sustain itself in its chosen ground, and thus be prompted to look with keener eyes at other common weeds.

OBSERVATIONS — 1. Do you think the jewelweed is an annual, sustaining life in its seeds during winter, or do its roots survive?

2. Do the roots strike deeply into the soil, or spread near the surface?

3. Study the stem; is it hard and woody or juicy and translucent, rough or smooth, solid or hollow?

4. Note the shape and position of the leaves; do they grow opposite or alternately on the stalk? Are their edges entire, toothed, or scalloped? Do they vary in color on upper and lower surfaces? Are they smooth or in the least degree rough or hairy? Plunge a plant under clear water in a good light and observe the beautiful transformation. Does the water cling to the leaves?

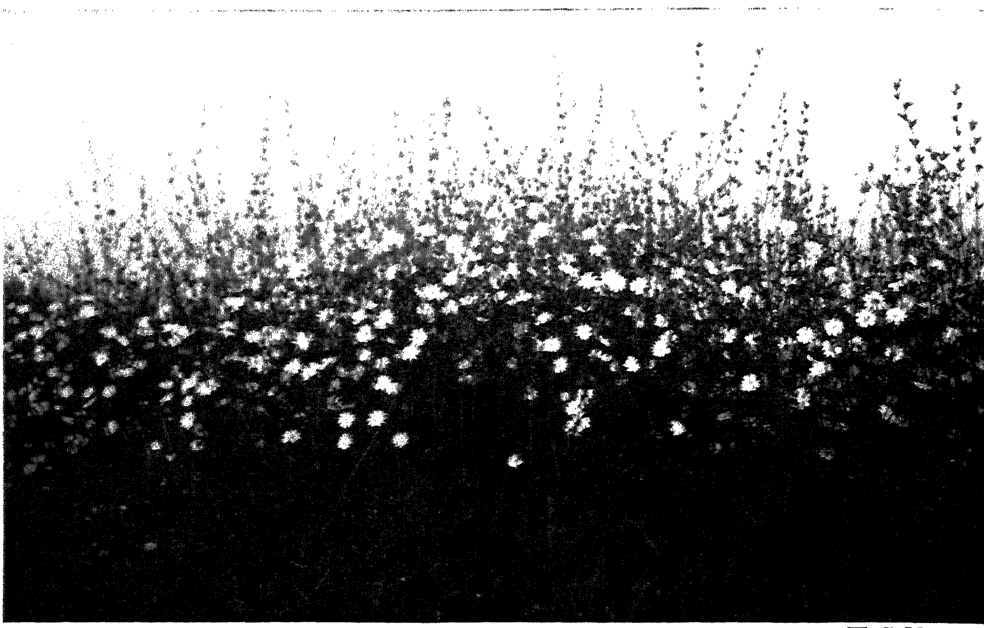
5. Where do the flowerstalks spring from the main stalk? Do the flowers grow singly or in clusters? Do the blossoms all open at nearly the same time or form a succession of bud, flower, and seed on the same stem?

6. Study the parts of the flower. Find the four sepals and describe the shape and position of each. Describe the nectar sac in the nectar horn. Can you find the two petals? Can you see that each petal has a lobe near where it joins the stem? Find the little knob hanging down above the entrance of the nectar sac; of what is it composed? Look at it with a lens, and tell how many stamens unite to make the knob. Where is the pollen and what is its color? What insect do you think could reach the nectar at the bottom of the spurred sac? Could any insect get at the nectar without rubbing its back against the flat surface of the pollen boxes? What remains after the stamens fall off? Describe how the bees do the work of pollination of the jewelweeds. Write or tell as a story your own observations on the actions of the different bees visiting these flowers.

7. Carefully observe a seed capsule without touching it; can you see the lines of separation between its sections? How many are there? What happens when the pod is touched? Are the loosened sections attached at the stalk, or at the apex of the pod? Hold a pod at arm's length when it is discharging its contents and measure the distance to which the seeds are thrown. Of what use is this habit of seed-throwing to the plant?

8. Describe the difference in shape and color between the pale yellow and the orange jewelweeds. Watch to see if the same insects visit both of these kinds of jewelweed.

WEEDS



W. C. Muenscher

Chicory enough to make anyone see blue

The worst weed in corn may be — corn.
— Professor I. P. Roberts

Nature is the great farmer. Continually she sows and reaps, making all the forces of the universe her tools and helpers: the sun's rays, wind, rain and snow, insects and birds, animals small and great, even to the humble burrowing worms of the earth — all work mightily for her, and a harvest of some kind is absolutely sure. But if man interferes and insists that the crops shall be only such as may benefit and enrich himself, she seems to yield a willing obedience, and under his control does immensely better work than when unguided. But Dame Nature is an "eye-servant." Let the master relax his vigilance for ever so short a time, and among the crops of his desire will come stealing in the hardy, aggressive, and to him useless plants that seem to be her favorites.

A weed is a plant growing where we wish something else to grow, and a plant may, therefore, be a weed in some locations and not in others. Our grandmothers considered "butter-and-eggs" a pretty posy, and planted it in their gardens, wherefrom it escaped, and it is now a bad weed wherever it grows. A weed may crowd out our cultivated plants, by stealing the moisture and nourishment in the soil which they should have; or it may shade them out by putting out broad leaves and shutting off their sunlight. When harvested with a crop, weeds may be unpalatable to the stock which feed upon it; or in some cases, as with the wild parsnip, the plant may be poisonous.

Each weed has its own way of winning in the struggle with our crops, and it behooves us to find that way as soon as possible in order to circumvent it. This we can do only by a careful study of the peculiarities of the species. To do this we must know the plant's life history; whether it is an annual, surviving the winter only in its seeds; or a biennial, storing in fleshy root or in broad, green, leafy rosette the food drawn from the soil and air during the first season, to perfect its fruitage in the second year; or a perennial, surviving and springing up to spread its kind and pester the farmer year after year, unless he can destroy it "root and branch." Purslane is an example of the first class, burdock or mullein of the second, and the field sorrel or Canada thistle of the third. According to their nature the farmer must use different means of extermination; he must strive to hinder the annuals and biennials from forming any seed whatever; and where perennials have made themselves a pest, he must put in a "hoed crop," requiring such constant and thorough tillage that the weed roots will be deprived of all starchy food manufactured by green leaves and be starved out. Especially, every one who plants a garden should know how the weeds look when young, for seedlings of all kinds are delicate and easy to kill before their roots are well established.

Suggested Reading — *A Manual of Weeds*, by Ada E. Georgia; *Weeds*, by W. C. Muenscher; also, readings on pages 459 and 461.

LESSON 135

Outline for the Study of a Weed

1. Why do we call a plant a weed? Is a weed a weed wherever it grows? How about "butter-and-eggs" when it grew in Grandmother's garden? Why do we call that a weed now? What did Grandmother call it?

2. Why must we study the habits of a weed before we know how to fight it?

We should ask of every weed in our garden or on our land the following questions, and let it answer them through our observations in order to know why the weed grows where it chooses, despite our efforts.

3. How did this weed plant itself where I find it growing? By what agency was its seed brought and dropped?

4. What kind of root has it? If it has a taproot like the mullein, what advantage does it derive from it? If it has a spreading shallow-growing root like the purslane, what advantage does it gain? If it has a creeping root with underground buds like the Canada thistle, how is it thereby helped?

5. Is the stem woody or fleshy? Is it erect or reclining or climbing? Does it gain any advantage through the character of its stem?

6. Note carefully the leaves. Are they eaten by grazing animals? Are they covered with prickles like the teasel or fuzz like the mullein, or are they bitter and acrid like the wild carrot?

7. Study the blossoms. How early does the weed bloom? How long does it remain in bloom? How are the flower buds and the ripening seeds protected?

8. Does it ripen many seeds? Are these ripened at the same time or are they ripened during a long period? Of what advantage is this? How are the seeds scattered, carried, and planted? Compute how many seeds one plant of this weed matures in one year.

9. What are some ways in which a weed may do harm to our cultivated crops?

That which ye sow ye reap. See yonder
fields!
The sesamum was sesamum, the corn
Was corn. The Silence and the Darkness
know!

— Edwin Arnold

POISON IVY[1]

Poison ivy may be found creeping over the ground, climbing as a vine, attached by aerial rootlets to trees, walls, or fences, or growing erect as a shrub. The alternate, compound leaves are made up of three

W. C. Muenscher

Poison ivy climbing on the trunk of a tree

leaflets; and this has given rise to the line often quoted:

Leaflets three, let it be.

During the fall and winter, the plant can usually be identified by the presence of clusters of small, white, berry-like fruits. It is thus easily distinguished from the woodbines or Virginia creepers which have leaves made up of five or more leaflets and in late summer have clusters of blue berries.

Prevention of Ivy Poisoning After Contact With the Plant

Wash the hands, the face, or affected parts in a solution of 5 per cent iron chloride in a half-and-half mixture of alcohol and water. If this solution is applied before or immediately after going into a region where poison ivy is known to grow no harmful effects need be expected. This remedy is nonpoisonous and inexpensive and it can be obtained at almost any drug store.

If the iron chloride is not available, considerable protection from the effects of exposure to poison ivy may be secured by thoroughly washing the skin of the affected parts several times with hot water and a laundry soap that contains an excess of free alkali. Use a heavy lather and rinse off at least three or four times.

Curative Treatment When Poisoning Has Begun

Soaking in hot water usually gives relief. The application of baking soda, one or two teaspoons to a cup of water, is often effective in relieving the pain caused by the inflammation. To soothe the pain and prevent the general spread of the inflammation, fluid extract of Grindelia diluted with six to ten parts of water is recommended. This may be applied with a clean bandage, which should be kept moist and frequently changed.

Do not apply ointment or other oily substances until after the poison has exhausted itself. Sugar of lead is not recommended.

If the case of poisoning is a severe one, it is best to consult a physician before attempting to use any remedy.

[1] Because each year thousands of people throughout the country suffer from the effects of poison ivy, the editors have thought it well to include here a summary of the treatment recommended in Cornell Extension Bulletin, *Poison Ivy and Poison Sumac*, by Professor W. C. Muenscher.

W. C. Muenscher, *Poison Ivy and Poison Sumac*, Cornell Extension Bulletin 191

Leaves of poison ivy and poison sumac and some harmless plants with which they are often confused

1, Poison ivy, *Rhus toxicodendron*. Leafstalk bearing three leaflets; buds visible. 2, Virginia creeper, *Parthenocissus quinquefolia*. Leafstalk bearing five leaflets. 3, Silky dogwood, *Cornus amomum*. Leafstalk with one blade, leaves opposite. 4, Fragrant sumac, *Rhus canadensis*. Leafstalk bearing three leaflets; buds hidden under base of leafstalk. 5, Poison sumac, *Rhus vernix*. Leaves alternate; leafstalk bearing several leaflets with smooth margins; buds visible. 6, Dwarf sumac, *Rhus copallina*. Margin of leaflets smooth or toothed, leaf axis winged. 7, Smooth sumac, *Rhus glabra*. Margin of leaflet toothed, buds hidden under base of leafstalks. 8, Staghorn sumac, *Rhus typhina*. Like 7, but leaves and twigs are hairy. 9, Mountain ash, *Sorbus americana*. Margin of leaflets toothed; buds visible. 10, Black ash. *Fraxinus nigra Marsh*. Leaves and buds opposite. 11, Elderberry, *Sambucus canadensis*. Leaves and buds opposite

THE COMMON OR FIELD BUTTERCUP

The buttercups, bright-eyed and bold,
Held up their chalices of gold
To catch the sunshine and the dew.

Leonard K. Beyer

Swamp buttercup

There are many widely varying species of buttercups. Some of them grow in woods, others in swamps, and some even in water. The blossoms of most buttercups are yellow but a few kinds have white blossoms. On some plants the blossoms are very showy and on others they are very inconspicuous. The common or field buttercup, which is widely distributed, is the one considered here.

Common buttercups and daisies are always associated in the minds of the children, because they grow in the same fields; yet the two are so widely different in structure that they may reveal to the child something of the marvelous differences between common flowers; for the buttercup is a single flower, while the single daisy is a large group of tiny flowers.

The buttercup sepals are five elongated cups, about one-half as long as the petals; they are pale yellow with brownish tips, but in the globular buds they are green. The petals are normally five in number, but often there are six or more; the petals are pale beneath, but on the inside they are a most brilliant yellow, and shine as if varnished. Probably it is due to this luminous color that one child is able to determine whether another likes butter or not, by noting when the flower is held beneath the chin, if it makes a yellow reflection; it would be a sodden complexion indeed that would not reflect yellow under this provocation. Each petal is wedge-shaped, and its broad outer edge is curved so as to help make a cuplike flower; if a fallen petal be examined, a tiny scale will be found at its base, as if its point had been folded back a trifle. However, this is not a mere fold, but a little scale growing there; beneath it is developed the nectar.

When the buttercup first opens, all of the anthers are huddled in the center, so that it looks like a golden nest full of

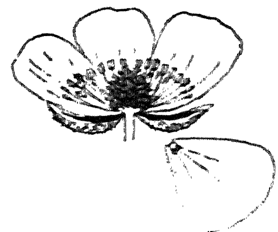
W. C. Muenscher

Marsh marigold or cowslip

golden eggs. Later the filaments stretch up, lifting the anthers into a loose, rounded tuft, almost concealing the bunch of pistils, which are packed close together beneath every stigma. Later, the filaments straighten back, throwing the anthers in a fringy ring about the pale green pistils; and each pistil sends up a short, yellowish stigma. The anthers open away from the pistils and thus prevent self-pollination to some degree; they also seem to shed much of their pollen before the stigmas are ready to receive it.

Sometimes petals and sepals fall simultaneously and sometimes first one or the other; but they always leave the green bunch of pistils with a ragged fringe of old stamens clinging to them. Later the pistils mature, making a globular head. Each fruit is a true akene; it is flattened and has at its upper end a short, recurved hook which may serve to help it to catch a ride on passers-by. However, the akenes, containing the seeds, are largely scattered by the winds.

The buttercup grows in sunny situations, in fields and along roadsides, but it cannot stand the shade of the woods. It is a pretty plant; its long stems are downy near the bottom, but smooth near the flower; the leaves show a variety of forms on the same plant; the lower ones have many (often seven) deeply cut divisions, while the upper ones may have three irregular lobes, the middle one being the longest. Beetles gather the nectar and pollen of buttercups, and therefore are its chief pollen carriers; but flies and small bees and other insects may also find their food in these brilliant colored cups.



Buttercup flower slightly enlarged. Note the scale covering the nectar at the base of the falling petal

Buttercup

LESSON 136

The Buttercup

Leading Thought — The buttercup may grow with the white daisies, in sunny places, but each buttercup is a single flower, while each daisy is a flower cluster.

Method — Buttercups brought by the pupils to school may serve for this lesson.

Observations — 1. Look at the back of a flower of the buttercup. What is there peculiar about the sepals? How do the sepals look on the buttercup bud? How do they look later?

2. Look into the flower. How many petals are there? Are there the same number of petals in all the flowers of the same plant? What is the shape of a petal? Compare its upper and lower sides. Take a

fallen petal, and look at its pointed base with a lens and note what is there.

3. How do the stamens look? Do you think you can count them? When the flower first opens how are the stamens arranged? How later? Do the anthers open towards or away from the pistils?

4. Note the bunch of pistils at the center of the flower. How do they look when the flower first opens? How later?

5. When the petals fall, what is left? Can you see now how each little pistil will develop into an akene?

6. Describe the globular head of akenes.

7. Look at the buttercups' stems. Are they as smooth near the base as near the flower? Compare the upper leaf with the lower leaf, and note the difference in shape and size.

8. Where do the buttercups grow? Do we find them in the woods? What insects do you find visiting the flowers?

THE HEDGE BINDWEED

I once saw by the roadside a beautiful pyramid, covered completely with green leaves and beset with pink flowers. I stopped to examine this bit of landscape gardening, and for the first time in my life I felt sorry for a burdock; for this burdock had met its match and more in standing up against a weakling plant which it must have scorned at first, had it been capable of this sensation. Its mighty leaves had withered, its flower-stalks showed no burs, for the bindweed had caught the burdock in its hundred embraces and had squeezed the life out of it. Once in northern Florida our eyes were delighted with the most beautiful garden we had ever seen, which resolved itself later into a field of corn, in which every plant had been made a trellis for the bindweed; there it flaunted its pink and white flowers in the sunshine with a grace and charm that suggested nothing of the oppressor.

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Bindweed

Sometimes the bindweed fails to find support to lift it into the air. Then it readily mats itself over the grass, making a carpet of exquisite pattern. This vine has quite an efficient way of taking hold. It lifts its growing tips into the air, swaying them with every breeze; and the way each extreme tip is bent into a hook seems just a matter of grace and beauty, as do the two or three loose quirls below it; but when during its graceful swaying the hook catches to some object, it makes fast with amazing rapidity; later the young arrow-shaped leaves get an ear over the support, and in a very short time the vine makes its first loop, and the deed is done. It twines and winds in one way, following the direction of the hands of the clock — from the right, under, and from the left, over the object to which it clings. If the support is firm, it makes only enough turns around it to hold itself firmly; but if it catches to something as unstable as its own stems, the stems twist until they become so hard-twisted that they form a support in themselves.

It is rather difficult to perceive the alternate arrangement of the leaves on the bindweed stem, since they twist under or over so that they spread their whole graceful length and breadth to the sun; to the careless observer they seem only to grow on the upper or outer side of the vine. The leaves are arrow-shaped, with two long backward and outward projecting points, or "ears," which are often gracefully lobed. Early in the year the leaves are glossy and perfect; but many insects nibble them, so that by September they are usually riddled with holes.

The flower bud is twisted as if the bindweed were so in the habit of twisting that it carried the matter farther than necessary. Enveloping the base of the flower bud are two large sepal-like bracts, each keeled like a duck's breast down the center; if these are pulled back, it is seen that they are not part of the flower, because they join the stem below it. There are five pale green sepals of unequal sizes, so that some look like fragments of sepals. The corolla is long, bell-shaped, opening with five starlike lobes; each lobe has a thickened white center; and while its margins are usually pink, they are sometimes a vivid pink-purple and sometimes entirely white. Looking down into this flower-bell, we find five little nectar wells; and each two of these wells are separated by a stamen which is joined to the corolla at its base and at its anther-end presses close about the style of the pistil. When the flower first opens it shows the spoon-shaped stigmas close together, pushing up through the anther cluster; later, the style elongates, bringing the stigmas far beyond the anthers. The pollen is white, and through the lens looks like tiny pearls.

When we study the maturing seed capsule, we can understand the uneven size of the sepals better; for after the corolla with the attached stamens falls, the sepals close up around the pistil; the smallest sepal wraps it first, and the larger ones in order of size enfold the matured seed pod; and outside of all, the great, leafy bracts with their strong keels provide protection. The pod has two cells and two seeds in each cell. But it is not by seeds alone that the bindweed spreads; it is the running rootstock which, when the plant once gets a start, helps it to cover a large area. The bindweed is a relative of the morning-glory and it will prove an interesting study to compare the two in methods of twining, in the time of day of the opening of the flowers, the shape of the leaves, etc. So far as my own observations go, the bindweed flowers seem to remain open only during the middle of the day, but Müller says the flowers stay open on moonlight nights and may attract hawk moths. This is an interesting question for investigation, and it may be settled by a child old enough to make and record truthful observations.

There are several species of bindweed, but all agree in general habits. The field bindweed lacks the bracts at the base of the flower.

LESSON 137

The Hedge Bindweed

Leading Thought — There are some plants which have weak stems and cling to objects for support. The bindweed is one of these, and the way that it takes hold of objects and grows upon them is an interesting story.

Method — It is better to study this plant where it grows; but if this is not practical, the vine with its support should be brought into the schoolroom, the two being carefully kept in their natural relative positions. Several of the questions should be given to the pupils for their personal observation upon this vine in the field. It is an excellent study for pencil or water-color drawing.

Observations — 1. How does the bindweed get support, so that its leaves and its flowers may spread out in the sunshine? Why does its own stem not support it? What would happen to a plant with such a weak stem if it did not twine upon other objects?

2. How does it climb upon other plants? Does its stem always wind or twist

in the same direction? How does it first catch hold of the other plant? If the supporting object is firm, does it wind as often for a given space as when it has a frail support? Can you see the reason for this?

3. Look at the leaves. Sketch one, to be sure that you see its beautiful form and veins. Note if the leaves are arranged alternately on the stem, and then observe how and why they seem to come from one side of the stem. Why do they do this?

4. What is there peculiar about the flower bud? Look at its stalk carefully and describe it. Cut it across and look at the end with a lens and describe it. Turn back two sepal-like bracts at the base of the flower or bud. Are they a part of the flower, or are they below it? Find the true sepals. How many are there? Are they all the same size?

5. Examine the flower in blossom. What is its shape? Describe its colors. Look down into it. How many stamens are there, and how are they set in the flower? How does the pistil look when the flower first opens? Later? Can you see the color of the pollen? Can you find where the nectar is borne? How many nectar wells are there?

6. What insects do you find visiting bindweed flowers? Do the flowers remain open at night or on dark days?

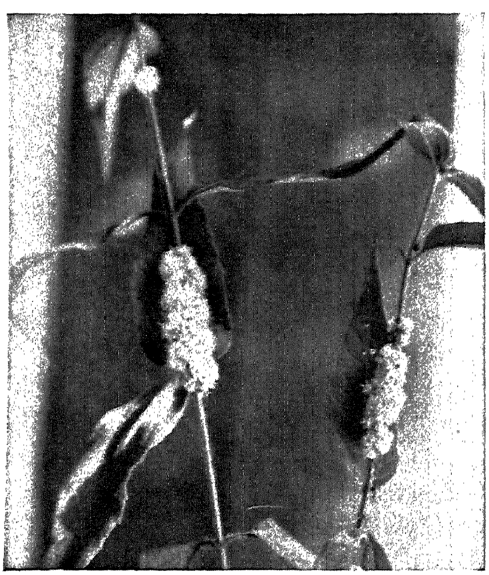
7. Study the seed capsule. How is it protected on the outside? What next enfolds it? Cut a seed capsule across with all its coverings, and see how it is protected. How many seeds are there in the capsule?

8. Has the bindweed other methods of spreading than by seeds? Look at the roots and tell what you observe about them.

9. Make a study of the plant on which the bindweed is climbing, and tell what has happened to it.

10. Compare the bindweed with the morning-glory, and notice the differences and resemblances.

THE DODDER



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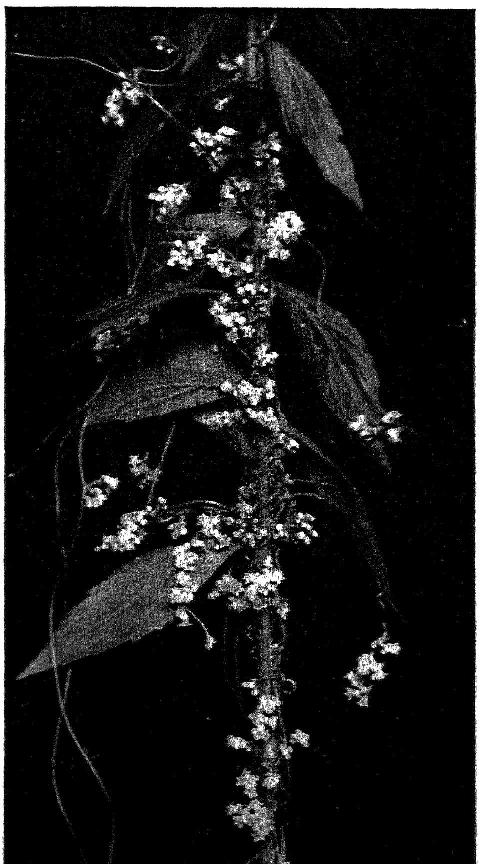
Dodder or love vine

The dodder, which is also known by names as diverse as "strangle-weed" and "love vine," is a good example of the changes that take place in a plant which has become a parasite. When a plant ceases to be self-supporting, when its gets its living from the food made by other plants for their own sustenance, it loses its own power of food-making. The dodder has no leaves of its own, for it does not manufacture or digest its own food. Its dull yellow stems reach out in long tendrils swayed by every breeze until they come in contact with some other plant. The tendrils wind about the victim plant, always under from the right side and over from the left. They get their hold by means of suckers which develop on the coiled stem; so firmly are these suckers attached that the yellowish stem will break before they can be torn from their hold. The devilfish uses the suckers on its tentacles only to hold fast its prey; but the suckers of the dodder penetrate the bark of the victim to the sap channels where they suck the matured sap which is necessary to the life of the host plant.

The development of the dodder from

this point is an example of the further history of a parasite. No sooner has it tapped a succulent victim than its now useless root and lower portions wither away and leave the dodder wholly deprived of contact with the earth.

The stems of the dodder are plentifully studded with small, dull-white flowers tightly bunched. The calyx has five lobes; the corolla is globular, with five little lobes around its margin and a stamen set in each notch. A few of the species have a four-lobed calyx and corolla; but however many the lobes, the flowers are shiftless looking and are yellowish or greenish white; despite its shiftless appearance, however, each flower usually matures four perfectly good, plump seeds. The seed vessels are globular capsules and develop rapidly while the blossoming continues



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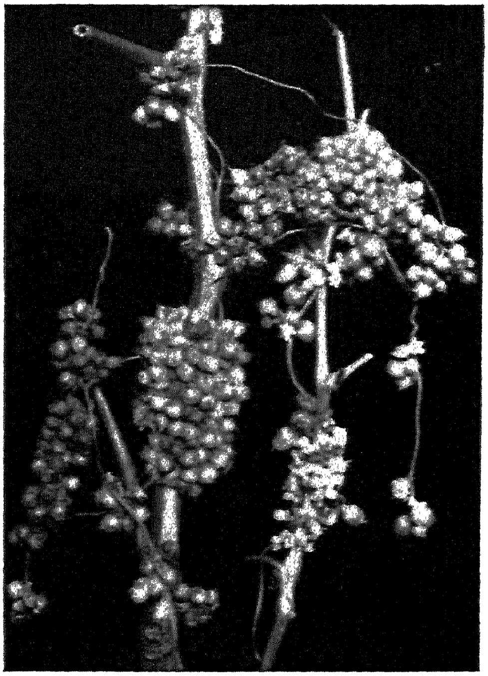
Dodder in flower on stem of goldenrod



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Dodder. This plant has severed all connection with the soil and secures its sustenance from a host plant, the jewelweed

unabated. They drop their cargo of seeds, which perpetuate the existence of this parasitic plant.

Kinds of dodder which attack clover and other farm crops get their seeds harvested with the rest; and the farmer who does not know how to test his clover seed for impurities, sows with it the seeds of its enemy.

There are nine species of dodder more or less common in America. Some of the species, among which is the flax dodder, live only upon certain other species of plants, while others take almost any plant that comes within reach. Where it flourishes, it grows so abundantly that it makes large yellow patches in fields, completely choking out the leaves of its victims.

LESSON 138

The Dodder

Leading Thought — There are some plants which not only depend upon other plants to hold them up, but even steal

Leonard K. Beyer

White or oxeye daisy

their living by drawing the vital sap from the host plants.

METHOD — Bring in dodder with the host plant for the pupils to study in the schoolroom, and ask them to observe afterwards the deadly work of this parasite in the field.

OBSERVATIONS — 1. What is the color of the stem? In which direction does it wind?

2. How is the stem fastened to the host plant? Tear off these suckers and examine with a lens the place where they were attached, and note if they enter into the stem of the host plant.

3. How does the dodder get hold of its host? Has the dodder any leaves of its own? How can it get along and grow without leaves?

4. How do the flowers look through a lens? Are there many flowers? Can you see the petal lobes and the stamens?

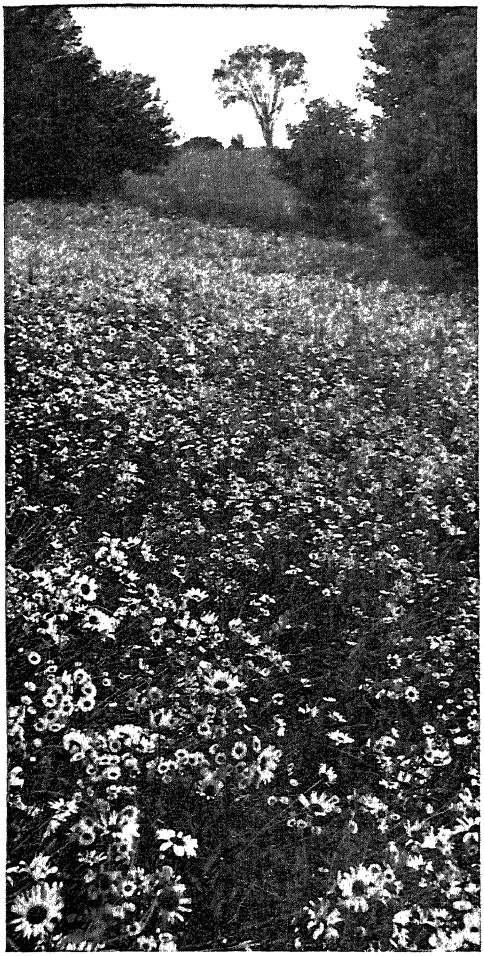
5. How many seeds does each flower develop? How do the seeds look? In what way are they a danger to our agriculture?

I should also avoid the information method. It does a child little good merely to tell him matters of fact. The facts are not central to him and he must retain them by a process of sheer memory; and in order that the teacher may know whether he remembers, the recitation is employed, — re-cite, to tell over again. The educational processes of my younger days were mostly of this order, — the book or the teacher told, I re-told, but the results were always modified by an unpredictable coefficient of evaporation. Good teachers now question the child to discover what he has found out or what he feels, or to suggest what further steps may be taken, and not to mark him on what he remembers. In other words, the present-day process is to set the pupil independently at work, whether he is young or old, and the information-leaflet or lesson does not do this. Of course, it is necessary to give some information, but chiefly for the purpose of putting the pupil in the way of acquiring for himself and to answer his natural inquiries; but information-giving about nature subjects is not nature-study. —

"THE OUTLOOK TO NATURE,"
L. H. BAILEY

THE WHITE DAISY

Every child loves this flower, and yet it is not well understood. It is always at hand for study from June until the frosts have laid waste the fields. However much enjoyment we get from the study of this beautiful flower-head, we should study the plant as a weed also, for it is indeed a pest to those farmers who do not practice a rotation of crops. Its root is long and tenacious of the soil, and it ripens many seeds which mingle with the grass seed and thus the farmer sows it to his own undoing. The bracts of the involucre, or the shingles of the daisy-house, are rather long, and have parchment-like margins. They overlap in two or three rows. In the daisy flower-head, the ray flowers are white; there may be twenty or thirty of



Verne Morton

A daisy meadow

these, making a beautiful frame for the golden-yellow disc flowers. The ray is rather broad, veined, and toothed at the tip. The ray flower has a pistil which shows its two-parted stigma at the base of the banner. The disc flowers are brilliant yellow, tubular, rather short, with the five points of the corolla curling back. The anther-tubes and the pollen are yellow; so are the stigmas. The arrangement of the buds at the center is exceedingly pretty. The flowers develop no pappus, and therefore the akenes have no balloons. They seem in the present day to depend upon the ignorance and helplessness of man to scatter their akenes far and wide with the grass and clover seed which he sows for his own crops. It was thus that the daisy came to America, and in this manner it still continues to flaunt its banners in our meadows and pastures. The white daisy is not a daisy, but a chrysanthemum. It has never been called by this name popularly, but has at least twenty other common names, among them the oxeye daisy, moonpenny, and herb Margaret.

LESSON 139

The White Daisy

Leading Thought — The white daisy is not a single flower but is made up of many little flowers and should be studied by the outline given in Lesson 131.

Yellow daisy or black-eyed Susan

THE YELLOW DAISY OR BLACK-EYED SUSAN

These beautiful, showy flowers have rich contrasts in their color scheme. The ten to twenty ray flowers wave rich, orange banners around the cone of purple-brown disc flowers. The rays are notched and bent downward at their tips; each ray flower has a pistil, and develops a seed. The disc flowers are arranged in a conical, button-like center; the corollas are pink-purple at the base of the tube, but their five recurved, pointed lobes are purple-brown. The anther-tube is purple-brown and the stigmas show the same color; but the pollen is brilliant orange, and adds much to the beauty of the rich, dark florets when it is pushed from the anther-tubes. There is no pappus developed, and therefore the seeds are not carried far by the wind.

The stem is strong and erect; the bracts of the involucre are long, narrow, and hairy, the lower ones being longer and wider than those above; they all spread out flat, or recurve below the open flower-head. In blossoming, first the ray flowers spread wide their banners; then the florets around the base of the cone open and push out their yellow pollen through the brown tubes; then day by day the blossoming circle climbs toward the apex — a beautiful way of blossoming upward.

LESSON 140

The Black-Eyed Susan

Leading Thought — This flower should be studied by the outline given in Lesson 131.

THE THISTLE

O. L. Foster

Bull or common thistle

On looking at the thistle from its own standpoint, we must acknowledge it to be a beautiful and wonderful plant. It is like a knight of old encased in armor and with lance set, ready for the fray. The most impressive species is the great pasture or bull thistle (*Cirsium pumilum*). It has a blossom-head three inches across. This is not so common as the lance-leaved thistle, which ornaments roadsides and fence corners, where it may remain undisturbed for the necessary second year of growth before it can mature its seeds. The most pernicious species, from the farmer's standpoint, is the Canada thistle. Its rootstocks are perennial, and they invade garden, grain-field, and meadow. They creep for yards in all directions, just deep enough to be sure of moisture, and send up new plants here and there, especially if the main stalk is cut off. Rootstocks severed by the plow send up shoots from both of the broken parts. Not so with the common thistle, which has a single main root, with many fibrous and clustered branches but with no side shoots.

The stem of the lance-leaved thistle is strong and woody, and is closely hugged by pricky leaf stems, except for a few inches above the root. The leaves are placed alternately on the stem; they are deep green, covered above with rough and bristling hairs, and when young are covered on the under side with soft, gray wool which falls away later. The spines grow on the edges of the leaves, which are deeply lobed and are also somewhat wavy and ruffled, thus causing the savage spears to meet the enemy in any direction. The veins are without spines. Small buds or branches may be found at the axils of the leaves; and if a plant is beheaded, those axillary buds nearest the top of the stem will grow vigorously.

The thistle flowers are purple in color and very fragrant; they grow in single heads at the summit of the stem, and from the axils of the upper leaves. The topmost heads open first. Of the individual flowers in the head, those of the outer rows first mature and their pistils protrude; the pollen grains are white. In each flower, the corolla is tube-shaped and purple, parting into five fringelike lobes at the top, and fading to white at its nectar-filled base.

The stamens have dark purple anthers, united in a tube in which their pollen is discharged. The pistil, ripening later, shoves out the pollen with its stigma, which at first is blunt at the end, its two-parted lips so tightly held together that not a grain of its own flower's pollen can be taken. But when thrust far out beyond the anther-tube, the two-parted stigma opens to receive the pollen which is brought by the many winged visitors; for of all flowers, the thistles with their abun-

A floret from a thistle flower-head

dant nectar are the favorites of insects. Butterflies of many species, moths, beetles, and bees — especially the bumblebees — are the happy guests of the thistle blooms.

The thistles believe in large families; a single head of the lance-leaved thistle

W. C. Baker

Canada thistle

has been known to have 116 seeds. Each seed is covered by a tight hard shell and the whole fruit is called an akene. Very beautiful and wonderful is the pappus of the thistle; it is really the calyx of the flower, its tube being a narrow collar, and the lobes being split into the silken floss. At the larger end of the akene is a circular depression with a tiny hub at its center; into this ring, and around the knob, is fitted the collar which attaches the down to the akene. Hold the balloon between the eye and the light, and it is easy to see that the down is made of many-branched plumes which interlace and make it more buoyant. When first taken from its crowded position on the flower-head, the pappus surrounds the corolla in a straight, close tube; but if placed for just a few moments in the sun, the threads spread, the filmy branchlets open out, and a fairy parachute is formed, with the seed hanging beneath; if no breath of air touches it while spreading, it will sometimes form a perfect funnel; when blown upon, some of the silken threads lose their places on the rim and rise to the center. When driven before the breeze, this balloon will float for a long distance. When it falls, it lets go of the akene as the wind moves it along the rough surface of the ground, and when it is thus unburdened the down fluffs out in every direction, making a perfect globe.

For the first season after the seed has rooted, the thistle develops only a rosette, meanwhile putting down roots and becoming permanently established. The next season, the flowers and akenes are developed, and then the plant dies. Would that this fact were true of the Canada thistle; but that, unfortunately, is perennial, and its persistent rootstocks can only be starved out by keeping the stalks cut to the ground for the entire season. This thistle trusts to its extensively creeping rootstocks more than to its seeds for retaining its foothold and for spreading. While it develops many akenes, a large number of its seeds are infertile and will not grow.

LESSON 141

The Common or Lance-leaved Thistle

Leading Thought — The thistle is covered with sharp spines, and these serve to protect it from grazing animals. It has beautiful purple flowers, arranged in heads similar to those of the sunflower.

Method — A thistle plant brought into the schoolroom — root and all — and placed in water will serve well for this lesson. The pupils should first be questioned about where the thistles are found. Any thistle will do for the lesson.

Observations — 1. Where do you find the thistles growing? Do you find more than one species growing thickly together? Do you find any of the common thistles growing in soil which has been cultivated this season?

2. Describe the stalk; is it smooth? Is it weak, or strong and woody? What sort of root has it?

3. Do the leaves grow alternately or opposite? Are they smooth or downy on one or both sides? Do the spines grow around the margins, or on the leaves and veins? Are the leaf edges flat, or wavy and ruffled?

4. How does this affect the direction in which the spines point? Are the leaves entire or deeply lobed? Have they petioles, or are they attached directly to the stalk?

5. Note if any buds or small branches are in the axils of the lower leaves. What effect does cutting the main stalk seem to have on each side shoot?

6. Do the flower-heads of the thistle grow singly or in clusters? Do they come from the summit of the stalk, or do they branch from its sides? Which blossom-heads open first — the topmost or those lowest on the stalk? Are the flowers fragrant? What insects do you most often see visiting thistle blossoms? Study the thistle flower according to Lesson 131.

7. Carefully study a thistle balloon. How is the floss attached to the akene? Is it attached to the smaller or the larger end? Hold the thistle balloon between your eye and the light. Does the down consist of single separate hairs, or have they many fine branches? How is the down arranged when all the flowers are packed together in the thistle-head? Take an akene from among its closely packed fel-

lows in the thistle-head, and put it in the sun or in a warm, dry place where it cannot blow away. How long does it take for the balloon to open out? What is its shape? Is there any down at the center of the balloon or is it arranged in a funnel-shaped ring? Can you find a perfectly globular thistle balloon with the akenes still attached to it? How far do you think the thistle balloons might travel?

8. If a thistle akene finds a place for planting during the autumn, how does the young plant look the next season? Describe the thistle rosette. What growth does it make the second summer? What happens to it then?

9. Why can you not cultivate out the Canada thistle as you can the other species? Why is it less dependent on its akenes for propagation than the others?

THE BURDOCK

Psychologists say that all young things are selfish, and the young burdock is a shining example of this principle. Its first leaves are broad and long, with long petioles by means of which they sprawl out from the growing stem in every direction, covering up and choking out all the lesser plants near them. In fact, the burdock remains selfish in this respect always, for its great basal leaves prevent other plants from getting much sunlight when they grow near its own roots. One wonders at first how a plant with such large leaves can avoid shading itself; we must study carefully the arrangement of its leaves in order to understand this. The long basal leaves are stretched out flat; the next higher, somewhat smaller ones are lifted at an angle so as not to stand in their light. This arrangement characterizes in general the leaves of the plant, for each higher leaf is smaller and has a shorter petiole, which is lifted at a narrower angle from the stalk; and all the leaves are so adjusted as to form a pyramid, allowing the sunlight to sift down to each part. While some of the uppermost leaves may be scarcely more than an inch long, the lower ones are very large. They are pointed at the tip and wide at the base; where the leaf joins the petiole it is irregular, bordered for a short distance on each side with a vein, and then finished with a "flounce," which is so full that it even reaches around the main stem — another peculiarity of structure which shuts off sunlight from plants below. On the lower

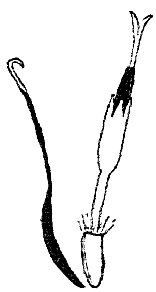
D. L. Foster

Common burdock, showing blossom and buds

side, the leaf is whitish and feltlike to the touch; above, it is a raw green, often somewhat smooth and shiny. The leaf is in quality poor, coarse, and flimsy, and it hangs — a web of shoddy — on its strong supporting ribs; its edges are slightly notched and much ruffled. The petiole and stems are felty in texture; the petiole is grooved, and expands at its base to grasp the stems on both sides with a certain vicious pertinacity which characterizes the whole plant.

The flower-heads come off at the axils

of the upper leaves, and are often so crowded that the leaf is almost lost to sight. It is amazing to behold the number of flower-heads which develop on one thrifty plant. The main stem and the pyramid of lower branching stems are often crowded with the green balls beset with bracts which are hooked, spiny, and which hold safe the flowers. This composite flower-head is a fortress bristling with spears which are not changed to peaceful pruning-hooks, although they are hooked at the sharp end, every hook turning toward the flowers at the center; the lower bracts are shorter and stand out at right angles, while the others come off at lesser angles, graded so as to form a globular



A burdock floret with hooked bract

involucre — a veritable blockhouse. The flower might be a tidbit for the grazing animal; but if so, he has never discovered it, for these hooks may have kept him from ever enjoying a taste. The bracts, not only by hooks at the tip, but also by spreading out at the bases, make a thickly battened covering for the flower-cluster.

But if we tear open one of these little heads, we are well repaid in seeing the quite pretty florets. The corollas are long, slender, pink tubes, with five, pointed lobes. The anther-tubes are purple, the pistils and the stigmas white; the stigmas are broad and feathery when they are dusting out the pollen from the anther-tubes, but later they change to very delicate pairs of curly Y's. The young akene is shining white, and the pappus forms a short, white fluff at the upper margin; but this is simply a family trait, for the burdock akenes never need to be ballooned to their destination; they have a surer method of travel. When in full bloom, the burdock flower-heads are very pretty and the skillful child weaver makes them into beautiful baskets. When I was a small girl, I made whole sets of furniture from these flowers; and then, becoming more ambitious, wove some into a coronet which I wore proudly for a few short hours, only to discover later, from my own experience, that great truth which Shakespeare voiced — " uneasy lies the head that wears the crown."

In winter, the tough, gray stalks of the burdock still stand; although they may partially break. They insert the hooks of their seed storehouses into the clothing or covering of the passer-by; and when one gets a hold, mayhap a dozen others will hold hands and follow. If they catch the tail of horse or cow, then indeed they must feel their destiny fulfilled; for the animal, switching about with its uneasy appendage, threshes out the seeds, and unheedingly plants them by trampling them into the ground. Probably some of the livestock of our Pilgrim Fathers came to America thus burdened; for the burdock is a European weed, although now it flourishes too successfully in America. The leaves of the burdock are bitter, and are avoided by grazing animals. Fortunately for us, certain flies and other insects apparently like their bitter taste, and lay eggs upon them, which hatch into larvæ that live all their lives between the upper and lower surfaces of the leaf. Often the leaves are entirely destroyed by the minute larvæ of a fly, which live together cozily between these leaf blankets, giving the leaves the appearance of being afflicted with large blisters. A small moth caterpillar finds both food and shelter in the ripe fruiting heads.

The burdocks have long vigorous taproots, and it is therefore difficult to eradicate them without much labor. But persistently cutting off the plant at the root will, if the cut be deep, finally discourage this determined weed.

LESSON 142

The Burdock

Leading Thought — The burdock thrives because its great leaves shade down plants in its vicinity, and also because it has taproots. It scatters its seed by hooking its seed-heads fast to the passer-by.

Method — Study a healthy burdock plant in the field, to show how it shades down other plants and does not shade itself. The flowers may be brought into the schoolroom for detailed study.

Observations — 1. Note a young plant. How much space do its leaves cover? Is anything growing beneath them? How are its leaves arranged to cover so much space? Of what advantage is this to the plant?

2. Study the full-grown plant. How are the lower leaves arranged? At what angles to the stalks do the petioles lie? Are the upper leaves as large as the lower ones? Do they stand at different angles to the stalk?

3. Study the arrangement of leaves on a burdock plant, to discover how it manages to shade down other plants with its leaves and yet does not let its own upper leaves shade those below.

4. Study a lower and an upper leaf. What is the general shape? What peculiarity where it joins the petiole? What is the texture of the leaf above and below? The color? Describe the petiole and how it joins the stem.

5. Where do the flowers appear on the stem? Are there many flowers developed? Count all the flower-heads on a thrifty burdock.

6. The burdock has its flowers gathered into heads, like the sunflower and thistle. Describe the burdock flower-head according to Lesson 131.

7. What insects visit the burdock flowers? Can you make baskets from the flower-heads?

8. Study the burdock again in winter, and see what has happened to it. Describe the fruit. How are the fruits carried far away from the parent plant? How many akenes in a single " house "? How do they escape?

9. Write the biography of a burdock plant which came to America as a fruit, attached to the tail of a Shetland pony.

PRICKLY LETTUCE, A COMPASS PLANT

The more we know of plants, the more we admire their ways of attaining success in a world where a species attains success only after a long struggle. The success of prickly lettuce depends much upon its being able to live in dry situations and withstand the long droughts of late summer. The pale green stems grow up slim and tall, bearing leaves arranged alternately and from all sides, since between two, one of which is exactly above the other, two other leaves are borne. Thus, if the leaves stood out naturally, the shape of the whole plant would be a somewhat blunt pyramid. But during the hot, dry weather, the leaves do not stand out straight from the stem; instead, they twist about so that they are practically all in one plane, and usually point north and south, although this is not invariably the case. The way this twisting is accomplished is what interests us in this plant. The long spatulate leaf has a thick, fleshy midrib, and at the base are developed two pointed lobes which clasp the stalk. The leaf is soft and leathery and always seems succulent, because it retains its moisture; it has a ruffled edge near its base, which gives it room for turning without tearing its margin. Each leaf tips over sidewise toward the stem. The ruffled margin of the upper edge is pulled out straight when the leaf stands in this position, while the lower margin is more ruffled than ever. Thus, it stands, turning edgewise to the sun, retaining its moisture and thriving when cultivated plants are dry and dying.

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Wild lettuce

It also has another "anchor to the windward." A plant so full of juice would prove attractive food for cattle when pastures are dry. The leaves of prickly lettuce perhaps escape because each has a row of very sharp spines on the lower side of the midrib. If we watch a grazing animal, such as a cow, reach out her tongue to pull the herbage into her mouth, we see that these spines repel her. The teasel has the same means of warning off meddlesome tongues. The prickly lettuce also has spines on its stem, and the leaves are toothed with spines at their points.

LESSON 143

Prickly Lettuce

Leading Thought — The sunshine sets the machinery in the leaf-factories going, and incidentally increases evaporation from the plant, as it does from any moist surface. The wild lettuce plant has the edges of its leaves turned to the sun; thus they stand in one plane and have less surface exposed directly to the sun. The leaves are usually directed north and south. The lettuce also has spines which protect it from grazing animals.

Method — The lettuce should be studied in the field, and is a good subject for a lesson in late summer or September. This lesson should supplement the one on transpiration. The young plants show this arrangement of the leaves best. The flowers may be studied by the outline given in Lesson 131.

Observations — 1. Where does the prickly lettuce grow? What sort of stem has it? How are the leaves arranged on the stem?

2. If the leaves stood straight out from

Cyrus Crosby

A common compass plant; note the prickles the stem, what would be the shape of the plant? How do the leaves stand? Is their upper surface exposed to the rays of the sun? Which portion of the leaf is turned toward the sun?

3. If the leaves turn sidewise and stand in one plane, do they stand north and south or east and west? How does the edgewise position of the leaf protect the plant during drought? Why does any plant wither during drought? If the leaves of the lettuce should extend east and west instead of north and south, would they get more sun? (See Lesson on the Sun, page 833.)

4. What is the shape of the lettuce leaf? How does it clasp the stalk? Does the leaf turn toward the stem or away from it?

5. How are the leaves protected against grazing cattle? How does the cow use her tongue to help bring herbage to her mouth? How are the prickly spines arranged on the lettuce leaf, and in what way may these spines protect the lettuce from grazing animals? Sketch a leaf showing its shape, its venation, and its spines.

Hugh Spencer

Common dandelion

THE DANDELION

This is the most persistent and indomitable of weeds, yet I think the world would be very lonesome without its golden flower-heads and fluffy seed-spheres. Professor Bailey once said that dandelions in his lawn were a great trouble to him until he learned to love them, and then the sight of them gave him keenest pleasure. And Lowell says of this " dear common flower " —

'Tis the Spring's largess, which she scatters now
To rich and poor alike, with lavish hand,
Though most hearts never understand
To take it at God's value, but pass by
The offered wealth with unrewarded eye.

It is very difficult for us, when we watch the behavior of the dandelions, not to attribute to them thinking power, they have so many ways of getting ahead of us. I always look at a dandelion and talk to it as if it were a real person. One spring when all the vegetables in my garden were callow weaklings, I found there, in their midst, a dandelion rosette with ten great leaves spreading out and completely shading a circle ten inches in diameter; I said, "Look here, Madam, this is my garden!" and I pulled up the squatter. But I could not help paying admiring tribute to the taproot, which lacked only an inch of being a foot in length. It was smooth, whitish, and fleshy, and, when cut, bled a milky juice; it was as strong from the end-pull as a whipcord; it also had a bunch of rather fine rootlets about an inch below the surface of the soil and an occasional rootlet farther down; and then I said, "Madam, I beg your pardon; I think this was your garden and not mine."

Dandelion leaves afford an excellent study in variation of form. The edges of the leaf are notched in a peculiar way, so that the lobes were, by some one, supposed to look like lions' teeth in profile; thus the plant was called in France "dents-de-lion" (teeth of the lion), and we have made from this the name dandelion. The leaves are bitter, and grazing animals do not like to eat them.

The hollow stalk of the blossom-head from time immemorial has been a joy to children. It may be made into a trombone, which will give to the enterprising teacher an opportunity for a lesson in the physics of sound, since by varying its length the pitch is varied. The dandelion-curls, which the little girls enjoy making, offer another lesson in physics — that of surface tension, too difficult for little girls to understand. If the plant is in a lawn, the stem is short, indeed so short that the lawn mower cannot cut off the flower-head. In this situation it will blossom and seed within two inches of the ground; but if the plant is in a meadow or in other high grass, the stalk lifts up sometimes two feet or more. We once found two such stems each measuring over thirty inches in height.

Before a dandelion head opens, the stem, unless very short, is likely to bend down, but the night before it is to bloom it straightens up; after the blossoms have matured it may again bend over, but straightens up when the seeds are to be cast off.

It often requires an hour for a dandelion head to open in the morning and it rarely stays open longer than five or six hours; it may require another hour to close. Usually not more than half the flowers of the head open the first day, and it may require several days for them all to blossom. After they have all bloomed and retired into their green house and put up the shutters, it may take them from one to two weeks to perfect their akenes.

In the life of the flower-head the involucre, or the house in which the flower family lives, plays an important part. The involucral bracts, in the row set next to the flowers, are sufficiently long to cover the unopened flowers; the bracts near the stem are shorter and curl back, making a frill. In the freshly opened flower-head, the buds at the middle all curve slightly toward the center, each bud showing a blunt, five-lobed tip which looks like the tips of five fingers held tightly together. The flowers in the outer row blossom first, straightening back and pushing the corolla outward; and now we can see that the five lobes in the bud are the five notches at the end of the corolla. All the flowers in the dandelion head have banners, but those at the center, belonging to the younger flowers, have shorter and darker yellow corollas. After a corolla has opened, there pushes out from its tubular base a darker yellow anther-tube; the five filaments below the tube are visible with a lens. A little later, the stigma-ramrod pushes forth from the tube, its fuzzy sides acting like a brush to bring out all the pollen; later it rises far above the anther-tube and quirls back its stigma-lobes, as if every floret were making a dandelion curl of its own. The lens shows us, below the corolla, the akene. The pappus is not set in a collar upon the dandelion seed, as it is in the aster seed; there is a short stem above the seed which is called the "beak" and the pappus is attached to this.

Every day more blossoms may open; but on dark, rainy days and during the night the little green house puts up its shutters around the flower family, and if the bracts are not wide enough to cover the growing family, the banners of the outer flowers have along their lower sides thick or brownish portions which serve to calk the chinks. It is interesting to watch the dandelion stars close as the night falls, and still more interesting to watch the sleepy-heads awaken long after the sun is up in the morning; they often do not open until eight o'clock.

After all the florets of a dandelion head have blossomed, they may stay in retirement for several days, and during this period the flowerstalk often grows industriously; and when the shutters of the little green house are again let down, what

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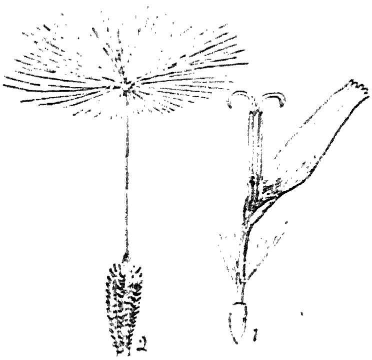
Dandelion, showing stages from bud to "old man"

a different appearance has the dandelion head! The akenes with their balloons are set so as to make an exquisite, filmy globe;



1, *Floret of dandelion; 2, akene of dandelion. Both enlarged*

now they are ready to coquette with the wind, and one after another all the balloons go sailing off. One of these akenes is well worth careful observation through a lens. The balloon is attached to the top of the beak as an umbrella frame is attached to the handle, except that the "ribs" are many and fluffy; while the dandelion youngster, hanging below, has an overcoat armed with grappling hooks, which enable it to cling fast when the balloon chances to settle to the ground.

Father Tabb says of the dandelion — "With locks of gold today; tomorrow silver gray; then blossom bald." But not the least beautiful part of the dandelion is this blossom-bald head after all the akenes are gone; it is like a mosaic, with a pit at the center of each figure where the akene was attached. There is an interesting mechanism connected with this receptacle. Before the akenes are fully out this soon-to-be-bald head is concave at the center; later it becomes convex, and the mechanism of this movement liberates the akenes which are embedded in it.

Each freshly opened corolla-tube is full to overflowing with nectar, and much pollen is developed; therefore, the dandelion has many kinds of insect visitors. But perhaps the bee shows us best where the nectar is found; she thrusts her tongue down into the little tubes below the rays, working very rapidly from floret to floret. The dandelion stigmas have a special provision for securing cross-pollination; if that fails, they may be self-pollinated; and now the savants have found that the pistils can also grow seeds without any pollen from anywhere. It surely is a resourceful plant!

The following are the tactics by which the dandelion conquers us and takes possession of our lands: (a) It blossoms early in the spring and until snow falls, producing seed for a long season. (b) It is broadminded as to its location, and flourishes on all sorts of soils. (c) It thrusts its long taproots down into the soil, and thus gets moisture and food not reached by other plants. (d) Its leaves spread out from the base, and crowd and shade many neighboring plants out of existence. (e) Many insects visit it, and so it has plenty of pollen carriers to insure strong seeds; it can also develop seeds from its own pollen, or it even can develop seeds without any pollen. (f) It develops almost numberless akenes, and the wind scatters them far and wide and they thus take possession of new territory. (g) It forms vigorous leaf-rosettes in the fall, and thus is able to begin growth early in the spring.

LESSON 144

The Dandelion

Leading Thought — The dandelions flourish despite our determined efforts to exterminate them. Let us study the way in which they conquer.

Method — The study should be made with the dandelions on the school grounds. Questions should be given, a few at a time, and then let the pupils consult the dandelions as to the answers.

The dandelion is a composite flower and may be studied according to Lesson 131. All the florets are ray flowers.

Observations — 1. Where do you find dandelions growing? If they are on the lawn, how long are their blossom- or seed-stalks? If in a meadow or among high grass, how long is the blossom-stalk? Is the blossom-stalk solid or hollow? Does it break easily?

2. Dig up a dandelion root and then explain why this weed withstands drought, and why it remains, when once planted.

3. Sketch or describe a dandelion leaf. Why was the plant named "lion's teeth"? How are the leaves arranged about the root? How does this help the dandelion and hinder other plants? In what condition do the leaves pass the winter under the snow?

4. Take a blossom not yet open. Note the bracts that cover the unopened flower-head. Note the ones below and describe them.

5. Note the dandelion flower-head just open. Which flowers open first? How do the buds look at the center? Do all the florets have rays? Are the ray flowers of the center of the head the same color and length as those outside? Examine a floret and note the young akene. Is the pappus attached to it or above it?

6. What happens to the dandelion blossom on rainy or dark days? Do you think that this has anything to do with the insect visitors? Do bees and other insects gather nectar during dark or rainy days?

7. Note at what hour the dandelions on the lawn close and at what hour they open on pleasant days.

8. Make notes on a certain dandelion plant three times a day: How long does it take the dandelion head to open fully on a sunny morning? How long does it remain open? How long does it take the flower-head to close? What proportion of the flowers in the head blossoms during the first day? What proportion of the flowers in the head blossoms during the second day? How long before they all blossom? Does the flower-head remain open longer in the afternoon on some days than on others, equally sunny? Does the stem bend over before the blossom-head opens?

9. After all the little flowers of a dandelion head have blossomed, what happens

to it? Measure the stem, and see if it stretches up during the time. How does the dandelion look when it opens again? Look at a dandelion head full of seed, and see how the seeds are arranged to make a perfect globe. Shake the seeds off and examine the " bald head " with a lens. Can you see where the seeds were set?

10. Examine a dandelion akene with a lens. Describe the balloon, the beak or stem of the balloon, and the akene.

11. How early in the spring, and how late in the fall, do dandelions blossom?

12. Watch a bee when she is working on a dandelion flower, and see where she thrusts her tongue and which flowers she probes.

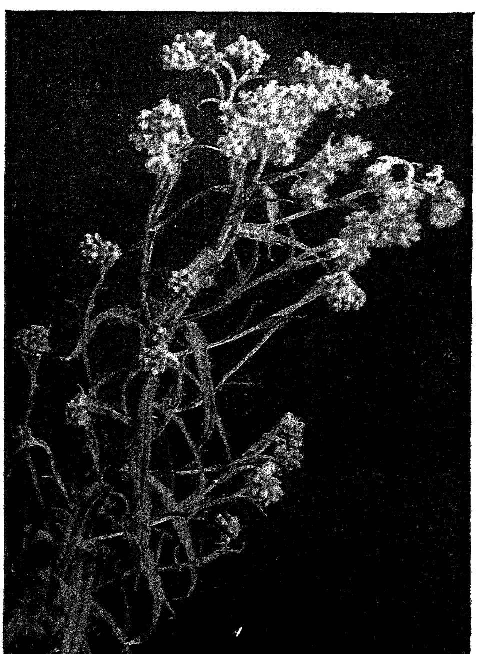
13. Tell all the things that you can remember about the dandelion which help it to live and thrive.

14. What use do we make of the dandelion?

THE PEARLY EVERLASTING

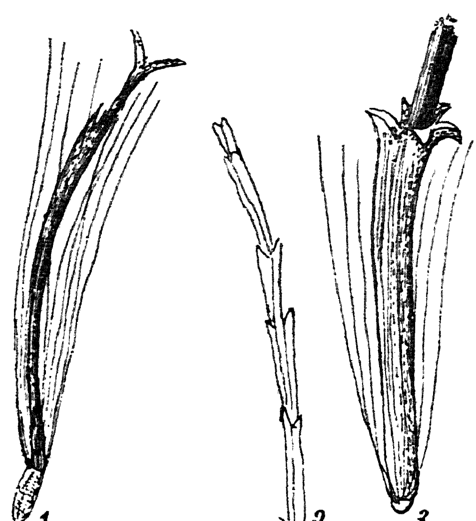
These wraithlike flowers seem never to have been alive, rather than to have been endowed with everlasting life. Cattle do not often eat them. The stems are covered with white felt; the long narrow leaves are very pale green, and when examined with a lens, look as if they were covered with a layer of cotton which disguises all venation except the thick midrib. The leaves are set alternate, and become shorter and narrower and whiter toward the top of the plant. All this cottony covering tends to prevent the evaporation of water from the plant during the long droughts. The everlasting never has much juice in its leaves, but what it has, it keeps.

The flowerstalks are rather stout, wooly, soft, and pliable. They come off at the axils of the threadlike whitish leaves. The pistillate and the staminate flowers are borne on separate plants, and usually in separate patches. The pistillate or seed-developing plants have globular flower buds, almost egg-shaped, with a fluffy lemon-yellow knob at the tip; this fluff is made up of stigmas split at the end.



Verne Morton

The pistillate flower-heads of pearly everlasting



1, *Pistillate floret;* 2, *pappus;* 3, *staminate floret. All enlarged*

At the center of this tassel of lemon-yellow stigma-plush, may often be seen a depression; at the bottom of this well, there are three or four perfect flowers. One of the secrets of the everlasting is, evidently, that it does not put all of its eggs in one basket; it has a few perfect flowers for insurance. This pistillate or

Leonard K. Beyer

A good stand of pearly everlasting

seed-bearing flower has a long, delicate tube, ending in five needle-like points and surrounded by a pretty pappus. The bracts of the flower-cluster seem to cling around the base of the beautiful yellow tassel of fertile flowers, as if to emphasize it. They look as if they were made of white Japanese paper, and when looked at through a lens, they resemble the petals of a water lily. They are dry to begin with, so they cannot wither.

The staminate or pollen-bearing flower-heads are like white birds' nests, the white bracts forming the nest and the little yellow flowers the eggs. The flower has a tubular, five-pointed, starlike corolla, with five stamens joined in a tube at the middle, standing up like a barrel from the corolla. The anther-tube is ocher-yellow with brown stripes, and is closed at first with five little flaps, making a cone at the top. Later, the orange-yellow pollen bulges out as if it were boiling over. The flowers around the edges of the flower disc open first.

LESSON 145

The Pearly Everlasting

Leading Thought — There are often found growing on the poor soil in dry pastures, clumps of soft, whitish plants which are seldom eaten by cattle. There is so little juice in them that they retain their form when dried and thus have won their name.

Method — The pupils should see these plants growing, so that they may observe the staminate and pistillate flowers, which are on separate plants and often in separate clumps. If this is not practicable, bring both kinds of flowers into the schoolroom for study.

Observations — 1. Where does the pearly everlasting grow? Do cattle eat it? What is the general color of the plant? With what is the stem covered?

2. What is the shape of the leaves? How are they veined? With what are they covered? How are they placed on the stem? What is the relative size of the lower and upper leaves?

3. Do you see some plants which have egg-shaped flower-heads, each with a yellow knob at the tip? Take one apart and look at it with a lens, and see what forms the white part and what forms the yellow knob. Do you see other flower-heads that look like little white birds' nests filled with yellow eggs? Look at one of them with a lens, and tell what kind of flower-head it is.

4. Except that the pistillate and staminate flowers are on different plants, the flowers of the pearly everlasting should be studied according to Lesson 131.

5. What do you know of the edelweiss of the Alps? How does it resemble the pearly everlasting? Do you know another common kind of everlasting called pussy's toes?

MULLEIN

I like the plants that you call weeds, —
Sedge, hardhack, mullein, yarrow, —
Which knit their leaves and sift their seeds
Where any grassy wheel-track leads
Through country by-ways narrow.
— LUCY LARCOM

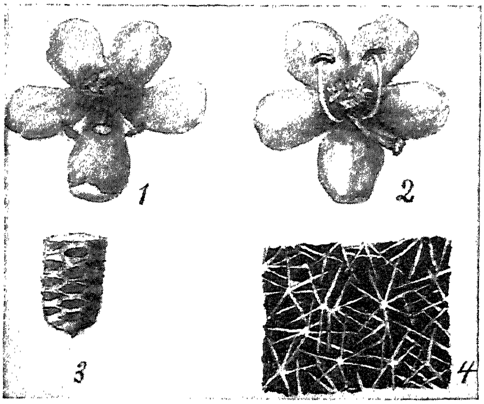
We take much pride unto ourselves because we belong to the chosen few of the "fittest," which have survived in the struggle for existence. But, if we look around upon other members of this select band, we shall find many lowly beings which we do not ordinarily recognize as our peers. Mullein is one of them, and after we study its many ways of "winning out" then we may bow to it and call it "brother."

I was wandering one day in a sheep pasture and looking curiously at the few plants left uneaten. There was a great thistle with its sharp spines and the pearly everlasting — too woolly and anæmic to be appetizing even to a sheep; and besides these, there was an army of mullein stalks — tall, slim, and stiff-necked, or branching like great candelabra, their upper leaves adhering alternately to the stalks for half their length. I stopped before one of them and mentally asked, "Why do the sheep not relish you? Are you bitter?" I took a bite, Nebuchadnezzar-like, and to my untrained taste it seemed as good fodder as any; but my tongue smarted and burned for some time after, from being pricked by the felt which covered the leaf. I recalled the practical joke of which my grandmother once made me the victim; she told me that to be beautiful, I needed only to rub my cheeks with mullein leaves, an experience which convinced me that there were other things far more desirable than beauty — comfort, for instance. This felt on the mullein is beautiful when looked at through a microscope; it consists of a fretwork of little, white, sharp spikes. No wonder my cheeks were red one day and purple the next. and no

Verne Morton

Mullein. Note the stone fence in the background. Mullein often grows in such places

wonder the sheep will not eat mullein unless starved! This frostlike felt covering not only may make the plant unpalatable to grazing animals but may also help to keep the water in the leaves from evaporating. I soon discovered another means by which the mullein resists drought, when I tried to dig up the plant with a stick; I followed its taproot down far enough to understand that it was a subsoiler and reached below most other plants for moisture and food. Although it was late autumn, the mullein was still in blossom; there were flowers near the tip and also one here and there on the capsule-crowded stem. I estimated there were hundreds of seed capsules on that one



1, 2, *Mullein flowers in different stages.* 3, *Mullein seed enlarged.* 4, *A bit of mullein leaf enlarged*

plant; I opened one, still covered with the calyx-lobes, and found that the mullein was still battling for survival; for I found this capsule and many others inhabited by little brown-headed white grubs, which gave an exhibition of St. Vitus dance as I laid open their home. They were the young of a snout beetle, which is a far more dangerous enemy of the mullein than is the sheep.

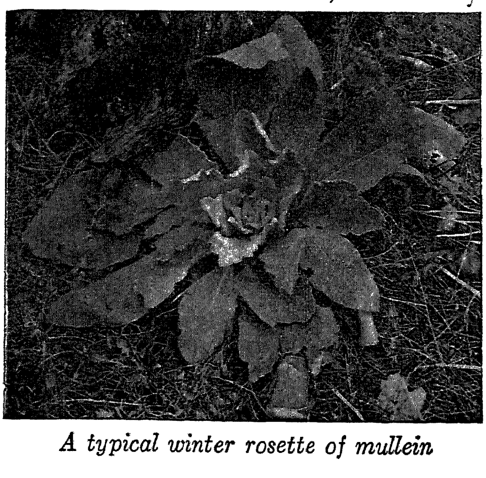
The mullein plant is like the old woman who lived in a shoe in the matter of blossom-children; she has so many that they are unkempt and irregular, but there are normally four yellow or white petals and a five-lobed calyx. I have never been able to solve the problem of the five stamens which, when the flower opens, are folded together in a knock-kneed fashion. The upper three are bearded below the anthers, the middle being the shortest. The lower two are much longer and have no fuzz on their filaments; they at first stand straight out, with the stigma between them; but after the upper anthers have shed their pollen, these stamens curve up like boars' teeth and splash their pollen on the upper petals, the stigma protruding one-sidedly below. Later the corolla, with the stamens which are attached to it, falls off, leaving the stigma and style attached to the seed capsule.

The color of the mullein flowers varies from lemon-yellow to white. The filaments are pale yellow; the anthers and pollen, orange. The seed capsule is encased in the long calyx-lobes, and is shaped like a blunt egg. By cutting it in two crosswise, the central core, tough and flattened and almost filling the capsule, is revealed, and growing upon its surface are numberless tiny brown seeds, as fine as gunpowder. Later the capsule divides partially in quarters, opening wide enough to shake out the tiny seeds with every wandering blast. The seed, when seen through a lens, is very pretty; it looks like a section of a corncob, pitted and ribbed. A nice point of investigation for some junior naturalist is to work out the fertilization of the mullein flower, and note what insects assist. The mullein has another spoke in the wheel of its success. The seed, scattered from the sere and dried plants, settles in any place where it can reach the soil, and during the first season grows a beautiful velvety rosette of fuzzy leaves. These rosettes lie flat under the snow, with their taproots strong and already deep in the soil, and are ready to begin their work of food-making as soon as the spring sun gives them power.

Suggested Reading — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 5, *Science at Home*; also, readings on page 513.

LESSON 146
Mullein

Leading Thought — The mullein has its leaves covered with felt, which may



A typical winter rosette of mullein

help to retard evaporation. The plant is seldom eaten by grazing animals. It has a deep root, and thus gets moisture beyond the reach of most other plants. It blossoms all summer and until the snow comes in the autumn, and thus forms many, many seeds, which the wind plants for it; and here in our midst it lives and thrives despite us.

METHOD — The pupils should have a field trip to see what plants are left uneaten in pastures, and thus learn where mullein grows best. The flower- or seed-stalk, with basal leaves and root, may be brought to the schoolroom for the lesson.

OBSERVATIONS — 1. Where does the mullein grow? Do you ever see it in swamps or woodlands? Do cattle or sheep eat it? Does it flourish during the summer drought? Look at a mullein leaf with a lens and describe its appearance.

2. What sort of root has the mullein? How is its root adapted to get moisture which other plants cannot reach? Describe the flowering stalk. How are the leaves arranged on it and attached to it? Are there several branching flowerstalks or a single one?

3. Describe the flower bud. Do the mullein flowers nearest the base or the tip begin to blossom first? Is this invariable, or do flowers open here and there irregularly on the stem during the season?

4. Describe the mullein flower. How many lobes has the calyx? Are these covered with felt? How many petals? Are there always this number? Are the petals of the same size? Are they always regular in shape?

5. How many stamens? How do the upper three differ from the lower two? Describe the style and stigma. What are the colors of petals, anthers, and stigma? What insects do you find visiting the flowers?

6. Describe the seed capsule, its shape and covering. Cut it across and describe the inside. Where are the seeds borne? Are there many? Look at the seed with a lens and describe it. How does the capsule open and by what means are the seeds scattered?

7. Does the mullein grow from the seed to maturity in one year? How does it look at the end of the first season? Describe the winter rosette, telling how it is fitted to live beneath the snows of winter. What is the advantage of this habit?

8. Write a theme telling some ways the mullein has of flourishing and of combating other plants.

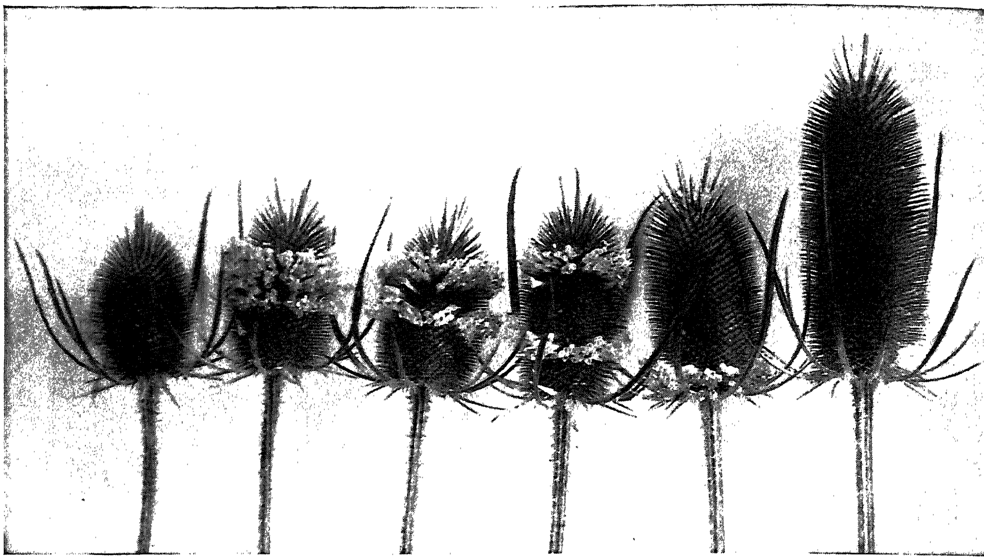
The mullein's pillar, tipped with golden flowers,
Slim rises upward, and yon yellow bird
Shoots to its top.

— "THE HILL HOLLOW,"
A. B. STREET

THE TEASEL

The old teasel stalks standing gaunt and gray in the fields, braving the blasts of winter, seem like old suits of armor, which elicit admiration from us for the strength and beauty of the protecting visor, breastplate, and gauntlets, and at the same time veer our thoughts to the knights of old who once wore them in the fray. Thus, with the teasel, we admire this panoply of spears, which recall the purple flowers and the ribbed akenes.

Let us study this plant in armor: First, its stem is tough, woody, hollow, with ridges extending its full length and each ridge armed with spines which are quite wide at the base and very sharp. It is impossible to take hold anywhere without being pricked by either large or small spines. The leaves are long, lanceolate, set opposite in pairs, rather coarse in texture, with a stiff, whitish midrib; the bases of the two leaves closely clasp the stem; the midrib is armed below with a row of long, white, recurved prickers, and woe unto



The teasel begins at the middle and blossoms both ways

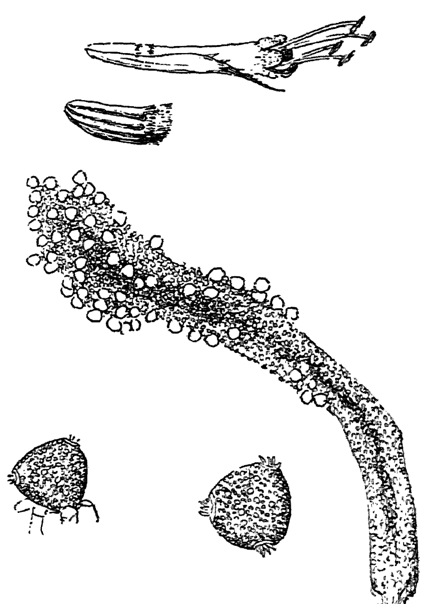
the tongue of grazing beast that tries to lift this leaf into the mouth. If one pair of clasping leaves points east and west, the next pairs above and below point north and south.

The flowerstalks come off at the axils of the leaves and therefore each pair stands at right angles to the ones above and below. The flowers are set in dense heads armed with spines, and the head is set in an involucre of long, upcurving spiny prongs. If we look at it carefully, the teasel flower-head wins our admiration, because of the exquisite geometrical design made by the folded bases of the spines, set in diagonal rows. If we pull out a spine, we find that it enlarges toward the base to a triangular piece that is folded at right angles, holding the flower. Note that the spiny bracts at the tip of the flower-head are longer and more awesome than those at the sides; if we pass our hands down over the flower-head we feel how stiff the spines or bracts are, and can hear them crackle as they spring back.

The teasel has a quite original method of blossoming. The goldenrod begins to blossom at the tip of the flowering branches and the blossom-tide runs inward and downward toward the base. The clover begins at the base and blossoms toward the tip, or the center. But the teasel begins at the middle and blossoms both ways. Some summer morning we will find its flower-head girt about its middle with a wide band of purple blossoms; after a few days these fade and drop off, and then there are two bands, sometimes four rows of flowers in each, and sometimes only two. Below the lower band and above the upper band, the enfolding bracts are filled with little round-headed lilac buds, while between the two rows of blossoms the protecting bracts hold the precious growing seed. Away from each other this double procession moves, until the lower band reaches the pronged involucre and the upper one forms a solid patch on the apex of the flower-head. Since the secondary blossom-heads starting from the leaf axils are younger, we may find all stages of this blossoming in the flower-heads of one plant.

No small flower better repays close examination than does that of the teasel. If we do not pull the flower-head apart, what we see is a little purple flower consisting of a white tube with four purple lobes at the end, the lower lobe being a little longer than the others and turning up slightly at its tip; projecting from between each of the lobes, and fastened to the tube, are four stamens with long white filaments and beautiful purple anthers filled with large, pearly white pollen grains; at the very heart of the flower, the white stigma may be seen far down the tube. But a little later, after the anthers have fallen or shriveled, the white stigma extends out of the blossom like a long white tongue and is crowded with white pollen grains.

But to see the flower completely we need to break or cut a flower-head in two. Then we see that the long white tube is tipped at one end with purple lobes and a fringe of anthers, and at the other is set upon a little green, fluffy cushion which caps the ovary; the shape of the ovary in the flower tells us by its form how the fruit will look later. Enfolding ovary and tube is the bract with its spiny edges, pushing its spear outward, but not so far out as the opening of the flower. The pollen of the teasel is white and globular, with three little rosettes arranged at equal distances upon it like a bomb with three



Teasel flower and fruit enlarged. The stigma of a teasel floret much magnified to show the pollen adhering to it. Below are pollen grains greatly magnified

Verne Morton

A winter rosette of teasel

fuses. These little rosettes are the growing points of the pollen grains and from any of them may emerge the pollen tube to push down into the stigma. The teasel pollen is an excellent subject for the children to study, since it is so very large; and if examined with a microscope with a three-fourths objective, the tubes running from the pollen grains into the stigma may be easily seen.

In blossoming, the teasel is not always uniform in the matter of rows of flowers. There may be more rows in the upper band than in the lower, or *vice versa*; this is especially true of the smaller secondary blossoms. But though the teasel flowers fade and the leaves fall off, still the spiny skeleton stands, the thorny stalks holding up the empty flower-heads like candelabra, from which the seeds are tossed far and wide, shaken out by the winds of autumn. But though battered by wintry blasts, the teasel staunchly stands; it will often stand even until the ensuing summer, its heads empty where once were blossom and seed. Alas, because of this emptiness, it has been debased by practical New England housewives into a utensil for sprinkling clothes for ironing.

The spines of one species of teasel were in earlier times used for raising the nap on woolen cloth, and the plant was grown extensively for that purpose. The bees are fond of the teasel blossoms and teasel honey has an especially fine flavor.

The teasels are biennial, and during the first season develop a rosette of crinkled leaves which have upon them short spines.

LESSON 147
The Teasel

Leading Thought — The teasel is a plant in armor. It has a peculiar method of beginning to blossom in the middle of the flower-head and then blossoming upward and downward from this point.

Method — In September, bring in a teasel plant which shows all stages of blossoming, and let the pupils make observations in the schoolroom.

Observations — 1. Where does the teasel grow? Is it eaten by cattle? How is it protected?

2. What sort of stem has it? Is it hollow or solid? Where upon it are the spines situated? Are the spines all of the same size? Can you take hold of the stem anywhere without being pricked?

3. What is the shape of the leaves? How do they join the stem? Are the leaves set opposite or alternate? If one pair points east and west in which direction will the pairs above and below point? How and where are the leaves armed? How does the cow or sheep draw leaves into the mouth with the tongue? If either should try to do this with the teasel, how would the tongue be injured?

4. Where do the flowerstems come off? Do they come off in pairs? How are the pairs set in relation to each other?

5. What is the general appearance of the teasel flower-head? Describe the long involucre prongs at the base. If the teasel is in blossom, where do you find the flowers? How many girdles of flowers are there around the flower-head? How many rows in one girdle? Where did the first flowers blossom in the teasel flower-head? Where on the head will the last blossoms appear? Where are the buds just ready to open? Where are the ripened akenes?

6. Examine a single flower. How is it protected? Cut out a flower and bract and see how the long-spined bract enfolds it. Would the bract spear deter cattle from grazing on the blossom? Where are the longest spines on the teasel head?

7. Study a single flower. What is the shape of its corolla? How is it colored? What color are the stamens? How many? Describe the pollen. If the pollen is being shed where is the stigma? After the pollen is shed, what happens to the stigma?

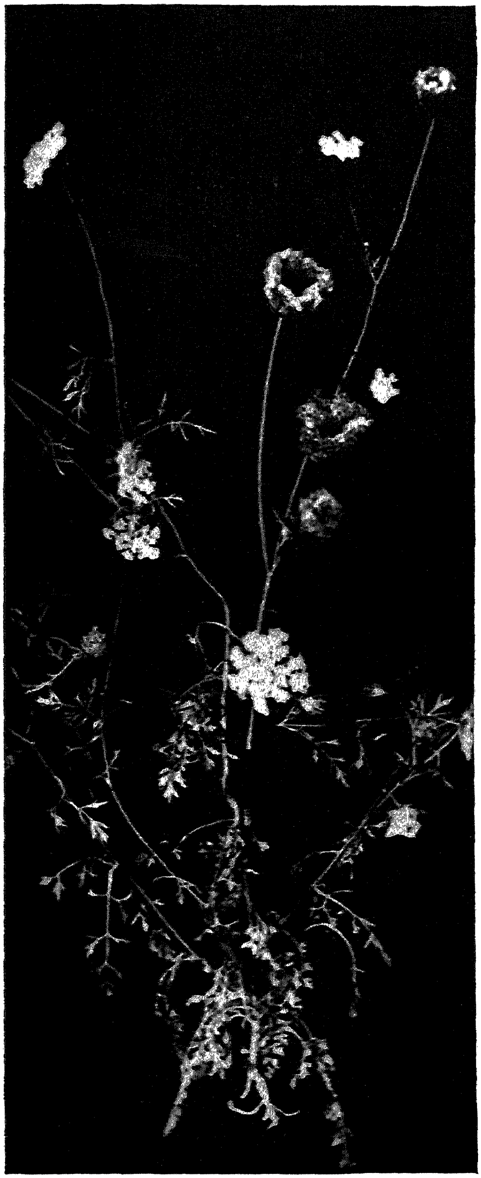
8. What do you find at the base of the flower? How does the young seed look? Later in the season take a teasel head and describe how it scatters its seed. How do the ripe seeds look?

9. For what were teasels once used? How many years does a teasel plant live? How does it look at the end of its first season? How is this an advantage as a method of passing the winter?

QUEEN ANNE'S LACE OR WILD CARROT

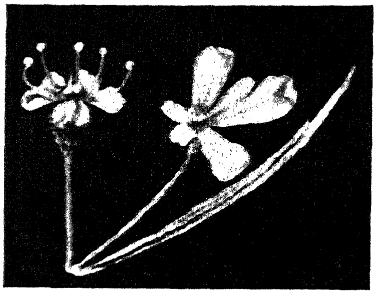
Queen Anne was apparently given to wearing lace made in medallion patterns; and even though we grant that her lace is most exquisite in design as well as in execution, we wish most sincerely that there had been established in America such a high tariff on this royal fabric as to have prohibited its importation. It has for decades held us and our lands prisoners in its delicate meshes, it being one of the most stubborn and persistent weeds that ever came to us from over the seas.

But for those people who admire lace of intricate pattern, and beautiful blossoms, whether they grow on scalawag plants or not, this medallion flower attributed to Queen Anne is well worth studying. It belongs to the family *Umbelliferæ*, which one of my small pupils always called "umbrelliferæ" because, he averred, they have umbrella blossoms. In the case of Queen Anne's lace the flower-cluster, or umbel, is made up of many smaller umbels, each a most perfect flower-cluster in itself. Each tiny white floret has five petals and should have five stamens with creamy anthers, but often has only two. However, it has always at its center a pistil composed of two parts set snugly together, which rests in a solid, bristly, green, cuplike calyx. Twenty or thirty of these little blossoms are set in a rosette, the stalks of graded length; and where the bases of the stalks meet are some long, pointed, narrow bracts. Each of these little flower-clusters, or umbels, has a long stalk, its length being just fit to bring it to its right place in the medallion pattern of



Verne Morton

Queen Anne's lace or wild carrot



An inner and a border floret and a bract of Queen Anne's lace, enlarged

this royal lace. And these stalks also have set at their bases some bracts with long, threadlike lobes, which make a delicate, green background for the opening blossoms; these bracts curl up about the buds and the seeds. If we look straight into the large flower-cluster, we can see that each component cluster, or umbellet, seems to have its own share in making the larger pattern; the outside blossoms of the outside clusters have the outside petals larger, thus forming a beautiful border. At the very center of this flower medallion, there is often a larger floret with delicate, wine-colored petals; this striking floret is not a part of a smaller flower-cluster, but stands in stately solitude upon its own isolated stalk. The reason for this giant floret at the center of the wide, circular flower-cluster is a mystery; and so far as I know, the botanists have not yet explained the reason for its presence. May we not, then, be at liberty to explain its origin on the supposition that her Royal Highness, Queen Anne, was wont to fasten her lace medallions upon her royal person with garnet-headed pins?

When the flowers wither and the fruits begin to form, every one of the little umbels turns toward the center, its stalk curving over so that the outside umbels reach over and close over the whole flower-head; and the threadlike bracts at the base reach up as if they, too, were in the family councils, and must do their slender duty in helping to make the fading flowers into a little, tightfisted clump. Such little porcupines as the fruits are! Each fruit is clothed with long spines set in bristling rows, and is a most forbidding-looking youngster when examined through a lens; and yet there is method in its spininess, and we must grudgingly grant that it is not only beautiful in its ornamentation but is also well fitted to take hold with a will when wandering winds sift it down to the soil.

The wild carrot is known in some localities as the "bird's-nest weed," because the maturing fruit-clusters, their edges curving inward, look like little birds' nests.

Charles F. Fudge

Fruiting cluster or "bird's nest" of wild carrot

But no bird's nest ever contained so many eggs as does this imitation one. In one we counted 34 tiny umbels on which ripened 782 fruits; and the plant from which this "bird's nest" was taken developed nine more quite as large.

Altogether the wild carrot is well fitted to maintain itself in the struggle for existence, and is most successful in crowding out its betters in pasture and meadow. Birds do not like its spiny seeds; the stem of the plant is tough and its leaves are rough and have an unpleasant odor and an acrid taste. Winter's cold cannot harm it, for it is a biennial; its seeds often germinate in the fall, sending down long, slender taproots crowned with tufts of inconspicuous leaves; it thus stores up a supply of starchy food which enables it to start early the next season with great vigor. The root, when the plant is fully grown, is six or eight inches long, as thick as a finger and yellowish white in color; it is very acrid and somewhat poisonous.

The surest way of exterminating the Queen Anne's lace is to prevent its prolific seed production by cutting or uprooting the plants as soon as the first blossoms open.

Suggested Reading—*Holiday Meadow*, by Edith M. Patch; also, readings on page 513.

LESSON 148

Queen Anne's Lace or Wild Carrot

Leading Thought — Queen Anne's lace is a weed which came to us from Europe and flourishes better here than on its native soil. It has beautiful blossoms set in clusters, and it matures many seeds which it manages to plant successfully.

Method — The object of this lesson should be to show the pupils how this weed survives the winter and how it is able to grow where it is not wanted. The weed is very common along most country roadsides, and in many pastures and meadows. It blossoms very late in the autumn, and is available for lessons often as late as November. Its fruit-clusters may be used for a lesson at almost any time during the winter.

Observations — 1. Look at a wild carrot plant; how are its blossoms arranged? Take a flower-cluster; what is its shape? How many small flower-clusters make the large one? How are these arranged to make the large cluster symmetrical?

2. Take one of the little flower-clusters from near the center, and one from the outside of the large cluster; how many little flowers, or florets, make up the smaller cluster? Look at one of the florets through a lens; can you see the cup-shaped calyx? How many petals has it? Can you see its five anthers and its two-parted white pistil?

3. Take one of the outer florets of the outside cluster; are all its flowers the same shape? How do they differ? Where are the florets with the large petals placed in the big flower-cluster? How does this help to make "the pattern"?

4. Do the outside or the central flowers of the large clusters open first? Can you find a cluster with an almost black or very dark red floret at its center? Is this dark flower a part of one of the little clusters or does it stand alone, its stalk reaching directly to the main stem? Do you think it makes the flowers of the Queen Anne's lace prettier to have this dark red floret at the center?

5. Take a flower-cluster with the flowers not yet open. Can you see the thread-like green bracts that close up around each bud? Can you see finely divided, thread-like bracts that stand out around the whole cluster? What position do these bracts assume when the flowers are open? What do they do after the flowers fade and the fruits are being matured?

6. What is the general shape of the fruit-cluster of the wild carrot? Have you ever found such a cluster broken off and blowing across the snow? Do you think this is one way the seed is planted?

7. Examine a fruit of the wild carrot with a lens. Is it round or oblong? Thin or flat? Is it ridged or grooved? Has it any hooks or spines by which it might cling to the clothing of passers-by, or to the hair or fleece of animals, and thus be scattered more widely? Does the fruit cling to its stem or break away when it is touched?

8. Take one fruit-cluster and count the number of seeds within it. How many fruit-clusters do you find on a single plant? How many fruits do you therefore think a single plant produces?

9. What would you consider the best means of destroying this prolific weed?

10. What do you think is the reason that the wild carrot remains untouched, so that it grows vigorously and matures its seeds in lanes and pastures where cattle graze?

11. Have you noticed any birds feeding on the fruits of the wild carrot?

I do not want change: I want the same old and loved things, the same wild flowers, the same trees and soft ash-green; the turtle-doves, the blackbirds, the coloured yellow-hammer sing, sing, singing so long as there is light to cast a shadow on the dial, for such is the measure of his song, and I want them in the same place. Let me find them morning after morning, the starry-white petals radiating, striving upwards to their ideal. Let me see the idle shadows resting on the white dust; let me hear the bumble-bees, and stay to look down on the rich dandelion disc. Let me see the very thistles opening their great crowns — I should miss the thistles; the reed-grasses hiding the moor-hen; the bryony bine, at first crudely ambitious and lifted by force of youthful sap straight above the hedgerow to sink of its own weight presently and progress with crafty tendrils; swifts shot through the air with outstretched wings like crescent-headed shaftless arrows darted from the clouds; the chaffinch with a feather in her bill; all the living staircase of the spring, step by step, upwards to the great gallery of the summer — let me watch the same succession year by year.

— "The Pageant of Summer,"
Richard Jefferies

GARDEN FLOWERS

People have always admired the wild flowers that grow in the woods and meadows, and have wanted to be able to bring them near their homes. And so when someone would see a flower that he thought especially beautiful growing in field or forest, he would take it from its native home and plant it in a garden. If others admired it, they would ask for seeds, roots, or cuttings; and thus the plant would come to many gardens. As many wild flowers are beautiful, and as various people have varying tastes, in this way many kinds of flowering plants have come into cultivation.

But man is seldom content to leave a thing as he finds it; and so after a time people set about improving upon nature. Plant breeders have tried in many ways to add to the attractiveness of flowers in size, color, and shape. Often they have succeeded, and some strains have been greatly improved: thus, the aster that grows in our gardens is much more elaborate than the natural plant; Shakespeare's modest wild eglantine has yielded sixteen varieties of sweetbriar. Others, like the morning-glory and the calla lily, have changed very little during years of cultivation. Perhaps it is well that we have not always succeeded in improving upon nature; it is pleasant to have cultivated elegance and natural simplicity side by side.

Some garden flowers have been popular for many years; these we call "old-fashioned." They are still popular today; they are not out-of-date, like old-fashioned clothes; in their case, "old-fashioned" means rather that they have stood the test of time. Everyone knows the charm of an old-fashioned garden. But there are also new strains that bid fair to win their way and to stand the test as well as the older flowers, from which some of them have been developed, as the delphinium from the old-fashioned larkspur. All of them, however, even the most elegant newcomer, came originally from some wild flower.

Wild or cultivated, simple or ornate, flowers are among the most important means of decorating our homes and gardens. Every dooryard throughout the land is a picture that is viewed by the passer-by. Whether the picture is attractive or not may depend very largely upon the presence or absence of attractive flowers in the yard or about the door.

SUGGESTED READING — *The Book of Annuals* and *The Book of Perennials*, both by Alfred C. Hottes; *Flowers and Their Travels*, by Frances M. Fox; *Garden Bulbs in Color*, by H. J. McFarland, R. Marion Hatton, and D. J. Foley; *Garden Guide: The Amateur Gardener's Handbook*, edited by A. T. De La Mare Company, Inc.; *The Garden Month by Month*, by Mabel C. Sedgwick; *The Gardener's First Year* and *The Gardener's Second Year*, both by Alfred Bates; *The Junior Gardener*, by Dorothy W. Greene and Rosetta C. Goldsmith; *Peter and Penny Plant a Garden*, by Gertrude and Frances Dubois; *The Children Make a Garden*, by Dorothy H. Jenkins; also, readings on page 459.

Ferry-Morse Seed Co.

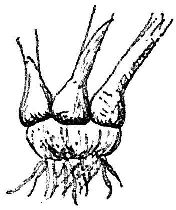
THE CROCUS

The crocus, like the snowdrop, cannot wait for the snow to be off the ground before it pushes up its gay blossoms, and it has thus earned the gratitude of those who are winter weary.

The crocus has a corm instead of a bulb like the snowdrop or daffodil. A corm is a solid, thickened, underground stem, and is not in layers, like the onion. The roots come off the lower side of the corm. The corm of the crocus is well wrapped in several, usually five, white coats with papery tips. When the plant begins to grow the leaves push up through the coats. The leaves are grasslike and may be in number from two to eight, depending on the variety. Each leaf has its edge folded, and the white midrib has a plait on either side, giving it the appearance of being box-plaited on the under side. The bases of the leaves enclosed in the corm coats are yellow, since they have had no sunlight to start their starch factories and the green within their cells. At the center of the leaves appear the blossom buds, each enclosed in a sheath.

The petals and sepals are similar in color, but the three sepals are on the outside, and their texture, especially on the outer side, is coarser than that of the three protected petals. But sepals and petals unite into a long tube at the base. At the very base of this corolla-tube; away down out of sight, even below the surface of the ground, is the seed box, or ovary. From the tip of the ovary the style extends up through the corolla-tube and is tipped with a ruffled three-lobed stigma.

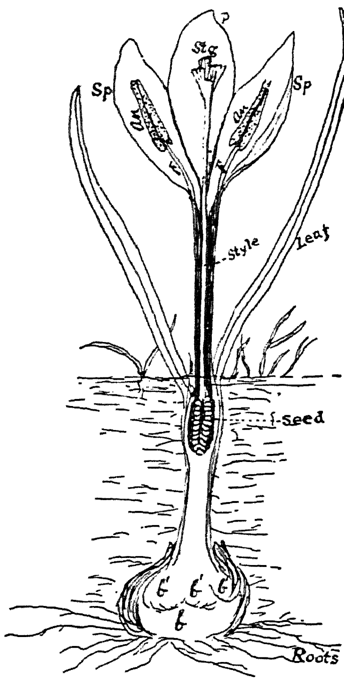
The three stamens are set at the throat of the corolla-tube. The anthers are very long and open along the sides. The anthers mature first, and shed their pollen



The old and young corms of the crocus

in the cup of the blossom where any insect, seeking the nectar in the tube of the corolla, must become dusted with it. However, if the stigma lobes fail to get pollen from other flowers, they later spread apart and curl over until they reach some of the pollen of their own flower.

Crocus blossoms have varied colors: white, yellow, orange, purple, the latter often striped or feather-veined. And while many seeds like tiny pearls are developed in the oblong capsule, yet it is chiefly by its corms that the crocus multiplies. On top of the mother corm of this year



The crocus

p, petal; sp, sepal; an, anther; f, filament; stg, stigma; b, mother corm; b′ b′ b′ young corms

develop several small corms, each capable of growing a plant next year. But after two years of this second-story sort of multiplication the young crocuses are pushed above the surface of the ground. Thus, they need to be replanted every two or three years. Crocuses may be planted from the first of October until the ground freezes. They make pretty borders to garden beds and paths. Or they may be planted in lawns without disturbing the grass, by punching a hole with a stick or dibble and dropping in a corm and then pressing back the soil in place above it. The plants will mature before the grass needs to be mowed.

LESSON 149

The Crocus

Leading Thought — The crocus blossoms appear very early in the spring, because the plants have food stored in underground storehouses. Crocuses multiply by seeds and by corms.

Method — If it is possible to have crocuses in boxes in the schoolroom windows, the flowers may thus best be studied. Otherwise, when crocuses are in bloom bring them into the schoolroom, corms and all, and place them where the children may study them at leisure.

Observations — 1. At what date in the spring have you found crocuses in blossom? Why are they able to blossom so much earlier than other flowers?

2. Take a crocus just pushing up out of its corm. How many overcoats protect its leaves? What is at the very center of the corm? Has the flower bud a special overcoat?

3. Describe the leaves. How are they folded in their overcoats? What color are they where they have pushed out above their overcoats? What color are they within the overcoats?

4. Do the flowers or the leaves have stems, or do they arise directly from the corm?

5. What is the shape of the open crocus flower? Can you tell the difference between sepals and petals in color? Can you tell the difference by their position? Or by their texture above or below? As you look into the flower, which makes the points of the triangle, the sepals or the petals?

6. Describe the anthers. How long are they? How many are there? How do they open? What is the color of the pollen? Describe how a bee becomes dusted with pollen. Why does the bee visit the crocus blossom? If she finds nectar there, where is it?

7. Describe the stigma. Open a flower and see how long the style is. How do the sepals and petals unite to protect the style? Where is the seed box? Is it so far down that it is below ground? How many seeds are developed from a single blossom?

8. How many colors do you find in the crocus flowers? Which are the prettiest in the lawn? Which in the flower beds?

9. How do the crocus blossoms act in dark and stormy weather? When do they open? How does this benefit them?

10. How do the crocus corms multiply? Why do they often need resetting?

11. Describe how to raise crocuses best: the kind of soil, the time of planting, and the best situations.

Out of the frozen earth below,
Out of the melting of the snow,
No flower, but a film, I push to light;
No stem, no bud — yet I have burst
The bars of winter, I am the first
O Sun, to greet thee out of the night!

Deep in the warm sleep underground
Life is still, and the peace profound:
Yet a beam that pierced, and a thrill that smote
Call'd me and drew me from far away;
I rose, I came, to the open day
I have won, unshelter'd, alone, remote.

— "THE CROCUS,"
HARRIET E. H. KING

When first the crocus thrusts its point of gold,
Up through the still snow-drifted garden-mould,
And folded green things in dim woods unclose
Their crinkled spears, a sudden tremor goes
Into my veins and makes me kith and kin
To every wild-born thing that thrills and blows.

— "A TOUCH OF NATURE,"
T. B. ALDRICH

THE DAFFODILS AND THEIR RELATIVES

Daffydown Dilly came up in the cold from the brown mold,
Although the March breezes blew keen in her face,
Although the white snow lay on many a place.

Thus it is that Miss Warner's stanzas tell us the special reason we so love the daffodils. They bring the sunshine color to the sodden earth, when the sun is chary of his favors in our northern latitude; and the sight of the daffodils floods the spirit with a sense of sunlight.

The daffodils and their relatives, the jonquils and narcissuses, are interesting when we stop to read their story in their form. The six segments of the perianth, or, as we would say, the three bright-colored sepals and the three inner petals of the flower, are different in shape; but they all look like petals and stand out in star-shape around the flaring end of the flower-tube, which, because of its shape, is called the corona, or crown; however, it looks more like a stiff little petticoat extending out in the middle of the flower than it does like a crown. When we look down into the crown of one of these flowers, we see the long style with its three-lobed stigma pushing out beyond the anthers, which are pressed close about it at the throat of the tube; between each two anthers may be seen a little deep passage, through which the tongues of the moth or butterfly can be thrust to reach the nectar. In a tube, slit open, we can see the nectar at the very bottom; it is sweet to the taste and has a decided flavor. In this open tube we may see that the filaments of the stamens are grown fast to the sides of the tube for much of their length, enough remaining free to press the anthers close to the style. The ovary of the pistil is a green swelling at the base of the tube; by cutting it across we can see that it is triangular in outline, and has a little cavity in each angle large enough to hold two rows of the little, white, shining, unripe seeds. Each of these cavities is partitioned from the others by a green wall.

When the flowerstalk first appears, it

Daffodil

comes up like a sheathed sword, pointing toward the zenith, green, veined lengthwise, and with a noticeable thickening at each edge. As the petals grow, the sheath begins to round out; the stiff stem at the base of the sheath bends at right angles. This brings a strain upon the sheath which bursts it, usually along the upper side, although sometimes it tears it off completely at the base. The slitted sheath, or spathe, hangs around the stem, wrinkled and parchment-like, very like the loose wrist of a suede glove. The stalk is a strong green tube; the leaves are fleshy and are grooved on the inner side. At the base the groove extends part way around the flowerstalk. The number of leaves varies with the variety, and they are usually as tall as the flowerstalk. There is one flower on a stalk in the daffodils and the poet's narcissus, but the jonquils and paper-white narcissus have two or more flowers on the same stalk.

A bed should be prepared by digging deep and fertilizing with stable manure. The bulbs should be planted in September or early October, and should be from four to six inches apart, the upper end of the bulbs at least four inches below the surface of the soil. They should not be disturbed but allowed to occupy the bed for a number of years, or as long as they give plenty of flowers. As soon as the surface of the ground is frozen in the winter, the beds should be covered from four to six inches in depth with straw-mixed stable manure, which can be raked off very early in the spring.

The new bulbs are formed at the sides of the old one; for this reason the daffodils will remain permanently planted, and do not lift themselves out of the ground like the crocuses. The leaves of the plant should be allowed to stand as long as they will after the flowers have disappeared, so that they may furnish the bulbs with plenty of food for storing. The seeds should not be allowed to ripen, as it costs the plant too much energy and thus robs the bulbs. The flowers should be cut just as they are opening. Of the white varieties, the poet's narcissus is the most satisfactory, as it is very hardy and very pretty, its corona being a shallow, flaring, greenish yellow rosette with orange-red border, the anthers of its three longest stamens making a pretty center. No wonder Nar-

Leonard K. Beyer

Poet's narcissus

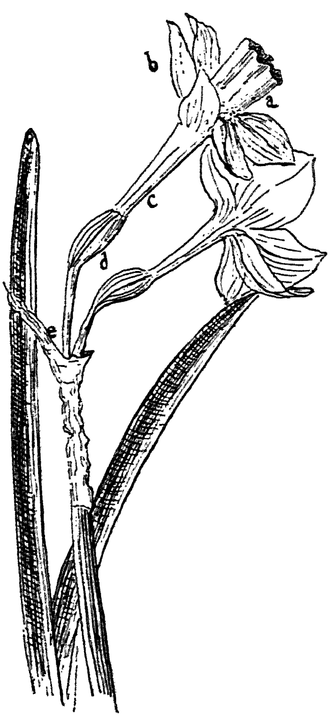
cissus bent over the pool in joy at viewing himself, if he was as beautiful a man as the poet's narcissus is a flower.

LESSON 150

Daffodils, Jonquils, and Narcissuses

Leading Thought — The daffodil, jonquil, and narcissus are very closely related, and quite similar. They all come from bulbs which should be planted in September; but after the first planting, they will flower on year after year, bringing much brightness to the gardens in the early spring.

Method — The flowers brought to school may be studied for form, and there should be a special study of the way the flower develops its seed, and how it is propagated by bulbs. The work should lead directly to an interest in the cultivation of the plants. In seedsmen's catalogues or other books, the children will find methods of planting and cultivating these flowers in cities. Daffodils are especially adapted for both window gardens and school gardens.



Jonquil showing detail of flower

a, corona or crown; b, sepals and petals forming perianth; c, corolla tube; d, ovary or seedcase; e, sheath or spathe

W. Atlee Burpee Co.

Paper-white narcissus

Observations — 1. Note the shape of the flower. Has it any sepals? Can you see any difference in color, position, and texture between the petals and sepals?

2. How do the petal-like parts of these flowers look? How many of them are there? Do they make the most showy part of the flower?

3. What does the central part of the flower look like? Why is it called the corona, or crown? Peel the sepals and petals off one flower, and see that the tube is shaped like a trumpet.

4. Look down into the crown of the flower and tell what you see. Can you see where the insect's tongue must go to reach the nectar?

5. Cut open a trumpet lengthwise to find where the nectar is. How far is it

from the mouth of the tube? How long would the insect's tongue have to be to reach it? What insects have tongues as long as this?

6. In order to reach the nectar how would an insect become dusted with pollen? Are the stamens loose in the flower-tube? Is the pistil longer than the stamens? How many parts to the stigma? Can you see how the flowers are arranged so that insects can carry pollen from flower to flower?

7. What is the green swelling in the stem at the base of the trumpet? Is it connected with the style? Cut it across and describe what you see. How do the young seeds look and how are they arranged?

8. Where the flowerstalk joins the stem, what do you see? Are there one or more flowerstalks coming from this spathe?

9. Describe the flowerstalk. Are the leaves wide or narrow? Are they as long as the flowerstalk, are they flat, or are they grooved?

10. What are the differences between daffodils, jonquils, and poet's narcissus? When should the bulbs for these flowers be planted? Will there be more bulbs formed around the one you plant? Will the same bulb ever send up flowers and leaves again? How do the bulbs divide to make new bulbs?

11. How should the bed for the bulbs be prepared? How near together should the bulbs be planted? How deep in the earth? How can they be protected during the winter?

12. Why should you not cut the leaves off after the flowers have died? Why should you not let the seeds ripen? When should the flowers be cut for bouquets? Who was Narcissus, and why should these early spring flowers be named after him?

I emphatically deny the common notion that the farm boy's life is drudgery. Much of the work is laborious, and this it shares with all work that is productive; for the easier the job the less it is worth doing. But every piece of farm work is also an attempt to solve a problem, and therefore it should have its intellectual interest; and the problems are as many as the hours of the day and as varied as the face of nature. It needs but the informing of the mind and the quickening of the imagination to raise any constructive work above the level of drudgery. It is not mere dull work to follow the plow — I have followed it day after day — if one is conscious of all the myriad forces that are set at work by the breaking of the furrow; and there is always the landscape, the free fields, the clean soil, the rain, the promise of the crops. Of all men's labor, the farmer's is the most creative. I cannot help wondering why it is that men will eagerly seek work in the grease and grime of a noisy factory, but will recoil at what they call the dirty work of the farm. So much are we yet bound by tradition!

— L. H. Bailey

THE TULIP

We might expect that the Lady Tulip would be a stately flower, if we should consider her history. She made her way into Europe from the Orient during the sixteenth century, bringing with her the honor of being the chosen flower of Persia, where her colors and form were reproduced in priceless webs from looms of the most skilled weavers. No sooner was she seen than worshiped, and shortly all Europe was at her feet.

A hundred years later, the Netherlands was possessed with the tulip mania. Growers of bulbs and brokers who bought and sold them indulged in wild speculation. Rare varieties of the bulbs became more costly than jewels, one of the famous black tulips being sold for about $1800. Since then, the growing of tulips has been one of the important industries of the Netherlands.

There are a great many varieties of tu-

Marion E. Wesp

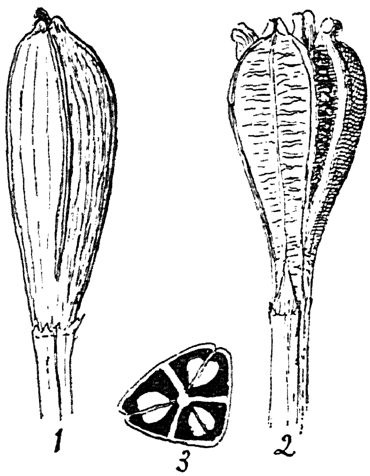
Tulips in a border

lips, and their brilliant colors make our gardens gorgeous in early spring. Although this flower is so prim, yet it bears well close observation. The three petals, or inner segments of the perianth, are more exquisite in texture and in satiny gloss on their inner surface than are the three outer segments or sepals; each petal is like grosgrain silk, the fine ridges uniting at the central thicker portion. In the red varieties, there is a six-pointed star at the heart of the flower, usually yellow or yellow-margined, each point of the star being at the middle of a petal or sepal; the three points on the petals are longer than those on the sepals.

When the flower bud first appears, it is nestled down in the center of the plant, scarcely above the ground. It is protected by three green sepals. As it stretches up, the bud becomes larger and the green of the sepals takes on the color of the tulip flower, until when it opens there is little on the outside of the sepals to indicate that they once were green. But they still show that they are sepals, for they surround the petals, each standing out and making the flower triangular in shape as we look into it. During storms and dark days, the sepals again partially close about the rest of the flower.

The seed vessel stands up, a stout, three-sided, pale green column at the center of the flower; in some varieties, its three lobed yellowish stigma makes a Doric capital; in others, the divisions are so curled as to make the capital almost Ionic. The six stout, paddle-shaped stamens have their bases expanded so as to encircle completely the base of the pistil column; these wide filaments are narrower just below the point where the large anthers join. The anther opens along each side to discharge the pollen; however, the anthers flare out around the seed vessel and do not reach half way to the stigma, a position which probably insures cross-pollination by insects, since the bees cannot reach the nectar at the base of the pistil without dusting themselves with pollen.

The flower stem is stout, pale green, covered with a whitish bloom. The leaves



Tulip seed capsule

1, Tulip seed capsule; 2, same opened; 3, cross section of same

are long, trough-shaped, and narrow with parallel veins; the bases of the lower ones encircle the flower stem and have their edges more or less ruffled and their tips recurved; the upper leaves do not completely encircle the flower stem at their bases. The texture of the leaves is somewhat softer on the inside than on the outside, and both sides are grayish green.

After the petals and stamens are dropped the seed vessel looks like an ornamental tip to the flowerstalk; it is three-sided, and has within double rows of seeds along each angle.

The bulb is formed of several coats, or layers, each of which extends upward and may grow into a leaf; this shows that the bulb is made up of leaves which are thickened with the food stored up in them during one season, so as to start the plant growing early the next spring. In the heart of each bulb is a flower bud, sheltered by the fleshy leaf-layers around it, which furnish it food in the spring. This structure of the bulb shows how the leaves clasp the flower stem at their bases. The true roots are below the bulb, making a thick tassel of white rootlets, which reach deep into the soil for minerals and water.

Tulips are very accommodating; they will grow in almost any soil, if it is well drained so that excessive moisture may not rot the bulbs. In preparing a bed, it should be rounded up so as to shed water; it should also be worked deep and made rich. If the soil is stiff and clayey, set bulbs only three inches deep, with a handful of sand beneath each. If the soil is mellow loam, set the bulbs four inches deep and from four to six inches apart each way, depending on the size of the bulbs. They should be near enough so that when they blossom the bed will be covered and show no gaps. Take care that the pointed tip of the bulb is upward and that it does not fall to one side as it is covered. October is the usual time for planting, as the beds are often used for other flowers during the summer. However, September is not too early for the planting, as the more root growth made before the ground freezes, the better; moreover, the early buyers have best choice of bulbs. The beds should be protected by a mulch of straw or leaves during the winter, which should be raked off as soon as the ground is thawed in the spring. The blossoms should be cut as soon as they wither, in order that the new bulbs which form within and at the sides of the parent bulb may have all of the plant food, which would otherwise go to form seed. Tulips may be grown from seed, but it takes from five to seven years to obtain blossoms, which may be quite unlike the parent. Most of these seedlings will be worthless; a few may develop into desirable new tulips. The bulblets grow to a size for blooming in two or three years; the large one which forms in the center of the plant will bloom the next season.

LESSON 151

The Tulip

Leading Thought — The tulips blossom early, because they have food stored in the bulbs the year before, ready to use early in the spring. There are many varieties; each is worth studying carefully, and we should all know how to grow these beautiful flowers.

METHOD — These observations may be made upon tulips in school gardens or bouquets. The best methods of cultivating should be a part of the garden training. For this, consult the seed catalogues; also let the pupils form some idea of the number of varieties from the seed catalogues. Water-color drawings may be used as helps in studying the tulip. The red varieties are best for beginning the study, and then follow with the other colors; note differences.

OBSERVATIONS — 1. What is the color of your tulip? Is it all the same color? Is the bottom of the flower different in color? What does the pretty shape of these different colors at the heart of the flower resemble?

2. Look at a tulip just opening. What causes it to appear so triangular? Can you see that the three sepals are placed outside the petals? Is there any difference in color between the sepals and petals on the inside? On the outside? Are the sepals and petals the same in length and shape? Are the three petals more satiny on the inside than the sepals? Is the center part of the petal as soft as the edges?

3. When the tulip flower bud first begins to show, where is it? What color are the sepals which cover it? Describe the opening of the flower. Do the green sepals fall off? What becomes of them?

4. In the open flower, where is the seed pod, and how does it look? How do the anthers surround the seed pod, or ovary? Describe the anthers, or pollen boxes. What color are they? What color is the pollen? Do the anthers reach up to the stigma, or tip of the seed pod? Where is the nectar in tulips? How do the insects become covered with the pollen in reaching it? Do the flowers remain open during dark and stormy days?

5. Describe the tulip stem and the leaves. Do the leaves completely encircle the flower stem at the base? Are their edges ruffled? In the sprouting plant, do these outer basal leaves enfold the leaves which grow higher on the stem? Are the leaves the same color above and below? What shade of green are they?

6. After the petals have dropped, study the seed pod. Cut it crosswise and note how many angles it has. How are these angles filled? Should tulips be allowed to ripen seeds? Why not?

7. Study a bulb of a tulip. There are outer and inner layers and a heart. What part of the plant do the outer layers make? What part does the center make? Where are the true roots of the tulip?

8. When should tulip bulbs be planted? How should you prepare the soil? How protect the bed during the winter? How long would it take to grow the flowers from the seed? Do you know the history of tulips?

THE PANSY

Some people are pansy-faced and some pansies are human-faced, and for some occult reason this puts people and pansies on a distinctly chummy basis. When we analyze the pansy face, we find that the dark spots at the bases of the side petals make the eyes, the lines radiating from them looking quite eyelashy. The opening of the nectar-tube makes the nose, while the spot near the base of the lower petal has to do for a mouth, the nectar guiding-lines being not unlike whiskers. Meanwhile, the two upper petals give a "high-browed" look to the pansy countenance, and make it a wise and knowing little face.

The pansy nectar is hidden in the spur made by the lower petal extending behind the flower. The lines on the lower and side petals all converge, pointing directly to the opening which leads to this nectar-well. Moreover, the broad lower petal serves as a platform for the bee to alight upon, while she probes the nectar-well with her tongue.

Verne Morton

But at the door leading to the nectar-well sits a little man; his head is green, he wears a white cape with a scalloped, reddish brown collar, and he sits with his bandy legs pushed back into the spur as if he were taking a foot bath in nectar. This little pansy man has plenty of work to do; for his mouth, which is large and at the top of his green head, is the stigma. The cape is made of five overlapping stamens, the brown, scalloped collar being the anthers; his legs consist of prolongations of the two lower stamens. And when the bee probes the nectar-well with her tongue, she tickles the little man's feet so that his head and shoulders wriggle; and thus she brushes the pollen dust from his collar against her fuzzy face, and at the same time his mouth receives the pollen from her dusty coat.

As the pansy matures, the little man grows still more manlike; after a time he sheds his anther cape, and we can see that his body is the ribbed seed pod. He did not eat pollen for nothing, for he is full of growing seeds. Sometimes the plush brushes, which are above his head in the pansy flower, become filled with pollen, and perhaps he gets a mouthful of it.

The pansy sepals, five in number, are fastened at about one-third of their length, their heart-shaped bases making a little green ruffle around the stem where it joins the flower. There is one sepal above and two at each side, but none below the nectar-spur. The flowerstalk is quite short and bends so that the pansy seems to look sidewise at us instead of staring straight upward. The plant stem is angled and crooked and stout. In form, the leaves are most varied; some are long and pointed, others wide and rounded. The edges are slightly scalloped and the leaf may have at its base a pair of large, deeply lobed stipules. In a whole pansy bed it would be improbable that one would find two leaves just alike.

The pansy ripens many seeds. The ribbed seed capsule, with its base set in the sepals, finally opens in three valves and the many seeds are scattered. To send them as far afield as possible, the edges of each valve of the pod curl inward, and snap the seeds out as boys snap apple seeds from the thumb and finger.

Pansies like deep, rich, cool, moist soil. They are best suited to a northern climate, and prefer the shady side of a garden to the full sunshine. The choice varieties are perpetuated through cuttings. They may be stuck in the open ground in summer in a half-shady place and should be well watered in dry weather. All sorts of pansies are readily raised from seed sown in spring or early summer, and seedlings, when well established, do not suffer, as a rule, from winter frosts.

The general sowing for the production of early spring bloom is made out of doors in August, while seeds sown indoors from February to June will produce plants to flower intermittently during the late summer and fall months. When sowing pansy seed in August, sow the seed broadcast in a seed-bed out-of-doors, cover it very lightly with fine soil or well-rotted manure, and press the seed in with a small board; then mulch the seed-bed to the thickness of one inch with long, strawy horse manure from which the small particles have been shaken off, so as to have the soil well and evenly covered. At the end of two weeks the plants will be up. Then remove the straw gradually, a little at a time, selecting a dull day if possible. Keep the bed moist.

If the pansies are allowed to ripen seeds the season of bloom will be short, for when its seeds are scattered the object of the plant's life is accomplished. Flowers borne with the forming seeds are smaller than the earlier ones. But if the flowers are kept plucked as they open, the plants persistently put forth new buds. The plucked flowers will remain in good condition longer if picked in the early morning before the bees begin paying calls, for a fertilized flower fades more quickly than one which has received no pollen.

LESSON 152

The Pansy

Leading Thought — The pansy is a member of the violet family. The flower often resembles a face; the colors, markings, and fragrance all attract the bees, who visit it for the nectar hidden in the spur of the lower petal.

Method — The children naturally love pansies because of the resemblance of these flowers to quaint little faces. They become still more interested after they see the little man with the green head who appears in the flower as it fades. A more practical interest may be cultivated by studying the great numbers of varieties in the seed catalogues and learning their names. This is one of the studies which leads directly to gardening. There are many beautiful pansy poems which should be read in connection with the lesson.

Observations — 1. How does the pansy flower resemble a face? Where are the eyes? The nose? The mouth? How many petals make the pansy forehead? The cheeks? The chin?

2. Where is the nectar in the pansy? Which petal forms the nectar-tube?

3. Describe how a bee gets the nectar. Where does she stand while probing with her tongue?

4. Where is the pollen in the pansy? What is the peculiar shape of the anthers? How do the two lower stamens differ in form from the three upper ones?

5. Where is the stigma? Does the bee's tongue go over it or under it to reach the nectar? Describe the pansy arrangement for dusting the bee with pollen and for getting pollen from her tongue.

6. Observe the soft little brushes at the base of the two side petals.

7. Take a fading flower; remove the petals, and see the little man sitting with his crooked legs in the nectar-tube. What part of the flower makes the man's head? What parts form his cape? Of what is his pointed, scalloped collar formed?

8. How many sepals has the pansy? Describe them. How are they attached? When the flower fades and the petals fall, do the sepals also fall?

9. Where in the flower is the young seed pod? Describe how this looks after the petals have fallen.

10. Describe how the seed pod opens. How many seeds are there in it? How are they scattered?

11. Study the pansy stem. Is it solid? Is it smooth or rough? Is it curved? Does it stand up straight or partially recline on the ground?

12. Take a pansy leaf and sketch it with the stipules at its base. Can you find two pansy leaves exactly alike in shape, color, and size?

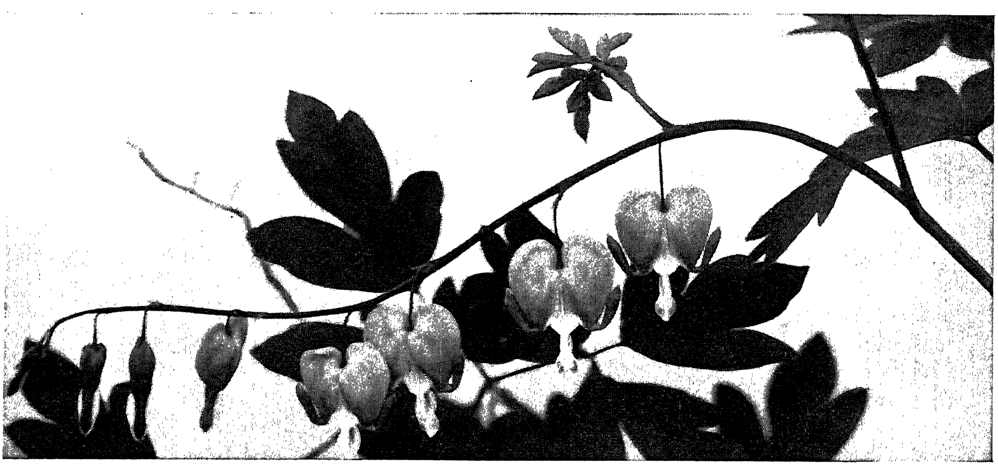
13. At what time should the pansy seed be planted? How should the soil be prepared?

I dropped a seed into the earth. It grew, and the plant was mine.

It was a wonderful thing, this plant of mine. I did not know its name, and the plant did not bloom. All I know is that I planted something apparently as lifeless as a grain of sand and there came forth a green and living thing unlike the seed, unlike the soil in which it stood, unlike the air into which it grew. No one could tell me why it grew, nor how. It had secrets all its own, secrets that baffle the wisest men; yet this plant was my friend. It faded when I withheld the light, it wilted when I neglected to give it water, it flourished when I supplied its simple needs. One week I went away on a vacation, and when I returned the plant was dead; and I missed it.

Although my little plant had died so soon, it had taught me a lesson; and the lesson is that it is worth while to have a plant.

— "The Nature-Study Idea,"
L. H. Bailey



Verne Morton

THE BLEEDING HEART

The summer's flower is to the summer sweet,
Though to itself it only live and die.

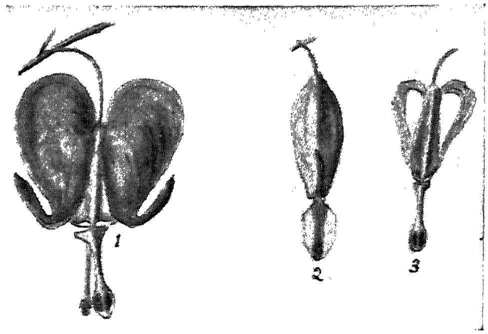
— Shakespeare

For the intricate structure of this type of flower, the bleeding heart is much more easily studied than its smaller wild sisters, the Dutchman's-breeches or squirrel corn; therefore it is well to study these flowers when we find them in profusion in our gardens, and the next spring we may study the wildwood species more understandingly.

The flowers of the bleeding heart are

beautiful jewel-like pendants arranged along the stem according to their age: the mature flower, ready to shed its petals, is near the main stem, while the tiny unopened bud is hung at the very tip, where new buds are constantly being formed during a long season of bloom. This flower has a strange modification of its petals; the two pink outer ones, which make the heart, are really little pitchers with nectar at their bottoms, and although they hang mouth downward the nectar does not flow out. When these outer petals are removed, we can see the inner pair placed opposite to them, the two of them close together and facing each other like two grooved ladles. Just at the mouth of the pitchers these inner petals are almost divided crosswise; and the parts that extend beyond are spoon-shaped, like the bowls of two spoons which have been pinched out so as to make a wide, flat ridge along their centers. These spoon-bowls unite at the tip, and between them they clasp the anthers and stigma. Special attention should be given to the division between the two portions of these inner petals; for it is a hinge, the workings of which are of much importance to the flower. On removing the outer petals, we find a strange framework around which the heart-shaped part of the flower seems to be modeled. These are filaments of the stamens grouped in threes on each side; the two outer ones of each group are widened into frills on the outer edge, while the central one is stiffer and narrower. At the mouth of the pitchers all these filaments unite in a tube around the style; near the stigma they split apart into six short, white, threadlike filaments, each bearing a small, brilliant yellow anther. So close together are these anthers that they are completely covered by the spoon-bowls made by the inner petals, the pollen mass being flat and disc-like. During the period when the pollen is produced, the stigma is flat and immature; but after the pollen is shed, it becomes rounded into lobes ready to receive pollen from other flowers.

Although the description of the plant of this flower is most complex and elaborate, the workings of the flower are most



1, Flower of bleeding heart with swing door ajar. 2, Side view of flower showing the broad tips of the inner petals. 3, Flower with outer petals removed showing inner petals — and the heart-shaped bases of the stamens

simple. As the nectar pitchers hang mouth down, the bee must cling to the flower while probing upward. In doing this she invariably pushes against the outside of the spoon-bowls, and the hinge at their base allows her to push them back while the mass of pollen is thrust against her body; as this hinge works both ways, she receives the pollen first on one side and then on the other, as she probes the nectar pitchers. And perhaps the next flower she visits may have shed its pollen, and the swing door will uncover the ripe stigma ready to receive the pollen she brings.

The sepals are two little scales opposite the bases of the outer petals. Before the flower opens, the spouts of the nectar pitchers are clamped up on either side of the spoon-bowls; at first they simply spread apart, but later they curve backward. The seed pod is long and narrow, and in cross section is seen to contain two compartments with seeds growing on every side of the partition.

The bleeding heart is a native of China, and was introduced into Europe about the middle of the last century.

LESSON 153

The Bleeding Heart

Leading Thought — The bleeding heart flower has its pollen and stigma covered by a double swing door, which the bees push back and forth when they gather the nectar.

METHOD — Bring a bouquet of the bleeding heart to the schoolroom, and let each pupil have a stem with its flowers in all stages. From this study, encourage them to watch these flowers when the insects are visiting them.

OBSERVATIONS — 1. How are these flowers supported? Do they open upward or downward? Can you see the tiny sepals?

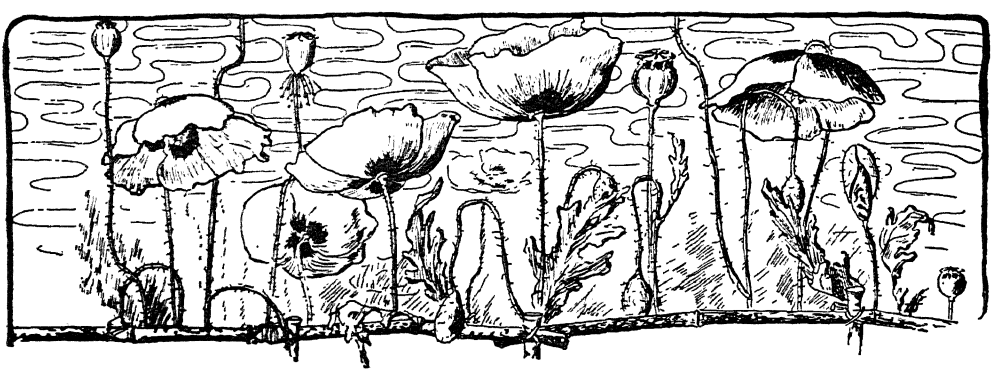
2. How many petals can you see in this flower? What is the shape of the two outer petals? How do they open? Where is the nectar developed in these petals?

3. Take off the two outer petals and study the two inner ones. What is their shape near the base? How are their parts which project beyond the outer petals shaped? What does the spoon-end of these petals cover? Can you find the hinge in these petals?

4. Where are the stamens? How many are there? Describe the shape of the stamens near the base. How are they united at the tip?

5. Where is the stigma? The style? The ovary?

6. Supposing a bee is after the nectar, where must she rest while probing for it? Can she get the nectar without pushing against the flat projecting portion of the inner petals? When she pushes these spoon-bowls back, what happens? Does she get dusted with pollen? After she leaves, does the door swing back? Suppose she visits another flower which has shed its pollen, will she carry pollen to its stigma? Does she have to work the hinged door to do this?



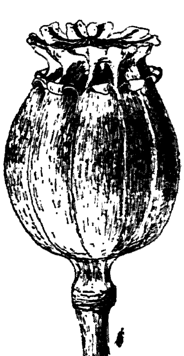
THE POPPIES

Perhaps we might expect that a plant which gives strange dreams to those who eat of its juices should not be what it seems in appearance. I know of nothing so deceptive as the appearance of the poppy buds, which, rough and hairy, droop so naturally that it seems as if their weight must compel the stem to bend; and yet, if we test it, we find the stem is as stiff as if made of steel wire. Moreover, the flower and the ripened seed capsule must be far heavier than the bud; and yet, as soon as the flower is ready to open, the stem straightens up, although it does not always remove the traces of the crook; and after the capsule is full of ripened seed, the stem holds it up particularly stiffly, as if inviting the wind to shake out the seeds.

The rough covering of the bud consists of two sepals, as can be easily seen; but if we wish to see the poppy shed its sepals, we must get up in the morning, for the deed is usually done as soon as the first rays of the early sun bring their message of a fair day. The sepals break off at their base and fall to the ground. The two opposite outer petals unfold, leaving the two inner petals standing erect, until the sunshine folds them back. An open poppy, when looked at below, shows two petals, each semicircular, and overlapping each other slightly; looked at from above, we see two petals, also half circles, set at right angles to the lower two, and divided from each other by the pistil.

The pistil of the poppy is, from the beginning, a fascinating box. At first, it is a vase with a circular cover, upon which are ridges, placed like the spokes of a wheel. If these ridges are looked at with a lens, particles of pollen may be seen adhering to them; this fact reveals the secret that each ridge is a stigma, and all of these radiating stigmas are joined so as better to catch the pollen. In a circle of fringe about the pistil are the stamens. In the study of the stamens, we should note whether their filaments expand or dilate near the anthers, and we should also note the color of the masses of pollen which crowd out from the anthers.

Despite the many varieties of poppies, there are only four species commonly cultivated. The opium poppy has upon its foliage a white bloom, the filaments of its stamens are dilated at the top, and its seed capsule is smooth. The Oriental poppy has all of these characteristics, except that its foliage is green and not covered with bloom. Its blossom is scarlet and very



Anna C. Stryke

The poppy seed-shaker

large, and has a purple center in the petals and purple stamens; it has three sepals. Its flowerstalks are stout and leafy. The corn poppy, which grows in the fields of Eu-

F. A. Southard, Jr.

Oriental poppies, showing buds and blossom

rope, is a weed we gladly cultivate. This naturally has red petals and is dark at the center of the flower; but it has been changed by breeding until now we have many varieties. Its foliage is finely cut and very bristly or hairy. Its seed capsule is not bristly. To see this poppy at its best, we should visit northern Italy or southern France in late May, where it makes the grain fields gorgeous. This is the original parent of all the Shirley poppies. The Arctic, or Iceland poppy, has flowers of satiny texture and finely crumpled; its colors are yellow, orange, or white, but never scarlet like the corn poppy; it has no leaves on its flower stem, and its seed capsule is hairy. Of these four species, the opium poppy and the corn poppy are annuals, while the Arctic and the Oriental species are perennials.

The bees are overfond of the poppy pollen and it is a delight to watch the fervor with which they simply wallow in it, brushing off all of the grains possible onto their hairy bodies. I have often seen a honeybee seize a bunch of the anthers and rub them against the underside of her body, meanwhile standing on her head in an attitude of delirious joy. As an indication of the honeybee's eye for color, I have several times seen a bee drop to the ground to examine a red petal which had fallen. This was evidence that she trusted, at least in part, to the color to guide her to the pollen.

But perhaps it is the development of the poppy seed capsule which we find the most interesting of the poppy performances. After fertilization, the stigma disc develops a scalloped edge, a stigma rounding out the point of each scallop; and a sharp ridge, which continues the length of the globular capsule, runs from the center of each scallop. If examined on the inside, it will be seen that the ridge on the capsule is the edge of a partition which extends only part way toward the center of the capsule. On these partitions, the little seeds are grown in great profusion, and when they ripen, they fall together in the hollow center of the seed box. But how are they to get out? This is a point of interest for the children to observe, and they should watch the whole process. Just beneath the stigma disc, and between each two of the sharp ridges, the point loosens; later, it turns outward and back, leaving a hole which leads directly into the central hollow portion of the capsule. The way these points open is as pretty a story as I know in flower history. This beautiful globular capsule, with its graceful pedestal where it joins the stem, is a seed-shaker instead of a salt- or pepper-shaker. Passing people and animals push against it and the stiff stem bends and then springs back, sending a little shower of seeds this way and that; or a wind sways the stalk, and the seeds are sown, a few at a time, and in different conditions of season and weather. Thus, although the poppy puts all her eggs in one basket, she sends them to market a few at a time. The poppy seed is a pretty object, as seen through the lens. It is shaped like a round bean, and is covered with a honeycomb network.

LESSON 154

The Poppies

Leading Thought — The poppies shed their sepals when the flowers expand; they offer quantities of pollen to the bees, which are very fond of it. The seed capsule develops holes around the top, through which the seeds are shaken, a few at a time.

Method — It is best to study these flowers in the garden, but the lesson may be given if some of the plants with the buds are brought to the schoolroom, care being taken that they do not droop.

Observations — 1. Look at the bud of the poppy. How is it covered? How many sepals? Can you see where they unite? Is the stem bent because the bud is heavy? What happens to this crook in the stem when the flower opens? Does the crook always straighten out completely?

2. Describe how the poppy sheds its sepals. At what time of day do the poppies usually open?

3. Look at the back of, or beneath, an open flower. How many petals do you see? How are they arranged? Look at the base of the flower. How many petals do you see? How are they arranged in relation to the lower petals and to the pistil?

4. Look at the globular pistil. Describe the disc which covers it. How many ridges on this disc? How are they arranged? Look at the ridges with a lens and tell what they are.

5. Look at the stamens. How are they arranged? Describe the anthers — their color, and the color of the pollen. Watch the bees working on the poppies, and note if they are after nectar or pollen.

6. Find all the varieties of poppies possible, and note the colors of the petals on the outside, the inside, and at the base; of the stamens, including filaments, anthers, and pollen; of the pistil disc and ovary. Sketch the poppy opened, and also in the bud. Sketch a petal, a stamen, and the pistil, in separate studies.

7. Study the poppy seed box as it ripens. How does the stigma disc look? What is the shape of the capsule below the disc? Is it ridged? What relation do its ridges bear to the stigma ridges on the disc? Cut a capsule open, and note what these ridges on the outside have to do with the partitions inside. Where are the seeds borne?

8. Note the development of the holes

beneath the edge of the disc of the poppy capsule. How are they made? What are they for? How are the seeds shaken from these holes? What shakes the poppy seed box and helps sow the seeds? Look at a seed through a lens, and describe its form and decoration.

9. Notice the form of the poppy leaf, and note whether it is hairy or covered with bloom. What is there peculiar about the smell of the poppy plant? Where do poppies grow wild?

10. Is the slender stem smooth, or grooved and hairy? Is it solid or hollow?

11. When a stem or leaf is pierced or broken off, what is the color of the juice which exudes? Does this juice taste sweet, or bitter and unpleasant?

THE CALIFORNIA POPPY

Although this brilliant flower blossoms cheerfully for us in our Eastern gardens, we can never understand its beauty until we see it glowing in masses on the California foothills. We can easily understand why it was selected as the flower of that great state, since it burnished with gold the hills, above the gold buried below; and in that land that prides itself upon its sunshine, these poppies seem to shine up as the sun shines down. The literature of California, and it has a noble literature of its own, is rich in tributes to this favored flower. There is a peculiar beauty in the contrast between the shining flower and its pale blue-green, delicate masses of foliage. Although it is called a poppy and belongs to the poppy family, yet it is not a true poppy, but belongs to a genus named after a German who visited California early in the nineteenth century, accompanying a Russian scientific expedition; this German's name was Eschscholtz, and he, like all visitors, fell in love with this brilliant flower, and in his honor it was named *Eschscholtzia* (es-sholts-ia) *californica*. This is not nearly so pretty or so descriptive as the name given to this poppy by the Spanish settlers on the Pacific Coast, for they called it Copa-de-oro, cups of gold.

California poppies

The bud of the *Eschscholtzia* is a pretty thing; it stands erect on the slender, rather long stem, which flares near the bud to an urnlike pedestal with a slightly ruffled rim, on which the bud is set. This rim is often pink above, and remains as a pretty base for the seed pod. But in some garden varieties, the rim is lacking. The bud itself is covered with a peaked cap, like a Brownie's toboggan cap stuffed full to the tip. It is the shape of an old-fashioned candle extinguisher; it is pale green, somewhat ribbed, and has a rosy tip; it consists of two sepals, which have been sewed together by Mother Nature so skillfully that we cannot see the seams. One of the most interesting performances to watch that I know is the way this poppy takes off its cap before it bows to the world. Like magic the cap loosens around the base; it is then pushed off by the swelling, expanding petals until completely loosened, and finally it drops.

The petals are folded under the cap in

an interesting manner. The outer petal enfolds all the others as closely as it can, and its mate within it enfolds the other two, and the inner two enfold the stamens

Anna C. Stryke

California poppies

with their precious gold dust. When only partially opened, the petals cling protectingly about the many long stamens; but when completely opened, the four petals flare wide, making a flower with a golden rim and an orange center, although among our cultivated varieties they range from orange to an anæmic white. To one who loves them in their glorious native hues, the white varieties seem almost repulsive. Compare one of these small, pale flowers with the great, rich, orange ones that glorify some favored regions in the Mojave Desert, and we feel the enervating and decadent influence of civilization.

The anthers are many and long, and are likely to have a black dot on the short filament; at first, the anthers stand in a close cluster at the center of the flower, but later they flare out in a many-pointed star. Often, when the flowers first open, especially the earlier ones, the stigmas cannot be seen at all; but after a time the three, or even six stigmas, spread wide athwart the flower and above the stamen-star, where they may receive pollen from the visiting insects. The anthers give abundance of pollen, but there is said to be no nectary present. This flower is a good guardian of its pollen, for it closes during the nights and also on dark and rainy days, only exposing its riches when the sunshine insures insect visitors. In our Eastern gardens it closes its petals in the same order in which they were opened, although there are statements that in California each petal folds singly around its own quota of anthers. The insects in California take advantage of the closing petals and often get a night's lodging within them, where they are cozily housed with plenty of pollen for supper and breakfast; and they pay their bill in a strange way by carrying off as much of the golden meal as adheres to them, just as the man who weighs gold dust gets his pay from what adheres to the pan of his scales.

After the petals fall, the little pod is very small, but its growth is as astonishing as that of Jack's beanstalk; it finally attains a slim length of three inches, and often more. It is grooved, the groove running straight from its rimmed base to its rosy tip; but later a strange twisting takes place. If we open one of these capsules lengthwise, we must admire the orderly way in which the little green seeds are fastened by delicate white threads, in two crowded rows, the whole length of the pod.

The leaf is delicately cut and makes the foliage a fine mass, but each leaf is quite regular in its form. It has a long, flattened petiole, which broadens and clasps the stem somewhat at its base. Its blade has five main divisions, each of which is deeply cut into finger-like lobes. The color of this foliage and its form show adaptations to desert conditions.

This plant has a long, smooth taproot,

especially adapted for storing food and moisture needed during the long, dry California summers; for it is perennial in its native state, although in the wintry East, we plant it as an annual.

LESSON 155

The California Poppy

Leading Thought — The California poppy is a native of California; there it blossoms during the months of February, March, and April in greatest abundance. It is found in the desert as well as among the foothills.

Method — If possible, the students should study this flower in the garden. In the East, it flowers until frost comes, and affords a delightful subject for a September lesson. In California it should be studied in the spring, when the hills are covered with it. But the plant may be brought into the schoolroom, root and all, and placed in a jar, under which conditions it will continue to blossom.

Observations — 1. Look at the California poppy as a whole and tell, if you can, why it is so beautiful when in blossom.

2. Look at the flower bud. What sort of stalk has it? What is the shape of the stalk just below the bud? What is the color of the little rim on which the bud rests? What peculiarity has this bud? Describe the little cap.

3. Watch a flower unfold. What happens to the "toboggan cap"? How does the bud look after the cap is gone? What is its appearance when the petals first open? When they are completely open?

4. Describe the anthers. How do they stand when the flower first opens? How later? Can you see the stigmas at first? Describe them as they look later.

5. Does the poppy remain open at night? Does it remain open during cloudy or rainy weather?

6. Do the petals have the same position that they did in the bud? As the flower matures, note how each petal curls. Do they all fall at once? Are there any anthers left after the petals fall?

7. How does the little pod look when the petals first fall? What happens to it later? Note the little rim at its base. Cut the seed pod open lengthwise, examine the seeds with a lens, and describe how they are fastened to the sides of the pod. Are the ribs straight from end to end in the pod at first? Do they remain in this position? How does the pod open and scatter its seeds?

8. Study the leaf of this California poppy. Describe how it joins the stem. Sketch a leaf showing its chief divisions into leaflets and how each leaflet is divided. Note that the juice of the stem has the peculiar odor of muriatic acid.

9. Look at the root. Do you think it is fitted to sustain the plant through a long, dry summer? What kind of summers do they have in California? Where does the poppy grow wild?

10. Read all the accounts you can find of the California poppy, and write a story describing why it was chosen as the flower of that great state, and how it came by its name.

In a low brown meadow on a day
Down by the autumn sea,
I saw a flash of sudden light
In a sweep of lonely gray;
As if a star in a clouded night
One moment had looked on me
And then withdrawn; as if the spring
Had sent an oriole back to sing
A silent song in color, where
Other silence was too bad to bear.

I found it and left it in its place,
The sun-born flower in cloth of gold
That April owns, but cannot hold
From spending its glory and its grace
On months that always love it less,
But take its splendid alms in their distress.
Back I went through the gray and the brown,
Through the weed-woven trail to the distant town;
The flower went with me, fairly wrought
Into the finest fiber of my thought.

— "A California Poppy in November,"
Irene Hardy

THE NASTURTIUM

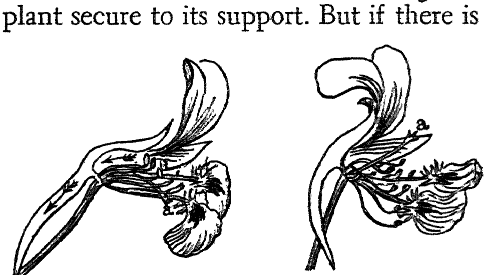
It is quite fitting that the nasturtium leaves should be shaped like shields, for that is one of their uses; they are shields which protect the young nasturtium seeds from the hot sun and from the view of devouring enemies. The nasturtiums are natives of Peru and Chili, and it is fitting that the leaves should develop in shield-shape, and the shields overlap until they form a tent which shades the tender developing seed from the burning sun. But they do not shield the flower, which thrusts its brilliant petals out between the shields, and calls loudly to the world to admire it. It would indeed be a pity for such a remarkable flower to remain hidden; its five sepals are united at their base, and the posterior one is extended into a long spur, a tube with a delectable nectar-well at its tip. The five petals are set around the mouth of this tube, the two upper ones differing in appearance and office from those below; these two stand up like a pair of fans, and on them are lines which converge; on the upper sepals are similar lines pointing toward the same interesting spot. And what do all these lines lead to, except a veritable treasure-cave filled with nectar! The lower petals tell another story; they stand out, making a platform or doorstep, on which the visiting bee alights. But it requires a big insect to pollinate this flower, and what if some inefficient little bee or fly should alight on the petal-doorstep and steal into the cave surreptitiously? This contingency is guarded against thus: each of these lower petals narrows to a mere insect foot-bridge at their inner end; and this foot-bridge is quite impassable, because it is beset with irregular little spikes and projecting fringes, sufficient to perplex or discourage any small insect from crawling that way.

W. Atlee Burpee Co.

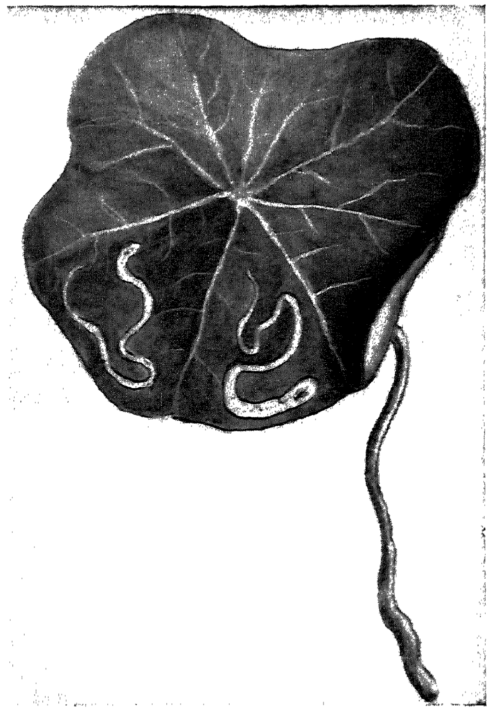
Single nasturtium

But why all these guiding lines and guarded bridges? If you watch the same blossom for several successive days, it will reveal this secret. When a flower first opens, the stamens are all bent downward, but when an anther is ready to open its pollen doors, the filament lifts it up and places it like a sentinel blocking the doorway to the nectar treasure. Then when the robber comes, whether it be butterfly, bee, or hummingbird, it gets a round of pollen ammunition for its daring. Perhaps there may be two or three anthers standing guard at the same time, but, as soon as their pollen is exhausted, they shrivel and give room for fresh anthers. Meanwhile, the stigma has its three lobes closed and lying idly behind and below the anthers; after all the pollen is shed, the style rises and takes its position at the cave entrance and opens up its stigmas, like a three-tined fork, to rake the pollen from any visiting insect, thus robbing the robber of precious gold dust which shall fertilize the seeds in its three-lobed ovary. Although the flower flares its colors wide, thus attracting the bees and hummingbirds, yet the growing seeds are protected. The stalk which held the flower up straight now twists around in a spiral and draws the triplet seeds down behind the green shields.

Nasturtium leaves are very pretty, and are often used as subjects for decorative water-color drawings. The almost circular leaf has its stalk attached below and a little at one side of the center; the leaves are brilliant green above but quite pale beneath, and are silvery when placed beneath the water. The succulent stems have a way of twisting half around the wires of the trellis and thus holding the plant secure to its support. But if there is



1, *Nasturtium flower in early stage of blossoming. Note the anthers lifted in the path to the nectar which is indicated by the arrow. The closed stigma is shown deflected at* a. 2, *The same flower in later stage; the anthers are empty and deflected. The stigma is raised* (a) *in the nectar path*



Nasturtium leaf showing the work of serpentine miners

no trellis, the main stem grows quite stocky, often lifting the plant a foot or two in height, and from its summit sending out a fountain of leaf- and flower-stalks. Some nasturtiums are dwarf and need no support.

The nasturtium is among the most interesting and beautiful of our garden flowers, and will thrive in any warm, sunny, fairly moist place. Its combinations of color are exceedingly rich and brilliant. H. H. says of it:

How carelessly it wears the velvet of the
same
Unfathomed red, which ceased when Titian ceased
To paint it in the robes of doge and priest.

LESSON 156

The Nasturtium

Leading Thought — The nasturtium has a special arrangement by which it sends its own pollen to other flowers and receives pollen from other flowers by insect messengers.

METHOD — The nasturtiums and their foliage should be brought into the schoolroom in sufficient quantity so that each child may have a leaf and a flower for study. The object of the lesson is to interest the pupils in studying, in their gardens, one flower from the bud until the petals wither, taking note of what happens each day and keeping a list of the insect visitors.

OBSERVATIONS — 1. Look at the back of the flower. What is there peculiar about the sepals? How many sepals are there? How many join to make the spur? What is in this spur? Taste of the tip. Find where the nectar is.

2. Look the flower in the face. How do the two upper petals differ in shape from the three lower ones? What markings are there on the upper petals? Where do these lines point? Are there any markings on the sepals pointing in the same direction? If an insect visiting a flower should follow these lines, where would it go?

3. Describe the shape of the lower petals. Suppose a little ant were on one of these petals and she tried to pass over to the nectar-tube or spur, would the fringes hinder her?

4. Look down the throat of the spur, and tell what a bee or other insect would have to crawl over before it could get at the nectar.

5. In your garden, or in the bouquet in the window if you cannot visit a garden, select a nasturtium that is just opening and watch it every day, making the following notes: When the blossom first opens, where are the eight stamens? Are the unripe, closed anthers lifted so as to be in the path of the bee which is gathering nectar? How do the anthers open? How is the pollen held up in the path to the nectar? Can you see the stigma of this flower? Where is it? *Note the same flower on successive days:* How many anthers are open and shedding pollen today? Are they all in the same position as yesterday? What happens to the anthers which have shed their pollen?

6. When the stigma rises in the nectar path, how does it look? Where are all the anthers when the stigma raises its three tines which rake the pollen off the visiting insect? Do you know why it is an advantage to the nasturtium to develop its seed by the aid of the pollen from another plant?

7. Can you see the beginning of the seedcase when the stigma arises to receive the pollen?

8. The flowers project beyond the leaves. Do the ripening seedcases do this? What happens to their stems to withdraw them behind the leaf?

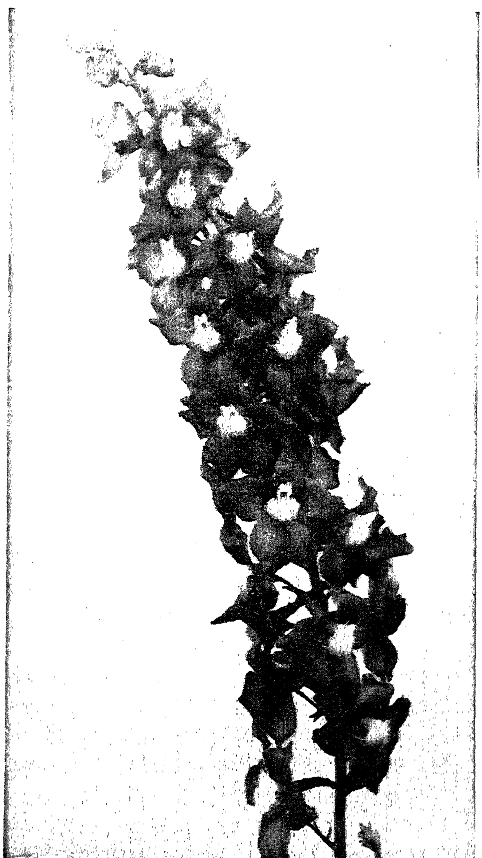
9. Sketch a nasturtium leaf, and explain in what way it is like a shield. How does the leaf look when under water?

10. What sort of stem has the nasturtium? How does it manage to climb the trellis? If it has no trellis upon which it can climb, does it lie flat upon the ground?

THE BEE-LARKSPUR

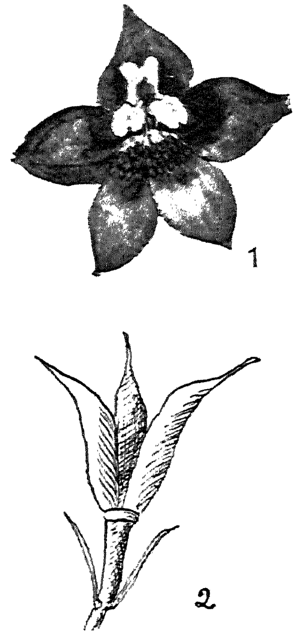
This common flower of our gardens, sending up from a mass of dark, deeply cut leaves tall racemes of purple or blue flowers, has a very interesting story to tell those who watch it day by day and get acquainted with it and its insect guests. The brilliant color of the flowers is due to the sepals, which are purple or blue, in varying shades; each has on the back side near its tip, a green thickened spot. If we glance up the flowerstalk, we can see that, in the upper buds, the sepals are green, but in the lower buds they begin to show the blue color; and in a bud just ready to open, we can see that the blue sepals are each tipped with a green knob, and this remains green after the sepals expand. The upper and rearmost sepal is prolonged into a spur, which forms the outside covering of the nectar-spur; it is greenish, and is wrinkled like a long-wristed suede glove; two sepals spread wide at the sides and two more below. All this expanse of blue sepals is a background for the petals, which, by their contrasting color, attract the bees looking for nectar. Such inconsequential petals as they are! Two of them " hold hands " to make an arch over the entrance to the nectar tube; and just below these on each side are two more tiny, fuzzy, spreading petals, often notched at the tip and always hinged in a peculiar way about the upper petal; they stand at the door to the nectar storehouse. If we peel off the wrinkled sepal-covering of the spur, we can see the upper petals extending back into it, making a somewhat double-barreled nectary.

If we look into a larkspur flower just opened, we see below the petals a bunch of green anthers, hanging by white thread-like filaments to the center of the flower and looking like a bunch of lilliputian bananas. Behind these anthers is an undeveloped stigma, not visible as yet. After the flower has been open for a short time, three or four of the anthers rise up and stand within the lower petals; while in this position, their white pollen bursts from them, and no bee may then thrust her tongue into the nectar-spur without being powdered with pollen. As soon as the anthers have discharged their pollen, they shrivel, and their places are taken by fresh ones. It may require two or three days for all the anthers to lift up and get rid of their pollen. After this has been accomplished, the three white, closely adhering pistils lift up their three stigmas into the path to the nectar; and now they are ready to receive the pollen which the blundering bee brings from other flowers. Since we cannot always study the same flower for several consecutive days, we can read the whole story by studying the flowers freshly opened on the upper por-



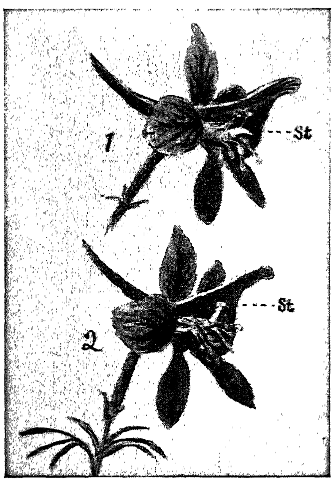
Cyrus Crosby

Bee-larkspur



1, *Drawing of the bee-larkspur flower enlarged.* 2, *The seed capsule of the bee-larkspur* tion of the stalk, and those below them that are in more advanced stages.

The bees, especially the bumblebee, will tell the pollination story to us in the garden. A visiting bee alights on the lower petals; grasping these firmly she thrusts her head into the opening between them and probes the spur twice, once in each nectar-well. It is a fascinating pastime to follow the bee as it goes from flower to flower like a Madam Pompadour, powdered with white pollen. The tips of the tall flower-



The larkspur

1, Early stage with stigma deflected. 2, Advanced stage with stigma raised

stalks are likely to bend or curl over; but no matter what the direction the broken or bent stem takes, the flowers will twist around on their pedicels until they face the world and the bee, exactly as if they were on a normally erect stem.

All the larkspurs have essentially the same pollen story, although some have only two petals; in every case the anthers at first hang down, and later rise up in the path to the nectar. Thus they discharge their pollen; after they wither, the stigmas arise in a similar position.

The bee-larkspur has a very beautiful fruit. It consists of three graceful capsules rising from the same base and flaring out into pointed tips. The seeds are fastened to the curved side of each capsule, which, when ripe, opens; and then they may be shaken out by the winds. When studying the bud, we notice two little bracts set at its base and these remain with the fruit.

LESSON 157

The Bee-Larkspur

Leading Thought — The bee-larkspur begins blossoming early in the season, the blossom stalk elongating and developing new buds at its tip until late in autumn. The flower has a very interesting way of inducing the bees to carry its pollen.

Method — Bring to the schoolroom a flowerstalk of the bee-larkspur, and there study the structure and mechanism of the flower. This lesson should inspire the pupils to observe for themselves the visiting bees and the maturing seeds. Ask them to write an account of a bumblebee making morning calls on the larkspurs.

Observations — 1. Which flowers of the larkspur open first — those near the tip of the stem or those below?

2. Examine the buds toward the tip of the flowerstalk. What color are the sepals in these buds? Do the sepals change color as the flower opens? Note the little green knobs which tip the closed sepals that clasp the bud. What color are the sepals on the open flower? Is there any green upon them when open?

3. Where is the nectar-spur? Which sepal forms this? How are the other sepals arranged?

4. Now that we know the flower gets its brilliant color from its sepals, let us find the petals. Look straight into the flower, and note what forms the contrasting color of the heart of the flower; these are the petals. Can you see that two are joined above the opening into the nectar-tube? How many are at the lower part of the entrance? How are these lower petals hinged about the upper one? Peel a sepal-cover from the nectar-spur, and see if the upper petals extend back within the spur, forming nectar-tubes.

5. Take a flower just opened, and describe what you see below the petals. What is the color of the anthers? Of the filaments? Can you see the stigma?

6. Take a flower farther down the stalk, which has therefore been open longer, and describe the position of the anthers in this. Are any of them standing upright? Are they discharging their pollen? What color is the pollen? Are these upright anthers in the way of the bee when she thrusts her tongue into the nectar-tube?

7. Take the oldest flower you can find. What has happened to the anthers? Can you see the pistils in this flower? In what position now are the stigmas?

8. Push aside the anthers in a freshly opened flower and see if you can find the stigmas. What is their position? How do they change in form and position after the pollen is shed? Do they arise in the path of the bee before all the pollen from the anthers of their own flower is shed?

9. Suggestions for Observation in the Garden — Watch a bumblebee working on the larkspur and answer the following questions: How does she hold on to the flower? Where does she thrust her tongue? Can she get the nectar without brushing the pollen from the anthers which are lifting up at the opening of the nectar-tube? In probing the older flowers, how would she come in contact with the lifted stigmas? How do the petals contrast in color with the sepals? Compare the common larkspur with the bee-larkspur, and notice the likeness and difference. What kind of fruit capsules has the bee-larkspur? Describe the seeds, and how they are scattered.

THE BLUE FLAG OR IRIS

Beautiful lily, dwelling by still rivers
Or solitary mere,
Or where the sluggish meadow brook delivers
Its waters to the weir!

The burnished dragon fly is thine attendant,
And tilts against the field,
And down the listed sunbeams rides resplendent
With steel-blue mail and shield.

— "Flower-de-luce," Henry W. Longfellow

The iris blossom has a strange appearance, and this is because nothing in it is what it seems. The style of the pistil is divided into three broad branches which look like petals. These, with the sepals, form a tunnel through which bees may pass. The true petals, marked with beautiful purple lines, stand between these tunnels. It has been said that such lines on flowers guide insects to the nectar-wells. This belief is open to question; for certainly these lines on the iris leading to the center of the flower do not lead to the nectar-wells. If we look directly down into the flower of the blue flag, we see ridges on the broad styles and purple veins on the petals, all leading to the center of the flower. If an insect alighting there should seek for nectar-wells at the point where all these lines meet, it would find no nectar.

Dr. Needham, in an admirable study of this flower and its visitors, tells us that he has seen the little butterflies called "skippers," the flag weevils, and other flower beetles apparently made victims of this deceptive appearance; this is some evidence that the guiding lines on flowers are noted and followed by insects.

The blue flag seems to be specially designed for bees; even the large showy blossom is, according to Sir John Lubbock, the favorite color of the bee. The bees seem to have no difficulty in finding

Leonard K. Beyer

Larger blue flag

the nectar. The sepal with its purple and yellow tip and its dark veining and golden guiding lines marks the path to the nectar, which is far from the center of the flower. The bee alights on the lip of the sepal, presses forward scraping her back against the down-hanging stigma, then scrapes along the open anther which lies along the roof of the tunnel. The tunnel leads to the nectar-wells at the very base of the sepal.

The bees which Dr. Needham found doing the greatest work as pollen carriers were small solitary bees (*Clisodon terminalis* and *Osmia destructa*); each of these alighted with precision on the lip which forms the landing-platform of each tunnel, pushed its way in, got the nectar from both wells, came out, and immediately went to another tunnel. One might ask why the bee in coming out did not deposit the pollen from the anther on the stigma of the same flower. The stigma prevents this by hanging down, like a flap to a tent, above the entrance; its surface is so directed that it gathers pollen from the entering bee and turns its blank side to the bee making an exit. This ingenious arrangement insures the cross-fertilization which Darwin has shown us is so necessary for the most vigorous and beautiful offspring.

The arrangement of the flower parts of the iris may be described briefly thus: three petals, three sepals, and a style with three branches; the latter are broad and flat and cover the bases of the three sepals, forming tubes which lead to the nectar; three anthers lie along the underside of the styles. The wild yellow iris is especially fitted for welcoming the bumblebee as a pollen-carrier, since the entrance between the style and the sepal is large enough to admit this larger insect. The bumblebees and the honeybees work in different varieties of iris in gardens.

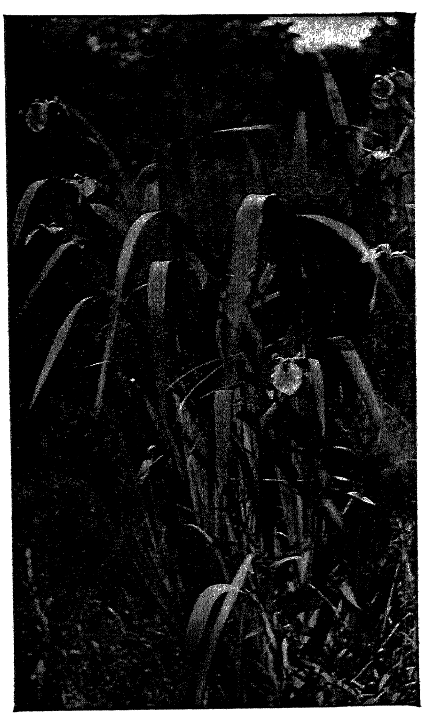
In some varieties of iris there is a coating resembling plush on the style which forms the floor of the tunnel. Through a lens this plush is exquisite — the nap of white filaments standing up tipped with brilliant yellow. Various theories as to the use of this plush have been advanced, a plausible one being that it is to keep the ants out; but the ants could easily pass along either side of it. One day in the garden while I was holding an iris in my hand, a bumblebee visited it eagerly, never noting me: after she had probed the nectar-wells, she probed or nibbled among the plush, working it thoroughly on her way out. Did she possibly find something there to eat?

LESSON 158

The Blue Flag or Iris

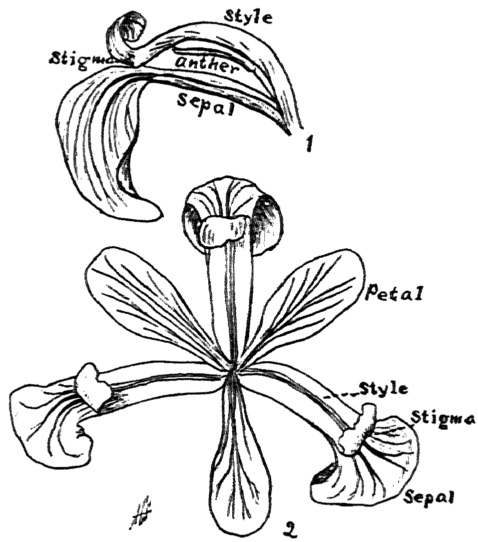
Leading Thought — Each iris flower has three side doors leading to the nectar-wells; and the bees, in order to get the nectar, must brush off the pollen dust on their backs.

Method — While the blue flag is the most interesting of our wild species of iris, yet the flower-de-luce, or the garden iris, is quite as valuable for this lesson. The form of the flowers may be studied in the schoolroom, but the pupils should watch the visiting insects in the garden or field.



Wild iris in natural surroundings

Observations — 1. Look for the side doors of the iris blossom. Which part of the flower forms the doorstep? How is it



Detail of the blossoms of the blue flag flower

1. Side view of the passage to the nectar. 2. Looking directly into the iris flowers. Note the deceiving guide-lines in the petals

marked? Which part of the flower makes the arch above the entrance?

2. Find the anther, and describe how it is placed. Can you see two nectar-wells? Explain how a bee will become dusted with pollen while getting the nectar.

3. Where is the stigma? What is there very peculiar about the styles of the iris? Can a bee, when backing out from the side door, dust the stigma with the pollen

Cyrus Crosby

Fleur-de-lis

she has just swept off? Why not? How does the stigma of the next flower that the bee visits get some of the pollen from her back?

4. Look straight down into an iris flower. Can you see the three petals? How are they marked?

5. Watch the insects visiting the iris. Do you know what they are? What do the different insects do?

6. Describe the way the iris flower bud is enfolded in bracts. What is there peculiar about the way the iris leaves join the stem?

7. How many kinds of flag, or iris, do you know?

8. Describe the seed vessel and seeds of the iris.

The fleur-de-lis is the national flower of France.

It is said that the Franks of old had a custom, at the proclamation of a king, of elevating him upon a shield or *target, and placing in his hand a reed,* or *flag in blossom, instead of a sceptre.*

— "AMONG THE FLOWERS AND TREES WITH THE POETS," WAIT AND LEONARD

THE SUNFLOWER

Anna C. Stryke

The sunflower. Next to the ray flowers are the florets in the last stages of blossoming with stigmas protruding; next within are rows in the earlier stage with pollen bursting from the anther-tubes, while at the center are unopened buds

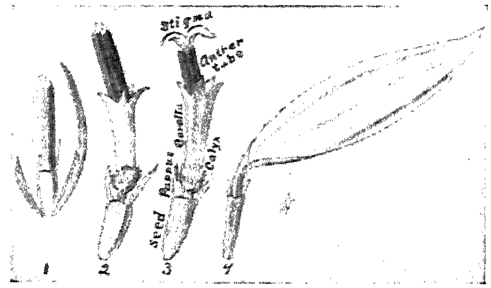
Many of the most beautiful of the autumn flowers belong to the *Compositæ*, a family of such complicated flower arrangement that it is very difficult for the child or the beginner in botany to comprehend it; and yet, when once understood, the composite scheme is very simple and beautiful, and is repeated over and over in flowers of very different appearance. It is a plan of flower cooperation; there are many flowers associated to form a single flower-head. Some of these, the "ray" or "banner" flowers, hold out bright pennants which attract insects; while the disc flowers, which they surround, attend to the matter of the pollination and production of seed.

The large garden sunflower is the teacher's ally to illustrate to the children the story of the composites. Its florets are so large that it is like a great wax model. And what could be more interesting than to watch its beautiful inflorescence — that orderly march toward the center in double lines of anther columns, with phalanxes bearing the stigmas surrounding them; and outside all, the ranks of ray flowers flaunting their flags to herald to the world this peaceful conquest of the sleeping, tented buds at the center?

Ordinarily, in nature-study we do not pull the flowers apart, as is necessary in botany; in nature-study, all that we care to know of the flower is what it does, and we can see that without dissection. But with the *compositæ* the situation is quite different. Here we have an assemblage of flowers, each individual doing its own work for the community; and in order to make the pupils understand this fact it is necessary to study the individual florets.

We begin with the study of one of

the buds at the center of the flower-head; this shows the white, immature seed below, and the closed, yellow corolla-tube above. Within the corolla may be seen the brown anther-tube, and on the upper part of the seed are two little, white, ear-like scales, to which especial notice should be directed, since in other composites there are many of these scales and they form the pappus — the balloon to carry the seed. The bud shows best the protecting chaffy scale which enfolds the seed, its pointed, spine-edged tip being folded over the young bud, as may be seen by examining carefully the center of a freshly opened sunflower. In this tubular bud (shown in figure) there is a telescopic arrangement of the organs, and one after another is pushed out. First, the corolla-tube opens, starlike, with five pointed lobes, very pretty and graceful, with a bulblike base; from this corolla pushes out the dark-brown tube, made up of five anthers grown together. By opening the corolla, we see the filaments of the stamens below the joined anthers. This anther-tube, if examined through a lens, shows rows of tiny points above and below, two to each anther, as if they had been opened like a book to join edges with their neighbors. The anther-tube is closed at the tip, making a five-sided cone; and at the seams, the yellow pollen bulges out, in starlike rays. The pollen bulges out for good reason, for behind it is the stigma, like a ramrod, pushing all before it in the tube, for it is its turn next to greet the outer world. The two stigma-lobes are pressed together like the halves of a sharpened pencil, and they protrude through the anther-tube as soon as all the pollen is safely pushed out; then the stigma-lobes separate, each curling backwards so as to offer a receptive surface to pollen grains from other florets, or even other sunflowers. In the process of curling back, they press the anther-tube down into the corolla, and thus make the floret shorter than when in the pollen stage. The ray flower differs in many essentials from the perfect florets of the disc. If we remove one from the flower-head, we



The flower of the sunflower head enlarged

1. A floret of the sunflower in the bud stage as it appears at the center of the sunflower. Note the protecting bract at the right. 2. A floret in earliest stage of blossoming. 3. A floret in the latest stage of bloom with the parts named. 4. A ray or banner flower

find at its base a seedlike portion, which is a mere pretense; it is shrunken, and never can be a seed because it has connected with it no stigma to bring to it the pollen. Nor does this flower have stamens nor a tubular corolla; instead it has one great, petal-like banner, many times longer and wider than the corollas of the other flowers. All this flower has to do is to hold its banner aloft as a sign to the world, especially the insect world, that here is to be found pollen in plenty, and nectar for the probing.

But more wonderful than the perfection of each floret is their arrangement in the flower-head. Around the edge of the disc the ray flowers, in double or treble rank, flare wide their long petals like the rays of the sun, making the sunflower a most striking object in the landscape. If the sunflower has been open for several days, next to the ray flowers will be seen a circle of star-mouthed corollas from which both ripened pollen and stigmas have disappeared, and the fertilized seeds below them are attaining their growth. Next comes a two- or three-ranked circle, where the split, coiled-back stigma-lobes protrude from the anther-tubes; within this circle may be two or three rows of florets, where pollen is being pushed out in starry radiance; and within this ring there may be a circle where the anther-tubes are still closed; while at the center lie the buds, arranged in an exquisite pattern of circling radii, cut by radii circling in the opposite direc-

Agronomy Dept. Cornell U.

A field of sunflowers

tion; and at the very center the buds are covered with the green spear-points of their bracts. I never look at the buds in the sunflower without wondering if the study of their arrangement is not the basis of much of the most exquisite decoration in Moorish architecture. To appreciate fully this procession of the bloom of the sunflower from its rim to its center, we need to watch it day by day — then only can its beauty become a part of us.

The great green bracts, with their long pointed tips, which overlap each other around the base of the sunflower head, should be noted with care, because these bracts have manifold forms in the great *Compositæ* family; and the pupil should learn to recognize this part of the flower-head, merely from its position. In the burdocks, these tracts form the hooks which fasten to the passer-by; in the thistle, they form the prickly vase about the blossom; while in the pearly everlasting, they make the beautiful, white, shell-like mass of the flower which we treasure as immortal. In the sunflower these bracts are very ornamental, being feltlike outside and very smooth inside, bordered with fringes of pretty hairs, which may be seen best through a lens. They overlap each other regularly in circular rows, and each bract is bent so as to fit around the disc.

In looking at a mass of garden sunflowers, we are convinced that the heavy heads bend the stems, and this is probably true, in a measure. But the stems are very solid and firm, and the bend is as stiff as the elbow of a stovepipe; and after examining it, we are sure that this bend is made with the connivance of the stem, rather than despite it. Probably most people, the world over, believe that sunflowers twist their stems so that their blossoms face the sun all day. This belief shows the utter contentment of most people with a pretty theory. If you believe it, you had best ask the first sunflower you see if it is true, and she will answer you if you will ask the question morning, noon, and night. My own observations make me believe that the sunflower, during the later weeks of its bloom, is like the Mohammedan, keeping its face toward the east. True, I have found many exceptions to this rule, although I have seen whole fields of sunflowers facing eastward, when the setting sun was gilding the backs of their great heads. If they do turn with the sun, it must be in the period of earliest blossoming before they become heavy with ripening seeds.

The sunflower seed is eagerly sought by many birds, and it is raised extensively for chicken-feed. The inadequate little pappus falls off, and the seeds are set, large end up, in the very ornamental diamond-shaped sockets. They finally become loosened, and as the great stem is assaulted by the winds of autumn, the bended heads shake out their seed and scatter them far afield.

LESSON 159

The Sunflower

Leading Thought — The sunflower is not a single flower, but is a large number of flowers living together; and each little flower, or floret, as it is called, has its own work to do.

Method — Early in September, when school first opens, is the time for this lesson. If sunflowers are growing near by, they should be studied where they stand;

and their story may thus be more completely told. Otherwise, a sunflower should be brought to the schoolroom and placed in water. If one is selected which has just begun to blossom, it will show, day by day, the advance of the blossoming ranks. I have kept such a flower fourteen days, and it blossomed cheerfully from its rim to its very center. A large sunflower that has only partially blossomed is also needed for taking apart to show the arrangement of this big flower-cluster. Take a bud from the center, a floret showing anther-tube and another showing the curled pair of stigmas, and a ray or banner flower. (See Fig. p. 575.) Each pupil should be furnished with these four florets; and after he has studied them, show him the other half of the sunflower, with each floret in place. After this preliminary study, let the pupils observe the blossoming sunflower for several consecutive days.

Observations — 1. A little flower which is part of a big flower-cluster is called a floret. You have before you three florets of a sunflower and a ray floret. Study first the bud. Of how many parts is it composed? What will the lower, white part develop into? Can you see two little white points standing up from it on each side of the bud? Note the shape and color of the unopened floret. Note that there is a narrow, stiff, leaflike bract, which at its base clasps the young seed, while its pointed tip bends protectingly over the top of the bud.

2. Take an open floret with the long, dark brown tube projecting from it. Note that the young seed is somewhat larger than in the bud, and that it still has its earlike projections at the top. Describe the shape of the open corolla. Look at the brown tube with a lens. How many sides has it? How many little points projecting at the top and bottom on each side of the tube? How does the tube look at the tip, through a lens? Can you see the pollen bursting out? If so, how does it look? Do you think that there is just one tubular anther, or do you think several anthers are joined together to make this tube? Open the corolla-tube carefully, and see if you can answer this last question. Open the anther-tube, and see if you can find the pistil with its stigmas.

3. Take a floret with the two yellow horns of the stigma projecting. Where is the brown anther-tube now? Is it as long as in the floret you have just studied? What has happened to it? What did the stigmas do to the pollen in the anther-tube? How do the two parts or lobes of the stigma look when they first project? How later?

4. Take a ray flower. How many parts are there to it? How does the seedlike portion of the blossom look? Do you think it will ever be a good seed? Describe the corolla of this flower. How much larger is it than the corolla of the florets? Has the ray flower any pistil or stamens? Of what use is the ray flower to the sunflower cluster? Do you think that we would plant sunflowers in our gardens for their beauty if they had no ray flowers?

5. After studying the separate flowers, study a sunflower in blossom, and note the following: Where are the ray flowers placed? How many rows are there? How are they set so that their rays make the sunflower look like the sun? Do you see why the central portion of the sunflower is called the disc, and the outer flowers are called the rays — in imitation of the sun?

6. Next to the ray flowers, what sort of florets appear? How many rows are there? What kind form the next circle, and in how many rows? What stages of the florets do you find forming the inner circle, and how many rows? What do you find at the center of the flower-head? Note the beautiful pattern in which the buds are arranged. Can you see the separate buds at the very center of the sunflower? If not, why?

7. Make notes on a sunflower that has just opened, describing the stages of the florets that are in blossom; continue these notes every day for a week, describing each day what has happened. If the sunflower you are observing is in garden or field, note how many days elapse between

the opening of the outer row of flowers and the opening of the central buds.

8. Look below or behind the sunflower, and note the way it is attached to the stem. What covers the disc? These green, overlapping, leaflike structures are called bracts. What is the shape of one of these bracts? What is its texture, outside and inside? Look at it with a lens, along the edges, and note what you see. How are the bracts arranged? Do they not "shingle" the house of the sunflower cluster? This covering of the disc, or the house of the sunflower cluster, is called the involucre.

9. Does the stem of the sunflower hold it upright? Some people declare that it twists its stem so as to face the sun all day. Do you think this is true?

10. Study a sunflower head after the seeds are ripe. Do the little ears which you saw at the top of the seeds still remain? How does the sunflower scatter the seeds? Note how the disc looks after the seeds are all gone. What birds are especially fond of sunflower seeds? Of what use are the seeds commercially?

Flowers have an expression of countenance as much as men or animals. Some seem to smile; some have a sad expression; some are pensive and diffident; others again are plain, honest, and upright, like the broad-faced Sunflower, and the hollyhock.

— Henry Ward Beecher

Eagle of flowers! I see thee stand,
And on the sun's noon-glory gaze;
With eye like his thy lids expand
And fringe their disk with golden rays;
Though fixed on earth, in darkness rooted there,
Light is thy element, thy dwelling air,
Thy prospect heaven.

— "The Sunflower," Montgomery

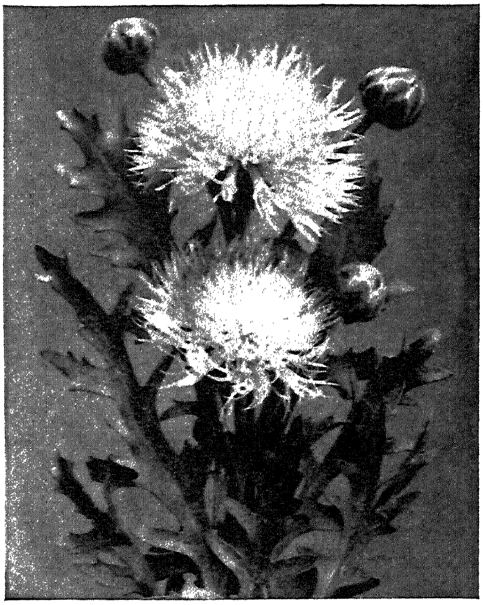
THE BACHELOR'S-BUTTON


Stumpp and Walter Co.
Bachelor's-button

This beautiful garden flower gives a variation in form from other composites when studied according to Lesson 131. This valued flower came to us from Europe and it sometimes escapes cultivation and runs wild in a gentle way. We call it bachelor's-button; but in Europe it is called the cornflower, and under this name it found its way into literature. None of the flowers that live in clusters repays close study better than does the bachelor's-button. The flowers are all tubular, but they do not have banners. Their tubes flare open like trumpets, and they are indeed color trumpets heralding to the insect world that there is nectar for the probing and pollen for exchange. Looked at from above, the marginal flowers do not seem tubular; from the sides, they show as uneven-mouthed trumpets with lobed edges; but though we search each trumpet to its slender depths we can find no pistils. These marginal flowers have no duty in the way of maturing seeds.

In some varieties the marginal flowers are white, and in others they are blue, pink, or purple. They vary in number from seven to fourteen or more.

The disc flowers have a long corolla-tube, which is white and delicately lobed and is enlarged toward the upper end to a purple bulb with five long slender lobes. The anther-tube is purplish black, and is bent into almost a hook, the tip opening toward the middle of the flower-head. The pollen is glistening white tinged with yellow, and looks very pretty as it bursts out from the dark tubes. The purple stigma first appears with its tips close together, but with a pollen brush just below it; later it opens into a short Y. The buds at the center of the flower are bent hook-shaped over the center of the flower-head. The involucral bracts or "shingles" are very pretty, each one ornamented with a scaly fringe; they form a long, elegantly shaped base to the flower-head. After the flowers have gone and the seeds, which are really akenes, have ripened, these bracts flare open, making a wide-mouthed urn from which the ripened seeds are shaken by the winds; and after the seeds are gone, the white fuzz of their empty cases remains at the bottom of the urn. The seed is plump and shining, with a short fringe of pappus around the top and a contracted place at one side near the base where it grew fast to the receptacle; for these seeds are not set on end, as are those of the sunflower. The short pappus is hardly sufficient to buoy up the seed, and yet undoubtedly aids it to make a flying jump with the passing breeze.



Stumpp and Walter Co.

Sweet sultan. This flower comes in many shades

LESSON 160

The Bachelor's-Button

Leading Thought — Each bachelor's-button is made up of many little flowers, which may be studied by the outline given in Lesson 131.

THE SALVIA OR SCARLET SAGE

The flower story of the sage is so peculiar that Darwin has used it to illustrate the mechanisms which the visiting insects must work in some flowers in order to get the nectar. The scarlet sage, which gladdens our flower-beds during the summer and autumn with its brilliance, has as interesting a story as has any of its family. Looking at it from the outside, we should say that its nectar-wells lie too deep to be reached by any creature except a moth or butterfly, or a humming-bird; there is no platform for a bee to alight upon, and the tube is too long to be fathomed by a bee's tongue; but the bees are very good business folk; they adapt themselves to flowers of various types, and in autumn the glow of the salvia attracts the eye scarcely more than the hum of the visiting bees attracts the ear.

The calyx of the salvia is as red as the corolla, and is somewhat fuzzy while the corolla is smooth. The calyx is a three-lobed bulging tube held stiff by rather strong veins; there is one large lobe above

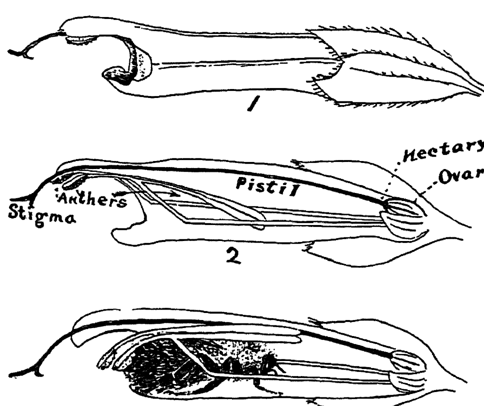
The salvia or scarlet sage, showing the bracts still present above and falling as the flowers open

and two small ōnes below the corolla. The corolla is a tube which is more than twice the length of the calyx; it is prolonged above into a projecting hood, which holds the anthers and the stigma; it has a short, cuplike lower lip and two little turned-back, earlike lobes at the side.

The special mechanism of the salvia is shown in the stamens; there are two of these lying flat along the floor of the corolla-tube and grown fast to it. Near the mouth of the tube, each of these lifts up at a broad angle to the roof, and is more or less T-shaped; at the tip of one of the arms of the T is an anther while the other arm is longer and slants down and inward to the floor of the tube, as shown at 2 in the figure.

The bee visiting the flower and entering the corolla-tube pushes her head against the inner arms of the stamens, lifting them, and in so doing causes the anthers on the front arms of the T to lower and leave streaks of pollen along her fuzzy sides. The stigma is at first concealed in the hood; but, when ripe, it projects and hangs down in front of the opening of the corolla-tube, where it may be brushed along one side or the other by the visiting insect, which has been dusted with the pollen of some other flower. The stigma lobes open in such a manner that they do not catch the pollen from the insect backing out of their own corolla. As the nectar is at the base of the corolla-tube, the bees, in order to get it, crawl in almost out of sight. Late in the season they seem to " go crazy " when gathering this nectar; I have often seen them searching the bases of the corolla-tubes which have fallen to the ground, in order to get what is left of the sweet treasure.

But the pollen story is not all that is of interest in the salvia. Some of the parts of the flower which are green in most blossoms are scarlet as a cardinal's robe



1, *Blossom of scarlet sage as seen from outside.* 2, *The same flower with side removed showing the arrangement of its parts.* 3, *A bee working the stamen's mechanism as she seeks the nectar* in this. If we glance at a flowerstalk, we see that at its tip it looks like a braided, flattened cone; this appearance is caused by the scarlet, long-pointed bracts, each of which covers with its bulging base the scarlet calyx, which in turn enfolds the scarlet flower bud. These bracts fall as the flowers are ready to open, making a brilliant carpet about the plant. Each flowerstalk continues to develop buds at its tip for a long season; and this, taken together with its scarlet bracts and flowers, renders the salvia a thing of beauty in our gardens, and makes it cry aloud to pollen-carriers that here, even in late autumn, there is plenty of nectar.

LESSON 161

Salvia or Scarlet Sage

Leading Thought — This flower has the bracts and calyx scarlet instead of green, and this makes it a brilliant mass of color which pleases our eyes and attracts the pollen-carrying insects. Its anthers are placed at the tip of two levers, which the insects push up and down as they enter the flower, thus becoming dusted with pollen.

Method — The structure of this flower may be studied in the schoolroom and its mechanism there understood; but the most important part of the lesson is the observation out-of-doors upon the way the bees work the stamen levers when seeking the nectar. This is best observed during late September or October, after other flowers are mostly gone, and when the bees are working with frantic haste to get all the honey possible.

Observations — 1. How does the calyx of the salvia differ from that of other flowers in color? How does it differ from the corolla in texture? How many lobes has it? How are they placed about the corolla?

2. What is the shape of the corolla? How does it make a hood over the entrance to the tube? What does the hood hold? Is there any platform made by the lower lip of the corolla for a visiting insect to alight upon?

3. Cut open one side of the corolla and describe how the stamens are arranged. Thrust your pencil into an uninjured flower and see if the anthers in the hood are moved by it. How? Describe how a bee in visiting this flower moves the anthers and becomes dusted with pollen.

4. Where is the stigma? How does it receive pollen from visiting insects? Would it be likely to get the pollen which has just been scraped off from its own anthers by the bee? Why?

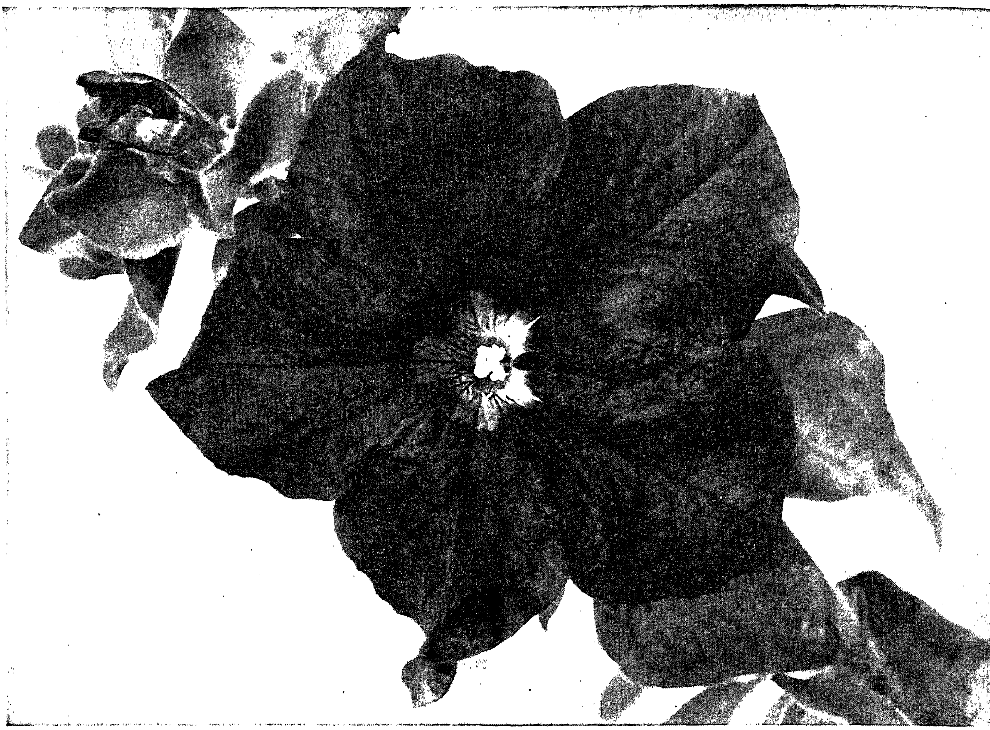
5. Experiment to find where the nectar is. Do you ever see bees getting the nectar from fallen flowers? Do they get the nectar from the "front" or the "back door"?

6. What other parts of this flower are red, which in other flowers are green? How does this make the budding portions of the flower stem look? Why does this make the salvia a more beautiful plant for our gardens?

7. Compare the mechanism of the stamens of the scarlet sage with the mechanism of the stamens of the common garden sage.

PETUNIAS

These red-purple and white flowers, which, massed in borders and beds, make gay our gardens and grounds in late summer and early autumn, have an interesting history. Professor L. H. Bailey uses it as an illustration in his thought-inspiring book, *The Survival of the Unlike*; he says that our modern petunias are a strange compound of two original species; the first one was found on the shores of the La Plata in South America and was introduced into Europe in 1823. "It is a plant of upright habit, thick sticky leaves and sticky stems, and very long-tubed white flowers which exhale a strong perfume at nightfall." The second species of



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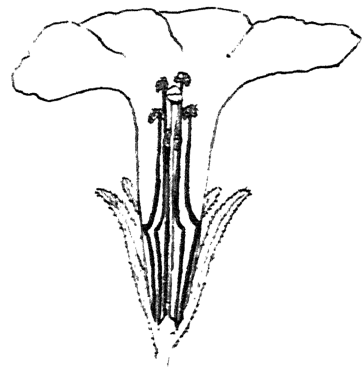
petunia came from seeds sent from Argentina to the Glasgow Botanical Gardens in 1831. "This is a more compact plant than the other, with a decumbent base, narrower leaves and small, red-purple flowers which have a very broad or ventricose tube, scarcely twice longer than the slender calyx lobes." This plant was called *Petunia violacea* and it was easily hybridized with the white species; it is now, strangely enough, lost to cultivation, although the white species is found in some old gardens. The hybrids of these two species are the ancestors of our garden petunias, which show the purple-red and white of their progenitors. The petunias are of the Nightshade family and are kin to the potato, tomato, eggplant, tobacco, and Jimson weed; and the long-tongued sphinx or hummingbird moths secure much nectar from their blossoms.

The petunia corolla is tubular, and the five lobes open out in salver-shape; each lobe is slightly notched at its middle, from which point a marked midrib extends to the base of the tube. In some varieties the edges of the lobes are ruffled. Within the throat of the tube may be seen a network of darker veins, and in some varieties this network spreads out over the corolla lobes. Although many colors have been developed in petunias, the red-purple and white still predominate; when the two colors combine in one flower, the pattern may be symmetrical, but is often broken and blotchy.

When a flower bud is nearly ready to open, the long, bristly tube of the corolla lies with its narrow base set in the calyx, the long, fuzzy lobes of which flare out in bell-shape; the tube is marked by lengthwise lines made by the five midribs; the lobes of the corolla are folded along the outer portions of these midribs, and these folded tips are twisted together much as if some one had given them a half turn with the thumb and finger. It is a pleasing experience to watch one of these flowers unfold. When a flower first opens, there lies near the bottom of the throat of the tube the green stigma, with two anthers snuggled up in front of it and two behind it, the latter being not quite so advanced in age as the former. As the filaments of the front pair of anthers are longer than those of the rear pair, the little group lies at a low angle offering a dusty doormat for entering insects. If we open a flower at this stage we find another anther, as yet unopened, which is on the shortest stamen of the five. This seems to be a little pollen reserve, perhaps for its own use later in the season. There is an interesting mechanism connected with these stamens; each is attached to the corolla-tube at the base for about half its length, and at the point of attachment curves suddenly inward so as to "cuddle up" to the pistil, the base of which is set in the nectar-well at the bottom of the flower. If we introduce a slender pencil or a toothpick into the flower-tube along the path which the moth's tongue must follow to reach the nectar, we can see that the stamens, pressing against it at the point where they curve inward, cause the anthers to move about so as to discharge their pollen upon it; and as the toothpick is withdrawn they close upon it cogently so that it carries off all the pollen with which it is brought in contact.

If we look at the stigma at the center of its anther guard, it has a certain close-fisted appearance, although its outer edges may be dusted with the pollen; as the flower grows older, the stigma stands above the empty anthers at the throat of the flower-tube and opens out into two distinct lobes. Even though it may have accepted some of its own pollen, it apparently opens up a new stigmatic surface for the pollen brought from other flowers by visiting insects.

Dr. James G. Needham says that at Lake Forest he has been attracted to the petunia beds in the twilight by the whirring of the wings of countless numbers of sphinx, or hummingbird moths, which were visiting these flowers. We also may find these moths hovering over petunia beds in almost any region if we visit them on the warmer evenings. And it is a safe guess that the remote white ancestor of our petunias had some special species of sphinx moth which it depended upon for carrying its pollen; and the strong perfume it exhaled at nightfall was an odor signal to its moth friends to come and feast.



A petunia blossom cut open on the upper side, showing the pistil surrounded by the incurved stamens and the partially opened stigma surrounded by the anthers. Note the short stamen below the pistil

With their long feeding tubes the hummingbird moths have little difficulty in securing the nectar, but bees also will work industriously in the petunias. They will scramble into the blossoms and, apparently complaining with high-pitched buzzing because of the tight fit, rifle the nectar-wells that seem to be better adapted to insects of quite different build.

The leaves of the petunia are so broadly ovate as to be almost lozenge-shape, especially the lower ones; they are soft, and have prominent veins on the lower side; they are without stipules, and have short flat petioles. The stems are soft and fuzzy and are usually decumbent at the base, except the central stems of a stool or clump, which stand up straight.

The flower stems come off at the axils of the leaves; the lower flowers open first. The blossoms remain open about two days; at the first sign of fading, the lobes of the corolla droop dejectedly like a frill that has lost its starch, and finally the corolla — tube and all — drops off, leaving a little conical seed capsule nestled snugly in the heart of the bell-shaped calyx. At this time, if this peaked cap of the seed capsule be removed, the many seeds look like tiny white pearls set upon the fleshy, conical placenta. As the capsule ripens, it grows brown and glossy like glazed manila paper and it is nearly as thin; then it cracks precisely down its middle, and the seeds are spilled out at any stirring of the stems. The ripe seeds are dark brown, almost as fine as dust, and yet, when examined with a lens, they are seen to be exquisitely netted and pitted.

Suggested Reading — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 5, *Science at Home*; also, readings on page 546.

LESSON 162

The Petunia

Leading Thought — The petunias are native to South America; they have an interesting history. Such insects as hummingbird moths are attacted to their flowers, and from them easily secure pollen and nectar.

Method — The petunias are such determined bloomers that they give us flowers up to the time of killing frosts, and they are therefore good material for nature lessons. Each pupil should have a flower in hand to observe during the lesson, and should also have access to a petunia bed for observations on the habits of the plant.

Observations — 1. What colors do you find in the petunia flowers? If they are striped or otherwise marked, what are the colors? Are the markings symmetrical and regular?

2. Sketch or describe a flower, looking into it. What is the shape of the corolla lobes? How many lobes are there? How are they veined? What peculiar markings are at the throat of the flower?

3. What are the color and position of the stigma? How are the stamens arranged? How many anthers do you see? What is the color of the anthers? Of the pollen?

4. Sketch or describe the flower from the side. What is the shape of the corolla-tube? Is it smooth or fuzzy? How is it marked? What are the number and shape of the sepals, or lobes, of the calyx?

5. Study a freshly opened flower, and describe the position and appearance of the anthers and stigma. Do they remain in these relative positions after the flower is old?

6. Cut open a flower, slitting it along the upper side. Describe the stamens and how they are attached. Is the pistil attached in the same manner? Where is the nectar? Thrust a slender pencil or a toothpick into the tube of a fresh flower. Does this spread the anthers apart and move them around? When it is withdrawn, is there pollen on it? Can you see in your open flower the mechanism by which the pollen is dusted on the object thrust into the flower?

7. What insects have tongues sufficiently long to reach the nectar-well at the bottom of the petunia flower? At what time do these insects fly? At what time of day do most of the petunia flowers open? Visit the petunia beds in the twilight, and note whether there are any insects visiting them. What insects do you find visiting these flowers during the day?

8. Sketch or describe the leaves of the petunia. How do the leaves feel? Look at a leaf with a lens and note the fringe of hair along its edges. Describe the veining of the leaf.

9. Describe the petunia stems. Are they stout or slender? How do they feel? With what are they covered? Where do the flowerstalks come off the main stem?

10. Describe or sketch a flower bud just ready to open. How are the tips of the lobes folded? How long does the flower remain in bloom? What is the first sign of its fading?

11. Describe the seed capsule. Where does it open? Are the seeds many or few, large or small? What is their color when ripe? When examined with a lens, have the seeds any noticeable pits or markings?

THE GARDEN OR HORSESHOE GERANIUM

The geraniums perhaps do more to brighten the world than almost any other cultivated flowers. They will grow for everyone, whether for the gardener in the conservatory of the rich, or in a tin can on the window sill of the crowded tenement of the poor. And it is interesting to know that this common plant has a cultivated ancestry of two hundred years' standing. These geraniums, which are really not geraniums botanically but are Pelargoniums, originally came from southern Africa, and the two ancestors of our common bedding geraniums were introduced into England in 1710 and 1714.

The geranium is of special value to the teacher, since it is available for study at any season of the year, and has a most interesting blossom. The single-flowered varieties should be used for this lesson, since the blossoms that are double have lost their original form. Moreover, the geranium's blossom is so simple that it is of special value as a subject for a beginning lesson in teaching the parts of a flower; and its leaves and stems may likewise be used for the first lessons in plant structure.

S. L. Sheldon

Horseshoe geranium. Note the positions of the opened flowers and the buds. Note the shape of the two upper petals with their colored lines. The flower at the left, seen in profile, shows that these upper petals project farther forward than those below. Note the cluster of young buds set in a circlet of bracts just below this flower

Swallowtail butterfly on a geranium

The stem is thick and fleshy, and is downy on the new growth; there is much food stored in these stems, which accounts for the readiness with which cuttings from them will grow. Two stipules are found on the stem at the base of each petiole. These stipules often remain after the leaves have fallen, thus giving the stem an unkempt look. The leaves are of various shapes, although of one general pattern; they are circular and beautifully scalloped and lobed, with veins for every lobe radiating from the petiole; they are velvety above and of quite different texture beneath, and many show the dark horseshoe which gives the name to this variety. The petiole is usually long and stiff and the leaves are set alternately upon the stem.

The flower has five petals, and at first glance they seem of much the same shape and position; but if we look at them carefully, we see that the upper two are much narrower at the base and project farther forward than do the lower three. Moreover, there are certain lines on these upper petals all pointing toward the center of the flower; and if we follow them we find a deep nectar-well just at the base of these upper petals and situated above the ovary of the flower. No other flower shows a prettier plan for guiding insects to the hidden sweets, and in none is there a more obvious and easily seen well of nectar. It extends almost the whole length of the flowerstalk, the nectar-gland forming a hump near the base of the stalk. If we thrust a needle down the whole length of this nectar-tube we can see that this bright flower developed its nectar especially for some long-tongued insect, probably a butterfly. It is interesting to note that in the double geranium where the stamens have been all changed to petals and where, therefore, no seeds are formed, this nectar-well has been lost.

There are five sepals, the lower one being the largest. But the geranium is careless about the number of its stamens; most flowers are very good mathematicians, and if they have five sepals and five petals they are likely to have five or ten stamens. The geranium often shows seven anthers, but if we look carefully we may find ten stamens, three of them without anthers. But this is not always true; there are sometimes five anthers and two or three filaments without anthers. The color of the anthers differs with the variety of the flower. The stamens broaden below, and their bases are joined, making a cup around the lower part of the ovary. The pistil is at the center of the flower and has no style, but at the summit divides into five long, curving stigmas; but again the geranium cannot be trusted to count, for sometimes there are seven or eight stigmas. Although many of our common varieties of geraniums have been bred so long that they have almost lost the habit of producing seed, yet we may often find in these single blossoms the ovary changed into the peculiar long beaklike pod, which shows the relationship of this plant to the crane's-bill or wild geranium.

When the buds of the geranium first appear, all of them are nestled in a nest of protecting bracts, each bud being enclosed in its own protecting sepals. But soon each flowerstalk grows longer and droops and often the bracts at its base fall off; from this mass of drooping buds, the ones at the center of the cluster lift up and open their blossoms first. Often, when the outside flowers are in bloom, those at the center have withered petals.

It would be well to say something to the pupils about those plants which have depended upon man so long for their planting that they do not develop any more seed for themselves. In connection with the geraniums, there should be a lesson on how to make cuttings and start their growth. The small side branches or the tips of the main stems may be used as cuttings. With a sharp knife make a cut straight across. Fill shallow boxes with sand, and plant the cuttings in these boxes, putting the stems for one-third of their length in the sand; place them in a cool room and keep them constantly moist. After about a month the plants may be repotted in fertile soil. The fall is the best time to make cuttings.

LESSON 163

The Garden or Horseshoe Geranium

Leading Thought — The geraniums are very much prized as flowers for ornamental beds. Let us see why they are so valued.

Method — A variety of geranium with single flowers should be chosen for this purpose, and it may be studied in the schoolhouse window or in the garden. As the parts of this flower are of a very general type, it is an excellent one with which to teach the names and purposes of the flower parts. Each child can make a little drawing of the sepals, petals, stamens, and pistil, and label them with the proper names.

OBSERVATIONS — 1. What sort of stem has the geranium? Is it smooth or downy? What makes the geranium stem look so rough and untidy?

2. Study the leaf. Show, by description or by drawing, its shape, its wings, and its veins. What are its colors and texture above? Beneath? Is the petiole long or short? What grows at the base of the petiole where it joins the stem? What marking is there on the leaf, which makes us call this a "horseshoe geranium"? Are there other geraniums with leaves of similar shape that have no horseshoe mark?

3. Study the flower. Are the petals all the same size and shape? How many of them are broad? How many narrow? Do the narrow ones project in front of the others? Do these have lines upon them? Where do these lines point? Find the nectar-well; how deep is it? Does it extend almost the entire length of the flower-stalk? For what insects is it fitted? Are there nectar-tubes in the stems of the geraniums with double flowers?

4. How many sepals are there? Are they all the same size? Where is the largest?

5. How many stamens can you see? What is the color of the filaments and of the anthers? How are the stamens joined at their bases? Can you find any stamens without anthers?

6. Where is the pistil situated? Can you see the ovary, or seed box? How many stigmas? Describe their color and shape?

7. In what part of the flower will the seeds be developed? How does the geranium fruit look? Sketch the pod. Do the geraniums develop many seeds? Why not? Do you know the seed pod of the wild geranium? If so, compare it with the pod of this plant.

8. Take a flower-cluster when the flowers are all in the bud, and note the following: When the buds first appear, what protects them? What becomes of these bracts later? How do the sepals protect the bud? Are the bud stems upright and

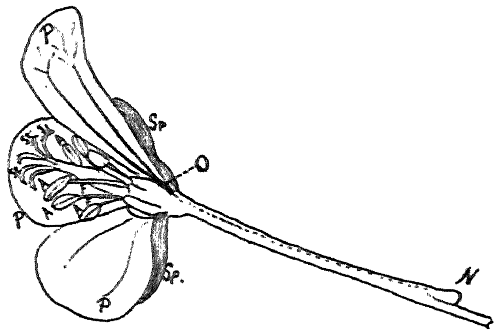


Diagram of a horseshoe geranium flower

Sp, sepals; P, petals; A, anthers; F, filament; St, stigma; O, opening to nectar gland; N, nectar gland

stiff or drooping? How many buds are there in a cluster?

9. Take notes on successive days as follows: What happens to the stalk as the bud gets ready to bloom? Is it a central or an outside blossom that opens first? How many new blossoms are there each day? How long is it from the time that the first bud opens until the last bud of the cluster blossoms? What has this to do with making the geranium a valuable ornamental plant?

10. Make some geranium cuttings, and note how they develop into new plants. Place one of the cuttings in a bottle of water and describe how its roots appear and grow.

God made the flowers to beautify
The earth, and cheer man's careful mood;
And he is happiest who hath power
To gather wisdom from a flower,
And wake his heart in every hour
To pleasant gratitude.

— WORDSWORTH

THE SWEET PEA

Here are sweet peas on tiptoe for a flight,
With wings of delicate flush o'er delicate white,
And taper fingers catching at all things,
To bind them all about with tiny rings.

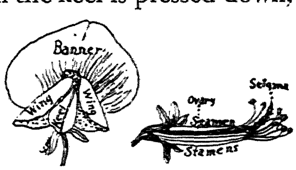
— KEATS.

Among the most attractive of the seeds which make up the treasure of the children's seed packets are the sweet peas. They are smooth little white or brown globules, marked with a scar on the side showing where they were attached to the

Sweet pea, blossoms and seed pods

pod. One of these peas divides readily into two sections; and after it has been soaked in water for twenty-four hours, the embryo of the future plant may, with the aid of a lens, be seen within it. After planting, the sprout pushes through the seed coat at a point very near the scar, and a leaf shoot emerges from the same place; but the two act very differently. The shoot lifts upward toward the light, and the root plunges down into the soil. As the plant grows, it absorbs the food stored in the seed; but the seed remains below ground and does not lift itself into the air, as happens with the bean. The root forms many slender branches, near the tips of which may be seen the fringe of roots, which take up the minerals and water from the soil. The first leaves of the pea seedling put forth no tendrils, but otherwise look like the later ones. The leaves grow alternately on the stalk, and they are compound, each having from three to seven leaflets. The petiole is winged, as is also the stem of the plant. There is a pair of large, clasping stipules at the base of each leaf. If we compare one of these leaves with a spray of tendrils, we can see that they resemble each other in the following points: The basal leaflets of the petiole are similar and the stipules are present in each case; but the leaflets nearest the tip are marvelously changed to little stiff stalks with a quirl at the tip of each, ready to reach out and hook upon any object that offers surface to cling to. Sometimes we find a leaflet paired with a tendril. The sweet pea could not grow vigorously without a support outside of itself.

Of course, the great upper petal of the sweet-pea blossom is called the banner! It stands aloft and proclaims the sweet pea as open; but before this occurs, it tenderly enfolds all the inner part of the flower in the unopened bud, and when the flower fades it again performs this duty. The wings are also well named; for these two petals which hang like a peaked roof above the keel seem like wings just ready to open in flight. The two lower petals are sewed together in one of Nature's invisible seams, making a long, curved treasure-chest resembling the keel of a boat, and it has thus been called. Within the keel are hidden the pistil and stamens. The ovary is long, pod-shaped and downy; from its tip the style projects, as strong as a wire, curving upwards, and covered with a brush of fine, white hairs; at the very tip of the style, and often projecting slightly from the keel, is the stigma. Around the sides and below the ovary and style are nine stamens, their filaments broadening and uniting to make a white, silken tube about the ovary, or young pod. From the tip of this stamen-tube, each of the nine filaments disengages itself, and lying close to the style thrusts its anther up into the point of the keel, below the stigma. But strange to say, one lone, lorn stamen " flocks by itself " above the pistil, curving its anther up stigmaward. If we touch the point of the keel with the finger, up fly — like a jack-in-the-box — the anthers splashing the finger with pollen; and if a bee, in her search for nectar, alights on the wings at the very base of the petals, up flies the pollen brush and daubs her with the yellow dust, which she may deposit on another stigma. The interesting part of this mechanism is the brush near the tip of the style below the stigma — a veritable broom, with splints all directed upward. As the pollen is discharged around it, the brush lifts it up when the keel is pressed down, and the



Blossom of sweet pea with parts labelled

stiff petals forming the keel, in springing back to place, scrape off the pollen and plaster it upon the visitor. But for all this elaborate structure, sweet peas, of all flowers, are the most difficult to cross-pollinate, since they are so likely to receive some of their own pollen during this process.

The sweet-pea bud droops, a tubular calyx with its five-pointed lobes forming a bell to protect it. Within the bud the banner petal clasps all in its protecting embrace.

After the petals fall, the young pod stands out from the calyx, the five lobes of which are recurved and remain until

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Sweet pea in flower

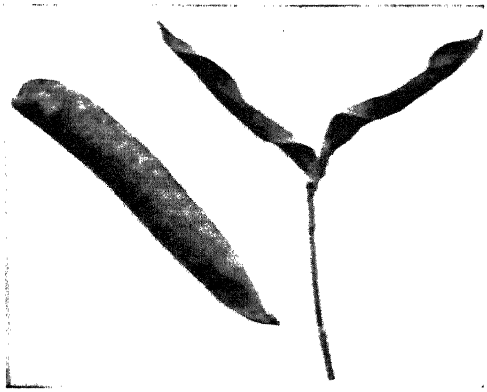
the pod is well grown. As the sweet pea ripens, all the moisture is lost and the pod becomes dry and hard; through the dampness of dews at night and the sun's heat which warps it by day, finally each side of the pod suddenly coils into a spiral, flinging the seed many feet distant in different directions.

LESSON 164

The Sweet Pea

Leading Thought — The sweet pea has some of its leaflets changed to tendrils which hold it to the trellis. Its flower is like that of the clover, the upper petal forming the banner, the two side petals the wings, and the two united lower petals the keel which protects the stamens and pistil.

Method — This should be a garden lesson. A study should be made of the peas before they are planted, and their germination carefully watched. Later, the method of climbing, the flower and the fruit should each be the subject of a lesson.



Sweet-pea pod bursting in spiral

Observations on Germination — 1. Soak some sweet peas over night; split them the next morning. Can you see the little plant within?

2. Plant some of the soaked peas in cotton batting, which may be kept moist. At what point does the sprout break through the seed covering? Do the root and leaf shoot emerge at the same place, or at different points? Which is the first to appear?

3. Plant some of the soaked peas in the garden. How do the young plants look when they first appear? Does the fleshy part of the seed remain a part of the plant and appear above the ground, as is the case with the bean? What becomes of the meat of the seed after growth has started?

4. Do the first leaves which unfold from the seed pea look like the later ones? Are the leaves simple or compound? Do they grow opposite each other or alternately?

5. Take a leaf and also a spray of the tendrils. How many leaflets are there in the compound leaf? Describe the petiole and the basal leaves. How far apart are the leaflets on the mid-stalk? Compare the stalk on which the tendrils grow with this leaf. Are the basal leaflets like those of the leaf? Is the petiole like that of the leaf? Do you think that the leaflets toward the tip of the stalk often change to tendrils? Why do you think so? How do tendrils aid the sweet pea? Do you see the earlike stipules at the base of the leaf? Are there similar stipules at the base of the tendril stem?

Observations on the Flower and Fruit — 1. Take the sweet pea in blossom. Why is the large upper petal called the banner? How does it compare in size with the other petals? What is its purpose when the flower is open? Why do you think the side petals are called wings? What is their position when the flower is open?

2. Describe that part of the flower below the wings. Do you think that it is made of two petals grown together? Why is it called the keel of the flower? Press down with your finger on the tip of the keel. What happens? Is your finger splashed with pollen? Where is the nectar in the sweet pea? Would an insect getting the nectar press down upon the keel and receive a splash of pollen?

3. Open the keel. How many stamens do you find within it? How many have their filaments joined together? Is there one separate from the others? Against what are the anthers pressed by the keel?

4. Remove the stamens and describe the pistil. Which part of this will make the pod in which the new peas will develop? Describe how the style is curved. How is the style covered near its tip? What is this brush for? Can you find the stigma with the help of the lens? When the bee is seeking for nectar and pushes down on the keel, does the stigma push out at the same point as the pollen? Does this enable the stigma sometimes to receive pollen which the bees bring from other flowers?

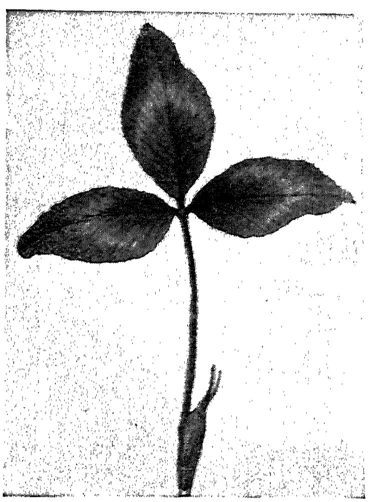
5. Describe an unopened flower bud. What is its position? How many lobes to the calyx? What is their shape, and how do they protect the bud? Which petal is folded over all the others? How does the position of the open flower differ from that of the bud?

6. How does the young pod look when the petals fall? How does it look when ripe? How does it open to scatter little, ripe sweet peas? Do the lobes of the sepals still remain with the pod?

THE CLOVERS

Sweet by the roadside, sweet by the rills,
Sweet in the meadows, sweet on the hills,
Sweet in its wine, sweet in its red,
Oh, half of its sweetness cannot be said;
Sweet in its every living breath,
Sweetest, perhaps, at last, in death.

— "A Song of Clover," Helen Hunt Jackson



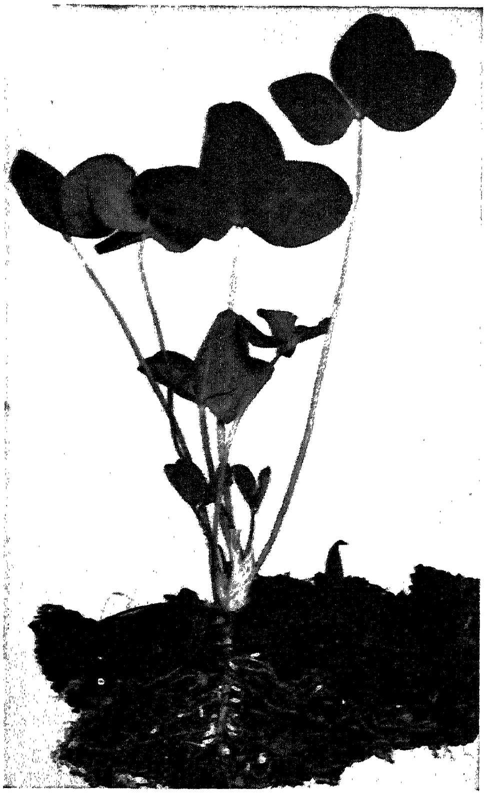
Ida Baker

Clover has for centuries been a most valuable forage crop; and for eons it has been the special partner of the bees, giving them honey for their service in carrying its pollen; and it has been discovered that it has also a mysterious and undoubtedly an ancient partnership with bacteria below ground, which, moreover, brings fertility to the soil. The making of a collection of the clovers of a region is a sure way of enlisting the pupils' interest in these valuable plants. The species have some similarities and differences, which give opportunity for much observation in comparing them. There may be found in most localities the white and yellow sweet clovers, the black and spotted medics, and their relative the alfalfa; while of the true clovers there are the red, the zigzag, the buffalo, the rabbit's-foot, the white, the alsike, the crimson, and two yellow or hop clovers.

In all the clovers, those blossoms which are lowest, or on the outside of the head, blossom first, and all of them have upon their roots the little swellings, or nodules, which are the houses in which the beneficent bacteria grow.

If we pull up or dig out the roots of

Heads of crimson clover



Farmers' Bulletin 455, U. S. D. A.

A young clover plant showing nodules or root tubercles

alfalfa, or of the true clovers or vetches, we find upon the rootlets little swellings which are called nodules, or root tubercles. Although these tubercles look so uninteresting, no fairy story was ever more wonderful than is theirs. They are, in fact, the home of the clover brownies, which help the plants to do their work. Each nodule is a nestful of living beings so small that it would take twenty-five thousand of them end to end to reach an inch; therefore, even a little swelling can hold many of these minute organisms, which are called bacteria. For many years people thought that these swellings were injurious to the roots of the clover, but now we know that the bacteria which live in them are simply underground partners of these plants. The clover roots give the bacteria homes and places to grow, and in return these are able to extract a very valuable chemical fertilizer from the air, and to change its form so that the clovers can absorb it. The name of this substance is nitrogen, and it makes up more than three-fourths of the air we breathe. Other plants are unable to take the nitrogen from the air and use it in making food; but these little bacteria extract it from the air which fills every little space between every two grains of soil and then change it to a form which the clovers can use. After the clover crop is harvested the roots remain in the ground, their little storehouses filled with this precious substance, and the soil falls heir to it.

Nitrogen in the form of commercial fertilizer is very expensive when the farmer has to buy it. So when he plants clover or alfalfa on his land, he is bringing to the soil this expensive element of plant growth, and it costs him nothing. This is why a good farmer practices the rotation of crops and puts clover upon his land every three or four years.

Alfalfa is so dependent on its little underground partners, that it cannot grow

Stumpp and Walter Co.

Red clover

well without them; and so the farmer plants, with the alfalfa seed, some of the soil from an old alfalfa field, which is rich in these bacteria, or better still, he inoculates the clover seed with a culture of the bacteria. On a farm I know, the bacterial soil gave out before all of the seed was planted; and when the crop was ready to cut it was easy to see just where the seed without the inoculated soil had been planted, for the plants that grew there were small and poor, while the remainder of the field showed a luxurious growth.

It is because of the great quantity of nitrogen absorbed from the air through the bacteria on its roots that the alfalfa is such a valuable fodder; for it contains the protein which otherwise would have to be furnished to cattle in expensive grain or cottonseed meal. The farmer who gives his stock alfalfa does not need to pay such large bills for grain. Other plants belonging to the same family as the clovers — like the vetches and cowpeas — also have bacteria on their roots. But each species of legume has its own species of bacteria, although in some cases soil inoculated with bacteria from one species of legume will grow them on roots of another species.

Stumpp and Walter Co.

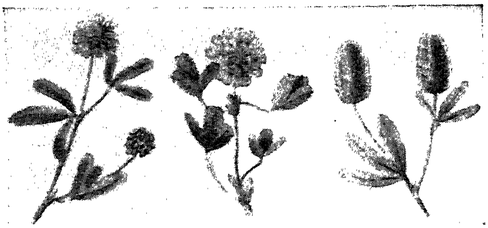
Alfalfa blossoms

Farmers' Bulletin 1722, U. S. D. A.

Single plant of alfalfa showing a portion of the root system

In addition to the enriching of the soil, clover roots, which penetrate very deeply, protect land from being washed away by freshets and heavy rains; and since clover foliage makes a thick carpet over the surface of the soil, it prevents evaporation and thus keeps the soil moist. Crimson clover is used extensively as a cover crop; it is sowed in the fall, especially where clean culture is practiced in orchards, and spreads its leaves above and its roots within the soil, keeping out weeds and protecting the land. (See also pages 770–75.) In the spring it may be plowed under, and thus it will add again to the fertility. This is also an æsthetically pleasing crop, for a field of crimson clover in bloom is one of the most beautiful sights in our rural landscape.

Red clover has such deep florets that, of all our bees, only the bumblebees have sufficiently long tongues to reach the nectar. It is, therefore, dependent upon this bee for developing its seed, and the enlightened farmer of today looks upon the



Yellow or hop clover, buffalo clover, and rabbit-foot or pussy clover

bumblebees as his good friends. The export of clover seed from the United States has sometimes reached the value of two million dollars a year, and this great industry can only be carried on with the aid of the bumblebee. There are sections of New York State where the growing of clover seed was once a most profitable business, but where now, owing to the dearth of bumblebees, no clover seed whatever is produced.

Suggested Reading — *Botany of Crop Plants*, by Wilfred W. Robbins; *Handbook of Farming for Boys and Girls*, by R. A. Power and Vincent E. Kivlin; *Our Plant Friends and Foes*, by William A. DuPuy; *Plants Useful to Man*, by Wilfred W. Robbins and Francis Ramaley; also, bulletins, leaflets, and circulars published by the United States Department of Agriculture.

LESSON 165

The Clovers

Leading Thought — The clovers enrich with nitrogen the soil in which they are planted. They are very valuable as food for stock. Their flowers are pollinated by bees.

Method — Each pupil should dig up a root of red clover or alfalfa to use for the lesson on the nodules. The flowers should be studied in the field, and also in detail in the schoolroom.

Observations — 1. How many kinds of clover do you know? How many of the medics?

2. In all clovers, which flowers of the head blossom first, those on the lower or outside, or those on the upper or inside?

3. Take up a root of red clover or alfalfa, noting how deep it grows. Wash the root free from soil, and find the little swellings on it. Write the story of what these swellings do for the clover, and incidentally for the soil.

4. How must the soil be prepared so that alfalfa may grow successfully? What does the farmer gain by feeding alfalfa, and why?

5. How do clover roots help to protect the land from being washed away by heavy rains?

6. How do clovers keep the soil moist? How does this aid the farmer?

7. What is a cover crop, and what are its uses?

8. Upon what insects does the red clover depend for carrying pollen? Can it produce seed without the aid of these valuable bees? Why not?

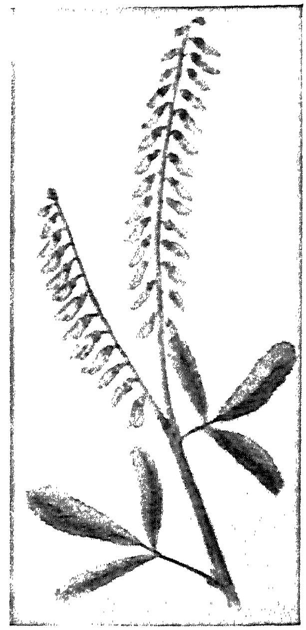
SWEET CLOVER

In passing along the country roads, especially those which have suffered upheaval from the road machines, suddenly we are conscious of a perfume so sweet, so suggestive of honey and other delicate things, that we involuntarily stop to find its source. Close at hand we find this perfume laboratory in the blossoms of the sweet clover. It may be the species with white blossoms, or the one with yellow flowers, but the fragrance is the same. There stands the plant, lifting high its beautiful blue-green foliage and its spikes of flowers for the enjoyment of the passer-by, while its roots are feeling their way down deep in the poor, hard soil, taking air and drainage with them and building, with the aid of their underground partners, nitrogen factories which will enrich the poverty-stricken earth, so that other plants may find nourishment in it.

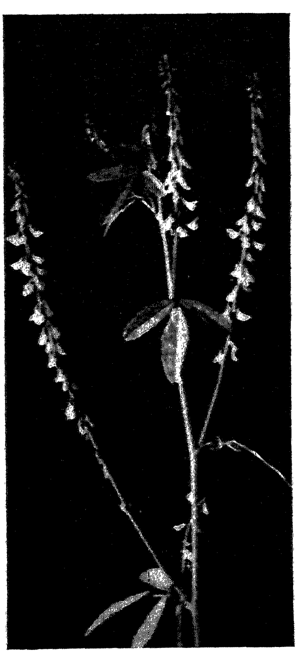
Never was there such another beneficent weed as the sweet clover — beneficent alike to man, bee, and soil. Usually we see it growing on soil so poor that it can only attain a height of from two to four feet; but if it once gets foothold on a generous soil, it rises majestically ten feet tall.

Like the true clover, its leaf has three leaflets, the middle one being longer and larger than the other two and separated from them by a naked midrib; the leaflets are long, oval in shape, with narrow, toothed edges, and they are dull, velvety green; the two stipules at the base of the leaf are little and pointed.

The blossoming of the sweet clover is a pretty story. The blossom stalk, which comes from the axil of the leaf, is at first an inch or so long, packed closely with little green buds having pointed tips. But as soon as the blossoming begins, the stalk elongates, bringing the flowers farther apart — just as if the buds had been fastened to a rubber cord which had been stretched. The buds lower down open first; each day some of the flowers bloom, while those of the day before linger, and thus the blossom tide rises, little by little, up the stalk. But the growing tip develops more and more buds, and thus the blossom story continues until long after the frosts have killed most other plants; finally the tip is white with blossoms, while the seeds developed from the first flowers on the plant have been perfected and scattered.



Yellow sweet clover



White sweet clover

The blossom is very much like a diminutive sweet pea; the calyx is like a cup with five points to its rim, and is attached to the stalk by a short stem. The banner petal is larger than the wings and the keel. A lens shows the stamens united into two groups, with a threadlike pistil pushing out between; both stamens and pistil are covered by the keel, as in the pea blossom.

The flowers are visited by bees and many other insects, which are attracted to them by their fragrance as well as by the white radiance of their blossoms. The ripened pod is well encased in the calyx at its base. The foliage of the sweet clover is fragrant, especially so when drying; it is to some extent used for fodder. The sweet clovers came to us from Europe and are, in a measure, compensation for some of the other emigrant weeds which we wish had remained at home.

Suggested Reading — Readings on pages 459, 461, 513, and 594.

LESSON 166

Sweet Clover

Leading Thought — This beneficent plant grows in soil that is often too poor for other plants to thrive in. It brings available nitrogen into the soil, and thus makes it fertile so that other plants soon find in its vicinity nourishment for growth.

Method — Plants of the sweet clover with their roots may be brought to the schoolroom for study. The children should observe sweet clover in the field; its method of inflorescence, and the insects which visit it, should be noted.

Observations — 1. What first makes you aware that you are near sweet clover? On what kinds of soil, and in what localities, does sweet clover abound?

2. Do you know how sweet clover growing in poor soils and waste places acts as a pioneer for other plants?

3. Dig up a sweet-clover plant, and see how far its stems go into the soil.

4. How high does the plant grow? What is the color of its foliage?

5. Compare one of the leaves with the leaf of a red clover, and describe the likeness and the difference. Note especially the edges of the upper and the lower leaves, and also the stipules.

6. Describe the way the sweet clover blossoms. Do the lower or upper flowers open first? How does the flowerstalk look before it begins to blossom? What happens to it after the blossoming begins? How long will it continue to blossom?

7. Take a blossom and compare it with that of a sweet pea. Can you see the banner? The wings? The keel? Can you see if the stamens are united into two sets? Can you see the pistil? Note the shape of the calyx.

8. How many flowers are in blossom at a time? Does it make a mass of white to attract insects? In what other way does it attract insects? What insects do you find visiting it?

9. How do the ripened pods look?

The blooming wilds His gardens are; some cheering
Earth's ugliest waste has felt that flowers bequeath,
And all the winds o'er summer hills careering
Sound softer for the sweetness that they breathe.

— Theron Brown

THE WHITE CLOVER

The sweet clover should be studied first, for after making this study it is easier to understand the blossoming of the white and the red clover. In the sweet clovers the flowers are strung along the stalk, but in the red, the white, and many others, it is as if the blossom stalk were telescoped, so that the flowers are all in one bunch, the tip of the stalk making the center of the clover head. We sometimes use the white clover in our lawns because of a peculiarity of its stem which, instead of standing erect, lies flat on the ground, sending leaves and blossoms upward and thus making a thick carpet over the ground. The leaves are very pretty; and although they grow upon the stems alternately, they always manage to twist around so as to lift their three leaflets upward to the light. The three leaflets are nearly equal in size, with fine, even veins and toothed edges; and each has upon it, near the middle, a pale, angular spot. The white clover, in common with other clovers, has the pretty habit of going to sleep at night. Botanists may object to this human term, but the great Linnæus first called it sleep, and we may be permitted to follow his example. Certainly the way the clover leaves fold at the middle, the three drawing near each other, looks like going to sleep, and is one of the things which even the little child will enjoy observing.

The clover head is made up of many little flowers; each one has a tubular calyx with five delicate points and a little stalk to hold it up into the world. In shape, the corolla is much like that of the sweet pea, and each secretes nectar at its base. The outside blossoms open first; and as soon as they are open, the honey bees, which eagerly visit white clover wherever it is growing, begin at once their work of gathering nectar and carrying pollen; as soon as the florets are pollinated they wither and droop below the flower-head.

Where I made One, turn down an empty Glass,

sings old Omar, and I always think of it when I see the turned-down florets of the white-clover blossom. In this case, however, the glass is not empty, but holds the maturing seed. This habit of the white-clover flowers saves the bees much time, since only those which need pollinating are lifted upward to receive their visits. The length of time the little clover head requires for the maturing of its blossoms depends much upon the weather and upon the insect visitors.

White-clover honey is in the opinion of many the most delicious honey made from any flowers except, perhaps, orange blossoms. So valuable is the white clover as a honey plant that apiarists often grow acres of it for their bees.

SUGGESTED READING — Readings on pages 459, 461, 513, and 594.

LESSON 167

THE WHITE CLOVER

LEADING THOUGHT — The white clover has creeping stems. Its flowers depend upon the bees for their pollination, and the bees depend upon the white-clover blossoms for honey.

METHOD — The plant may be brought into the schoolroom while in blossom, and its form be studied there. Observations as to the fertilization of the flowers should be made out-of-doors.

OBSERVATIONS — 1. Where does the white clover grow? Why is it sometimes used in lawns?

2. Note carefully the clover leaf, the shape of the three leaflets, stalks, and edges. Is part of the leaflet lighter colored than the rest? If so, describe the shape. Are the leaflets unequal or equal in size? Does each leaf come directly from the root? Are they alternately arranged? Why do they seem to come from the upper side of the stem?

Stumpp and Walter Co.

White clover

3. Note the behavior of the clover

leaves at night. How do the two side leaflets act? The central leaflet?

4. Take a white-clover head, and note that it is made up of many little flowers. How many? Study one of the little flowers with a lens. Can you see its calyx? Its petals? Its stalk? In what way is it similar to the blossom of the sweet pea?

5. Take a head of white clover which has not yet blossomed. Tie a string about its stalk so that you may be sure you are observing the same flower and make the following observations during several days: Which blossoms begin to open first — those outside or inside? How many buds open each day? What happens to the blossoms as they fade? How many days pass from the time the flowers begin to blossom until the last flower at the center opens?

6. What insects do you see working on the white-clover blossoms? How does the bee act when collecting nectar? Can you see where she thrusts her tongue? What does the bee do for the clover blossom?

7. Tie little bags of cheesecloth over two or three heads of white clover and see if they produce any seed.

Little flower; but if I could understand
What you are, root and all, and all in all,
I should know what God and man is.

— TENNYSON

To me the meanest flower that blows can give
Thoughts that do often lie too deep for tears.

— WORDSWORTH

I know a place where the sun is like gold,
And the cherry blooms burst with snow,
And down underneath is the loveliest nook
Where the four leaf clovers grow.

— ELLA HIGGINSON

THE MAIZE OR INDIAN CORN

Hail! Ha-wen-ni-yu! Listen with open ears to the words of thy people. Continue to listen. We thank our mother earth which sustains us. We thank the winds which have banished disease. We thank He-no for rain. We thank the moon and stars which give us light when the sun has gone to rest. We thank the sun for warmth and light by day. Keep us from evil ways that the sun may never hide his face from us for shame and leave us in darkness. We thank thee that thou hast made our corn to grow. Thou art our creator and our good ruler, thou canst do no evil. Everything thou doest is for our happiness.

Thus prayed the Iroquois Indians when the corn had ripened on the hills and valleys of New York State long before it was a state, and even before Columbus had turned his ambitious prows westward in quest of the Indies. Had he found the Indies with their wealth of fabrics and spices, he would have found there nothing so valuable to the world as has proved this golden treasure of ripened corn.

The origin of Indian corn, or maize, is shrouded in mystery. There is a plant which grows on the tablelands of Mexico which is possibly the original species; but so long had maize been cultivated by the American Indians that it was thoroughly domesticated when America was first discovered. In those early days of American colonization, it is doubtful, says Professor John Fiske, if our forefathers could have remained here had it not been for Indian corn. No plowing, or even clearing, was necessary for the successful raising of this grain. The trees were girdled, thus killing their tops to let in the sunlight, the rich earth was scratched a little with a primitive tool, and the seed put in and covered; and the plants that grew therefrom took care of themselves. If the pioneers had been obliged to depend alone upon the

Arthur C. Parker

Seneca Indian women husking corn for braiding

wheat and rye of Europe, which only grows under good tillage, they might have starved before they gained a foothold on our forest-covered shores.

The Corn Plant

In studying the maize it is well to keep in mind that a heavy wind is a serious enemy to it; such a wind will lay it low, and from such an injury it is difficult for the corn to recover and perfect its seed. Thus, the mechanism of the corn stalk and leaf is adapted for prevention of this disaster. The corn stalk is, practically, a strong cylinder with a pithy center; the fibers of the stalks are very strong, and at short intervals the stalk is strengthened by hard nodes, or joints; if the whole stalk were as hard as the nodes, it would be inelastic and would break instead of bend; as it is, the stalk is very elastic and will bend far over before it breaks. The nodes are nearer each other at the bottom, thus giving strength to the base; they are farther apart at the top, where the wind strikes, and where the bending and bowing of the stalk is necessary.

The leaf comes off at a node and clasps the stalk for a considerable distance, thus making it stronger, especially toward the base. Just where the leaf starts away from the stalk there is a little growth which serves as a rain guard; if water should seep between the stalk and the clasping leaf, it would afford harbor for destructive fungi. The structure of the corn leaf enables it to escape injury from the wind; the strong veins are parallel with a strong but flexible midrib at the center; often, after the wind has whipped the leaves severely, only the tips are split and injured. The edges of the corn leaf are ruffled, and where the leaf leaves the stalk there is a wide fold in the edge at either side; this arrangement gives play for a sidewise movement without breaking the leaf margins. The leaf is thus protected from the wind, whether it is struck from above or horizontally. The

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A good hill of corn. The hills of corn about this one have been removed so that it may stand out more clearly. Note the tassels and the drooping position of the well-filled ears

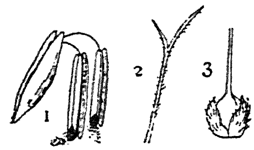
true roots of the corn plant go quite deep into the soil, but are hardly adequate to the holding of such a tall, slender stalk upright in a wind storm; therefore, all about the base of the plant are brace-roots, which serve to hold the stalk erect — like the stay-ropes about a flagpole.

The Ear of Corn

The ears of corn are borne at the joints or nodes; and the stalk, where the ear presses against it, is hollowed out so as to hold it snugly. In the following ways, the husks show plainly that they are modified leaves: the husk has the same structure as the leaf, having parallel veins; it comes off the stem like a leaf; it is often green, and therefore does the work of a leaf; it changes to leaf shape at the tip of the ear, thus showing that the husk is really that part of the leaf which usually clasps the stem. If a husk tipped with a leaf is examined, the part serving as a rain guard will be found at the place where the two join. As a matter of fact, the ear of corn is on a branch stalk which has been very much shortened, so that the nodes are very close together, and therefore the leaves come off close together. By stripping the husks back one by one, the change from the outside, stiff, green leaf structure to the inner delicate, papery wrapping for the seed, may be seen in all its stages. This is a beautiful lesson in showing how the maize protects its seed, and the husk may well be compared to the clothing of a baby. The pistillate flowers of the corn, which finally develop into the kernels, grow in pairs along the sides of the end portion of the shortened stalk, which is what we call the "cob." Therefore, the ear will show an even number of rows, and the cob shows distinctly that the rows are paired. The corn silk is the style and stigma of the pistillate flowers; and therefore, in order to secure pollen, it must extend from the ovule, which later develops into a kernel, to the tip of the ear, where it protrudes from the end of the husk. A computation of the number of kernels in a row and on the ear makes a very good arithmetic lesson for the primary pupils, especially as the kernels occur in pairs.

The Growth of the Corn

If we cut a kernel of corn crosswise we can see, near the point where it joins the cob, the little plant. Corn should be germinated between wet blotters in a seed-testing experiment before observations are made on the growing corn of the fields. When the corn first appears, the corn leaves are in a pointed roll within a colorless sheath which pierces the soil. Soon they spread apart, but it may be some time before the corn stalk proper appears. Then it stretches up rapidly, and very soon will be tipped with beautiful pale brown tassels. These tassels merit careful study, for they are the staminate flowers. Each floret has two anthers hanging down from it, and each half of each anther is a little bag of pollen grains; and in order that they shall be shaken down upon the waiting corn silk below, the bottom of each bag opens wide when the pollen is ripe. The corn silk, at this stage, is branched at the tip and clothed with fine hairs, so that it may catch a grain of the precious pollen. Then occurs one of the most wonderful pollen stories in all nature, for the pollen-tube must push down through the center of the corn silk for its whole length, in order to reach the waiting ovule and thus make possible the development of a kernel of corn. These young, unfertilized kernels are pretty objects, looking like seed pearls, each wrapped in furry bracts. If the silk from one of these young flowers does not receive its grain of pollen, then the kernel



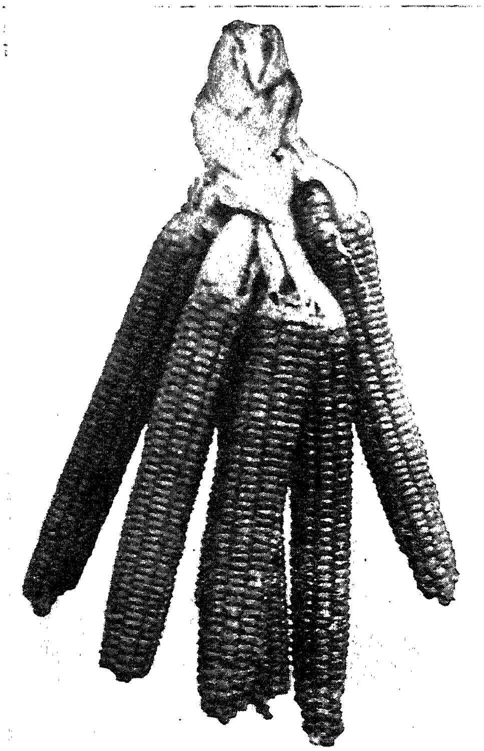
1, *The anthers of corn.* 2, *The tip of the corn silk showing the stigma.* 3, *The pistillate flower, which will develop into the kernel*

will not develop and the ear will be imperfect. On the other hand if the pollen from another variety of corn falls upon the waiting stigmas of the silk, we shall find the ear will have upon it a mixture of the two varieties. This is best exemplified when we have the black and white varieties of sweet corn growing near each other.

A tassel of corn, showing the pollen-bearing flowers

One reason why corn is such a valuable plant to us is that its growth is so rapid. It is usually not planted until late spring, yet, with some varieties, by September the stalks may be as much as twenty feet in height. The secret of this is that the corn, unlike many other plants, has many points of growth. While young, the part of the stalk just above each node is a growing center and the tip of the stalk also grows; the first two experiments suggested below will demonstrate this. In most plants, the tip of the stem is the only center of growth. When blown down by the wind, the corn has a wonderful way of lifting itself, by inserting growing wedges in the lower sides of the nodes. A corn stalk blown down by the wind will often show this wedge shape at every joint, and the result will be an upward curve of the whole stalk. Of course, this cannot be seen unless the stalk is cut lengthwise through the center. Experiment 3 is suggested to demonstrate this.

During drought the corn leaves check the transpiration of water by rolling together lengthwise in tubes, thus offering less surface to the sun and air. The farmer calls this the curling of the corn, and it is



Ears of corn with braided husks as the Indians used to carry them

always a sign of lack of moisture. If a corn plant with leaves thus curled be given plenty of water, the leaves will soon straighten out again into their normal shape.

SUGGESTED READING — *Corn and Corn Growing,* by Henry A. Wallace and Earl N. Bressman; *Nature and Science Readers,* by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons; The Story Book of Foods from the Field* (The Story Book of Corn), by Maud F. and Miska Petersham; *Useful Plants of the World,* by Willard N. Clute; also, readings on pages 459 and 594.

LESSON 168
THE MAIZE

LEADING THOUGHT — The Indian corn, or maize, is a plant of much beauty and dignity. It has wonderful adaptations for the development of its seed and for resisting the wind.

METHOD — The study may begin in spring when the corn is planted, giving the pupils the outline for observations to be filled out in their notebooks during the summer, when they have opportunities for observing the plant; or it may be studied in the autumn as a matured plant. It may be studied in the schoolroom or in the field, or both.

OBSERVATIONS ON THE CORN PLANT — 1. Describe the central stem. How many joints or nodes has it? Of what use to the plant are these nodes? Are the joints nearer each other at the bottom or the top of the plant?

2. Where do the leaves come off the stem? Describe the relation of the bases of the leaves to the stem. Of what use is this to the plant?

3. Note the little growth on the leaf where it leaves the stalk. Describe how this prevents the rain from seeping down between the stalk and the clasping leaf. What danger would there be to the plant if the water could get into this narrow space?

4. What is the shape of the leaf? Describe the veins. Does the leaf tear easily across? Does it tear easily lengthwise?

Agronomy Dept., State College of Agr., Cornell U.

A corn shock. In regions where corn is not harvested by machinery, and where it is not used for silage, it is often shocked to permit it to mature

Of what use to the plant is this condition?

5. Are the edges of the corn leaf straight or ruffled? How does this ruffled edge permit the leaf to turn without breaking? Describe at length the benefit the corn plant derives from having leaves which are not easily broken across and which can bend readily sidewise as well as up and down.

6. Describe the roots of the corn plant. Describe the brace-roots. Explain their use.

7. Describe all the ways in which the corn plant is strengthened against the wind.

Observations on the Ear of Corn — 8. Where on the corn plant are the ears borne? Are two ears borne on the same side of the stalk? Remove an ear, and see how it was fitted against the side of the stalk.

9. Where do the ears come off the stalk in relation to the leaves?

10. Examine the outside husks, and compare them with the green leaves. What is there to suggest that the corn husk is a leaf changed to protect the seed? Do you think that the husk represents that portion of the leaf which clasps the stalk? Why? Describe how the inner husk differs from the outer in color and texture. Describe how this is a special protection to the growing kernels.

11. After carefully removing the husk, examine the silk and see if there is a thread for every kernel. Is there an equal amount of silk lying between every two rows? Do you know what part of the corn flower is the corn silk? What part is the kernel?

12. How many rows of kernels are there on an ear? How many kernels in a row? How many on the whole ear? Do any of the rows disappear toward the tip of the ear? If so, do they disappear in pairs? Do you know why? Are the kernels on the tip of the ear and near the base as perfect as those along the middle? Do you know whether they will germinate as quickly and vigorously as the middle ones?

13. Study a cob with no corn on it and note if the rows of kernel-sockets are in distinct pairs. This will, perhaps, show best if you break the cob across.

Extension Chart, U. S. D. A.

Sugar cane, a near relative of corn, is a crop of tropical and subtropical regions. The stalks in the foreground have been stripped of leaves and are ready for the mill

14. Break an ear of corn in two, and sketch the broken end showing the relation of the cob to the kernels.

15. Are there any places on the ear you are studying where the kernels did not grow or are blasted? What may have caused this?

16. Describe the requisite for a perfect ear of seed corn. Why should the plant from which the seed ear is taken be vigorous and perfect?

Observations on the Growth of Corn — Work for the Summer Vacation — 17. How does the corn look when it first comes up? How many leaves are there in the pointed roll which first appears above the ground? How long before the central stalk appears?

18. When do the tassels first appear? What kind of flowers are the corn tassels? Describe the anthers. How many on each flower? Where do the anthers open to discharge their pollen?

19. Note that the kernel is the ovary. The silk is the style; it is attached to the ovary and is long enough to extend out beyond the husks; at its tip is the branched stigma.

20. What carries the pollen for the

corn plant? If you have rows of popcorn and sweet corn or of sweet corn and field corn next to each other why is it that the ears will show a mixture of both kinds?

EXPERIMENT 1

Compare the growth of the corn plant with that of the pigweed. When the corn stalk first appears above ground, tie two strings upon it, one just above a joint and one below it. Tie two strings the same distance apart on the stem of a pigweed. Measure carefully the distance between these two strings on the two plants. Two weeks later measure the distance between the strings again. What is the result?

EXPERIMENT 2

Measure the distance between two of the nodes or joints near the tip of a certain corn stalk. Two weeks later measure this distance again and compare the two.

EXPERIMENT 3

When a stalk of corn is still green in August, bend it down and place a stick across it at about half its length. Describe how it differs in position after two or three weeks. Cut lengthwise across one of the nodes, beyond the point held down by the stick, and see the wedge-shaped growth within the joint which helps to raise the stalk to an upright position.

EXPERIMENT 4

During the August drought, note that the corn leaves are rolled. Give a corn plant with rolled leaves plenty of water and note what happens. Why?

U. S. Department of Agriculture

Cotton pickers at work

THE COTTON PLANT

There are some plants which have made great chapters in the histories of nations, and cotton is one of them. The fiber of cotton was used for making clothing so long ago that its discovery is shrouded in the myths of prehistoric times. But we believe it first came into use in India, for in this land we find certain laws concerning cotton which were codified about 800 B.C.; and allusions to the fine, white raiment on the peoples of India are frequent in ancient history. Cotton was introduced into Egypt from India at an early date; it was in common use there about 150 B.C.

But not until our Civil War laid fallow the cotton fields of the United States, did Egypt realize the value of its crop; and although much money was lost there in agricultural speculation after our own product was again put on the market, still cotton has remained since that time one of Egypt's most valuable exports.

When Columbus discovered America he found cotton growing in the West Indies, and the chief articles of clothing of the native Mexicans were made of cotton. Cloths of cotton were also found in ancient tombs of Peru, proving it was used there long before the white man set his foot upon those shores. When Magellan made his famous voyage around the world in 1500, he found the cotton fiber in use in Brazil.

It is a strange fact that the only region of the world between the parallels of 40° north and 40° south latitude where cotton did not grow as a native or cultivated plant when America was discovered was the region of our Gulf states, which now produces more cotton than any other. The first mention of cotton as a crop in the American colonies is in the report published in 1666. At the time of the Revolutionary War the cotton industry was thoroughly established. It is one of the significant facts of history that the invention of the cotton gin by Eli Whitney in 1793, which revolutionized the cotton industry and brought it to a much more profitable basis, wrought great evil in the United States, since it revived the profits of slave-holding. The institution of slavery was sinking out of sight by its own weight; Washington showed that it was the most expensive way to work land, and Jefferson failed to liberate his own slaves simply because he believed that liberty would come to all slaves inevitably, since slave-holding was such an expense to the plantation owners. But the cotton gin, which removed the seeds rapidly — a process theretofore done slowly and laboriously by hand — suddenly made the raising of cotton so profitable that slaves were again employed in its production with great financial benefits. And thus it came about that the cotton plant innocently wielded a great influence in the political as well as the industrial life of our country.

Cotton in blossom

The cotton plant has a taproot, with branches which go deep into the soil. The stem is nearly cylindrical, the branches often spreading and sometimes irregular; the bark is dark and reddish; the wood is white. In Egypt, and probably in other arid countries, the stalks are gathered for fuel in winter.

The leaves are alternate, with long petioles. The upper leaves are deeply cut, some having five, some seven, some three, and some even nine lobes; strong veins extend from the petiole along the center of each lobe; the leaves near the ground may not be lobed at all. Where the petiole joins the stem, there is a pair of long, slender, pointed stipules, but they often fall off early. A strange characteristic of the cotton leaves is that they bear nectar-glands; these may be seen on the underside and along the main ribs of the leaf; they appear as little pits in the rib; some leaves may have none, while others may have from one to five.

The flower bud is partially hidden beneath the clasping bracts of the involucre. These bracts are three or four in number, and they have the edges so deeply lobed

U. S. Department of Agriculture

A single cotton plant loaded with maturing bolls

that they seem branched. By pushing back the bracts we can find the calyx, which is a shallow cup with five shallow notches in its rim. The petals are rolled in the bud like a shut umbrella. The open flower has five broadly spreading petals; when the bud first opens in the morning, the petals are whitish or pale yellow with a purplish spot at the base, by noon they are pale pink, by the next day they are a deep purplish red and they fall at the end of the second day. There are nectar-glands also in the flower at the base of the calyx, and the insects are obliged to thrust their tongues between the bases of the petals to reach the nectar; only long-tongued bees, moths, and butterflies are able to attain it.

There are many stamens which have their filaments united in a tube extending up into the middle of the flower and enlarging a little at the tip; below the enlarged base of this tube is the ovary which later develops into the cotton boll; within the stamen-tube extends the long style, and from its tip are thrust out three to five stigmas like little pennants from the top of a chimney; and sometimes they are more or less twisted together. The young boll is covered and protected by the fringed bracts, which cover the bud and remain attached to the ripened boll. The calyx, looking like a little saucer, also remains at the base of the boll. The boll soon assumes an elongated, oval shape, with long, pointed tip; it is green outside and covered with little pits, as large as pinpoints. There are, extending back from the pointed tip, three to five creases or sutures, which show where the boll will open. If we open a nearly ripened boll, we find that halfway between each two sutures where the boll will open there is a partition extending into the boll dividing it into compartments. These are really carpels, as in the core of an apple, and their leaf origin may be plainly seen in the venation. The seeds are fastened by their pointed ends along each side of the central edge of the partition, from which they break away very easily. The number of seeds varies, usually two or three along each side; the young seeds are wrapped in the young cotton, which is a stringy, soft white mass. The cotton fibers are attached to the covering of the seed around the blunt end, and usually the pointed end is bare. When the boll opens, the cotton becomes very fluffy and if not picked will blow away. The wild cotton disseminates its seeds by sending them off on the wings of the wind. Heavy winds at the cotton-picking time are a menace to the crop and often occasion serious loss.

The mechanism of the opening of the cotton boll is very interesting; along the central edge of each partition and extending up like beaks into the point of the boll is a stiff ridge, about the basal portion of which the seeds are attached; as the boll becomes dry, this ridged margin becomes as stiff as wire and warps outward; at the same time, the outside of the boll is shriveling. This action tears the boll apart along the sutures and exposes the seeds with their fluffy balloons to the action of the wind. The ripe, open, empty boll is worth looking at; the sections are wide apart and each white, delicate, parchment-like partition or carpel, has its wire edge curved back gracefully. The outside of the boll is brown and shriveled, but inside it is still white and shows that it had a soft lining for its seeds.

The amount of the cotton crop per acre varies with the soil and climate; the amount that can be picked per day also depends upon the cotton as well as upon the picker. Children have been known to pick one hundred pounds per day, and a first-class picker from five hundred to six hundred pounds, or even eight hundred; one man has made a record of picking sixty pounds in an hour. Cotton is one of the most important crops grown in America, and there are listed more than one hundred and thirty varieties which have originated in our country.

Suggested Reading — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 3, *Surprises*, Book 5, *Science at Home*; *The Story of Cotton*, by Dorothy Scarborough; also, readings on pages 459 and 594.

LESSON 169

Cotton

Leading Thought — Cotton has had a great influence upon our country politically as well as industrially. Its fiber was used by the ancients, and it is today one of the most important crops in the regions where it is grown.

Method — A cotton plant with blossoms and ripe bolls upon it may be brought into the schoolroom or studied in the field.

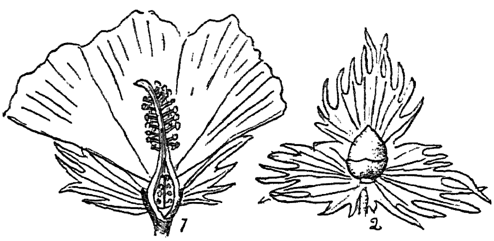
Observations — 1. How many varieties of cotton do you know? Which kind is it you are studying?

2. What sort of root has the cotton plant? Does it go deep into the soil?

3. How high does the plant grow? Are the stems tough or brittle? What is the color of the bark? Of the wood? Do you know of a country where cotton stalks are used for fuel? Do the stem and branches grow erect or very spreading?

4. Are the leaves opposite or alternate? Are the petioles as long as the leaves? Are there any stipules where the petioles join the main stem? How many forms of leaves can you find on the same stem? How do the upper differ from the lower leaves? Describe or sketch one of the large upper leaves, paying especial attention to the veins and the shape of the lobes.

5. Look at the lower side of a leaf and find, if you can, a little pit on the midrib near its base. How many of these pits can you find on the veins of one leaf? What is



1, *The cotton flower cut in half, showing the stamen-tube at the center, up through which extends the style of the pistil. Note the bracts and calyx.* 2, *A young boll, with calyx at its base, set in the involucral bracts*

the fluid in these pits? Taste it and see if it is sweet. Watch carefully a growing plant and describe what insects you find feeding on this nectar. Note if the wasps and ants feeding on this nectar attack the caterpillars of the cotton worm which destroy the leaf. Where are the nectar-glands of plants usually situated?

6. Study the flower bud; what covers it? How many of these bracts cover the flower bud? What is their shape and how do their edges look? Push back the bracts and find and describe the calyx. How are the petals folded in the bud?

7. Take the open flower; how many petals are there, and what is their shape? At what time of day do the flowers open? What color are the petals when the flowers first open? What is their color later in the day? What is their color the next day? When do the petals fall?

8. Describe the stamens; how are they joined? How are the anthers situated on the stamen-tube? Is the stamen-tube perfectly straight or does it bend at the tip?

9. Peel off carefully the stamen-tube and describe what you find within it. How many stigmas come out of the tip of the tube? Find the ovary below the stamen-tube. Which part of the flower grows into the cotton boll?

10. Take a boll nearly ripe; what covers it? Push away the bracts; can you find the calyx still present? What is the shape of the boll? What is its color and texture? Can you see the creases where it will open? How many are there of them?

11. Open a nearly ripe boll very carefully. How many partitions are there in it? Where are they in relation to the openings? Gently push back the cotton from the seeds without loosening them, and describe how the seeds are connected with the partitions. Is the seed attached by its pointed or by its blunt end?

12. How many seeds in each chamber in the cotton boll? Where on the seed does the cotton grow? How does the cotton blanket wrap about the seed? If the cotton is not picked what happens to it? Of what use to the wild cotton plant are seeds covered with cotton?

13. What makes the cotton boll open? Describe an open and empty boll outside and inside.

14. How much cotton is considered a good crop per acre in your vicinity? How much cotton can a good picker gather in a day?

15. Write English themes on the following topics: "The History of the Cotton Plant from Ancient Times until To-day," "How the Cotton Plant Has Affected American History."

Queen-consort of the kingly maize,
The fair white cotton shares his throne,
And o'er the Southland's realm she claims
A just allegiance, all her own.
— Minnie Curtis Wait

Verne Morton

THE STRAWBERRY

Of all the blossoms that clothe our open fields, one of the prettiest is that of the wild strawberry. And yet so influenced is man by his stomach that he seldom heeds this flower except as a promise of a crop of strawberries. It is comforting to know that the flowers of the field " do not care a rap " whether man notices them or not; insect attentions are what they need, and they are surely as indifferent to our indifference as we are to theirs.

The field strawberry's five petals are little cups of white held up protectingly around anthers and pistils; each petal has its base narrowed into a little stalk which the botanists call a claw. When the blossom first opens, the anthers are little, flat, vividly lemon-yellow discs, each disc consisting of two clamped together sternly and determinedly as if they meant never to open and yield their gold dust. At the very center of the flower is a little, greenish-yellow cone, which, if we examine with a lens, we can see is made up of many pistils set together, each lifting up a little circular stigma. Whether all the stigmas receive pollen or not determines the formation of a good strawberry.

The sepals are slender and pointed and seem to be ten in number, every other one being smaller and shorter than its neighbors; the five shorter ones, however, are not sepals but are bracts below the calyx.

Left, a strawberry leaf. Right above, a pistillate flower. Right below, a perfect flower

The sepals unite at their bases so that the strawberry has really a lobed calyx instead of separate sepals. The blossom stalk is soft, pinkish, and silky; it wilts easily. There are several blossoms borne upon one stalk and the central one opens first.

The strawberry leaf is beautiful; each of its three leaflets is oval, deeply toothed, and has strong regular veins extending from the midrib to the tip of each tooth. In color it is rich, dark green and turns to

Strawberry fruit

wine color in autumn. It has a very pretty way of coming out of its hairy bud scales, each leaflet folded lengthwise and the three pressed together. Its whole appearance then is infantile in the extreme, it is so soft and helpless looking. But it soon opens out on its pink, downy stem and shows the world how beautiful a leaf can be.

If a comparison of the wild and cultivated strawberries is practicable, it makes this lesson more interesting. While the wild flowers are usually perfect, many cultivated varieties have the pollen and pistils borne in different flowers, and they depend upon the bees to carry their pollen. The blossom stalk of the garden strawberry is round, smooth, and quite strong, holding its branching panicle of flowers erect, and it is usually shorter than the leafstalks among which it nestles. The flowers open in a series, so that ripe and green fruit, flowers, and buds may often be found on the same stem. As the strawberry ripens, the petals and stamens wither and fall away; the green calyx remains as the hull, which holds in its cup the pyramid of pistils which swell and ripen into the juicy fruit. To the botanists the strawberry is not a berry, that definition being limited to fruits having a juicy pulp and containing many seeds, like the currant or grape. The strawberry is a fleshy fruit bearing its akenes, the hard parts which we have always called seeds, in shallow pits on its surface. These akenes are so small that we do not notice them when eating the fruit, but each one is a tiny nut, almond-shaped, and containing within its tough little shell a starchy meat to sustain the future plant which may grow from it. It is by planting these akenes that growers obtain new varieties.

The root of the strawberry is fibrous and threadlike. When growers desire plants for setting new strawberry beds they are careful to take only such as have light colored and fresh-looking roots. On old plants the roots are rather black and woody and are not so vigorous.

The stem of the strawberry is partially underground and so short as to be unnoticeable. However, the leaves grow upon it alternately one above another, so that the crown rises as it grows. The base of each leaf has a broad, clasping sheath which partly encircles the plant and extends upward in a pair of earlike stipules.

The runners begin to grow after the fruiting season has closed; they originate from the upper part of the crown; they are strong, fibrous, and hairy when young. Some are short between joints, others seem to reach far out as if seeking for the best location before striking root; a young plant will often have several leaves before putting forth roots. Each runner may start one or more new strawberry plants. After the young plant has considerable root growth, the runner ceases to carry sap from the main stem and withers to a mere dry fiber. The parent plant continues to live and bear fruit, for the strawberry is a perennial, but the later crops are of less value. Gardeners usually renew their plots each year, but if intending to harvest a second year's crop, they cut off the runners as they form.

Suggested Reading — Readings on pages 459 and 594.

LESSON 170

The Strawberry

Leading Thought — The strawberry plant has two methods of perpetuating itself, one by the akenes which are grown on the outside of the strawberry fruits, and one by means of runners which start new plants wherever they find place to take root. Cultivated plants are grown from runners, but new species must be grown from seed.

Method — It would be well to have a strawberry plant, with roots and runners attached, for an observation lesson by the class. Each pupil should have a leaf, including the clasping stipules and sheath at its base. Each one should also have a strawberry blossom and bud, and if possible a green or ripe fruit.

Observations — 1. What kind of root has the strawberry? What is its color?

2. How are the leaves of the strawberry plant arranged? Describe the base of the leaf and the way it is attached to the stem. How many leaflets are there? Sketch a strawberry leaf, showing the edges and form of the leaflets, and the veins.

3. From what part of the plant do the runners spring? When do the runners begin to grow? Does the runner strike root before forming a new plant or does the little plant grow on the runner and draw sustenance from the parent plant?

4. What happens to the runners after the new plants have become established? Does the parent plant survive or die after it sends out many runners?

5. Describe the strawberry blossoms. How many parts are there to the hull or calyx? Can you see that five of these are set below the other five?

6. How many petals are there? Does the number differ in different flowers? Has the wild strawberry as many petals as the cultivated ones?

7. Study with a lens the small green button at the center of the flower. This is made up of pistils so closely set that only their stigmas may be seen. Do you find this button of pistils in the same blossom with the stamens? Does the wild blossom have both stamens and pistils in the same flower?

8. Describe the stamens. What insects carry pollen for the strawberry plants?

9. Are the blossoms arranged in clus-

ters? Do the flowers all open at the same time? What parts of the blossom fall away and what parts remain when the fruit begins to form?

10. Are the fruits all of the same shape and color? Is the pulp of the same color within as on the surface? Has the fruit an outer coat or skin? What are the specks on its surface?

11. How many kinds of wild strawberries do you know? How many kinds of cultivated strawberries do you know?

12. Describe how you should prepare, plant, and care for a strawberry bed.

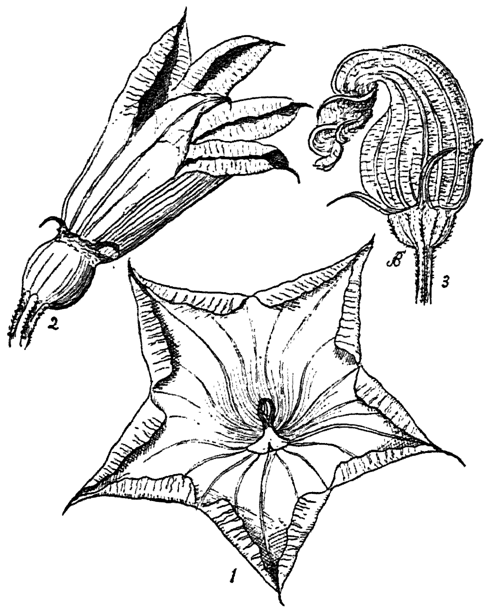
Verne Morton

"When the frost is on the punkin and the fodder's in the shock"

THE PUMPKIN

If the pumpkin were as rare as some orchids, people would make long pilgrimages to look upon so magnificent a plant. Although it trails along the ground, letting Mother Earth help it support its gigantic fruit, yet there is no sign of weakness in its appearance; the vine stem is strong, ridged, and spiny. The spines upon it are surely a protection under some circumstances, for I remember distinctly that when, as children, barefooted and owning the world, we "played Indian" and found our ambush in the long rows of ripening corn, we skipped over the pumpkin vines, knowing well the punishment they inflicted on the unwary feet.

From the hollow, strongly angled stem arise in majesty the pumpkin leaves, of variously lobed patterns, but all formed on the same decorative plan. The pumpkin leaf is as worthy of the sculptor's chisel as is that of the classic acanthus; it is palmately veined, having from three to five lobes, and its broad base is supported for a distance on each side of the angled petiole by the two basal veins. The leaves are deep green above and paler below; they are covered on both sides with minute bristles, and their edges are finely toothed. The bristly, angled stalk which lifts it aloft is a quite worthy support for so beautiful a leaf. And, during our child-



The closing of a pumpkin flower

1, Staminate flower beginning to close; note the folded edges of the lobes. 2, Pistillate flower nearly closed. 3, Staminate flower closed and in its last stage

hood, it was also highly esteemed as a trombone, for it added great richness of quality to our orchestral performances, balancing the shrillness of the basswood whistle and the sharp buzzing of the dandelion-stem pipe.

Growing from a point nearly opposite a leaf may be seen the pumpkin's elaborate tendril. It has a stalk like that of the leaf, but instead of the leaf blade it seems to have the three to five naked ribs curled in long, small coils very even and exact. Perhaps, at some period in the past, the pumpkin vines lifted themselves by clinging to trees, as do the gourd vines of today. But the pumpkin was cultivated in fields with the maize by the North American Indians, long before the Pilgrim Fathers came to America and made its fruit into pies. Since the pumpkin cannot sustain itself in our northern climate without the help of man, it was evidently a native of a warmer land. With cultivation it now sends its long stems out for many feet, resting entirely upon the ground. But, like a conservative, elderly maiden lady, it still wears corkscrew curls in memory of a fashion long since obsolete. Occasionally, we see the pumpkin vines at the edge of the field pushing out and clambering over stone piles, and often attempting to climb the rail fences, as if there still remained within them the old instinct to climb.

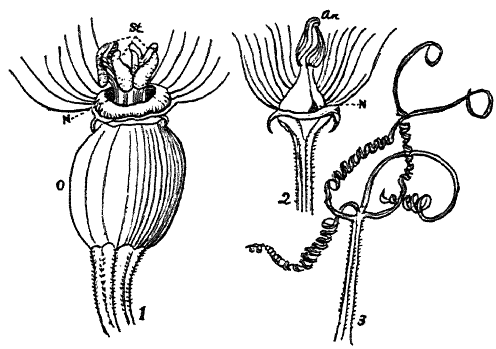
But though its foliage is beautiful, the glory of the pumpkin is its vivid yellow blossom and, later, its orange fruit. When the blossom first starts on its career as a bud, it is enfolded in a bristly, ribbed calyx with five stiff, narrow lobes, which close up protectingly about the green, cone-shaped bud, a rib of the cone appearing between each two lobes of the calyx. If we watch one of these buds day after day, we find that the green cone changes to a yellow color and a softer texture as the bud unfolds, and then we discover that it is the corolla itself; however, these ribs which extend out to the tip of the corolla lobes remain greenish below, permanently. The expanding of the flower bud is a pretty process; each lobe, supported by a strong midrib, spreads out into one of the points of a five-pointed star; each point is very sharp and angular because, folded in along these edges in one of the prettiest of Nature's hems is the ruffled margin of the flower. Not until the sun has shone upon the star for some little time of a summer morning do these

Verne Morton

The staminate blossom of the pumpkin, showing the anther knob at the left. A bud of the staminate flower at the center and a closed blossom at the right turned-in margins open out; and, late in the afternoon or during a storm, they fold down again neatly before the lobes close up; if a bee is not lively in escaping she may, willy-nilly, get a night's lodging, for these folded edges literally hem her in.

The story of the treasure at the heart of this starry, bell-shaped flower is a double one, and we had best begin it by selecting a flower that has below it a little green globe — the ovary — which will later develop into a pumpkin. At the heart of such a flower there stand three stigmas, that look like lilliputian boxing gloves; each is set on a stout, postlike style, which has its base in a great nectar-cup, the edges of which are slightly incurved over its welling sweetness. In order to reach this nectar, the bee must stand on her head and brush her pollen-dusted side against the stigmas. Professor Duggar has noted that in dry weather the margins of this nectar-cup contract noticeably, and that in wet weather the stigmas close down as if the boxing gloves were on closed fists.

The other half of the pumpkin-blossom story is to be found in the flowers which have no green globes below them, for these produce the pollen. Such a flower has at its center a graceful pedestal with a broad base and a slender stem, which upholds a curiously folded, elongate knob, that looks like some ancient or primitive jewel wrought in gold. The corrugations on its surface are the anther cells, which are curiously joined and curved around a central oblong support; by cutting one across, we can see plainly the central core, bordered by cells filled with pollen. But where is the nectar-well in the smooth cup of this flower? Some have maintained that the bees visit this flower for the sake of the pollen, but I am convinced that this is not all of the story. In the base of the pedestal which supports the anther knob there appear, after a time, three inconspicuous openings; and if we watch a bee, we shall see that she knows these openings are there and eagerly thrusts her tongue down through them. If we remove the anthers and the pedestal, we shall find nectar below the latter; the nectar-cup is carpeted with the softest of buff velvet, and while it does not reek with nectar, as does the cup which encompasses the



1, Base of pistillate blossom; O, ovary which develops into the pumpkin; N, nectar cup; St, stigmas. 2, Base of a staminate blossom; N, opening into the nectar cup; An, anthers joined, forming a knob. 3, Pumpkin tendril

styles of the pistil, yet it secretes enough of the sweet fluid so that we can taste it distinctly. Thus, although the bees find pollen in this flower they also find nectar there. The pumpkin is absolutely dependent upon the work of bees and other insects for carrying its pollen from the blossom that bears it to the one which lacks it, as this is the only way that the fruit may be developed.

And after the pollen has been shed and delivered, the flower closes, to open no more. The fading corolla looks as if its lobes had been twisted about by the thumb and finger to secure tightness; and woe betide the bee caught in one of these prisons, unless she knows how to cut through its walls or can find within sustenance to last until the withered flower falls. The young pumpkin is at first held up by its stiff stem but later rests upon the ground.

The ripe pumpkin is not only a colossal but also a beautiful fruit. The glossy rind is brilliant orange and makes a very efficient protection for the treasures within it. The stem is strong, five-angled, and stubborn, and will not let go its hold until the fruit is over-ripe. It then leaves a star-shaped scar to match the one at the other end of the fruit, where once the blossom sat enthroned. The pumpkin in shape is like a little world flattened at the poles, and with the lines of longitude creased

A squash plant breaking out of the seed coats at the left. The operation further progressed is shown at the right

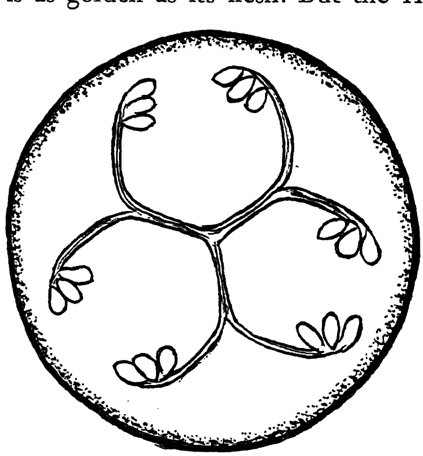
into its surface. But the number of these longitudinal creases varies with individual pumpkins, and seems to have no relation to the angles of the stem or the three chambers within.

If we cut a small green pumpkin across, we find the entire inside solid. There are three fibrous partitions extending from the center, dividing the pulp into thirds; at its outer end each partition divides, and the two ends curve in opposite directions. Within these curves the seeds are borne. A similar arrangement is seen in the sliced cucumber. As the pumpkin ripens, the partitions surrounding the seeds become stringy and very different from the " meat " next to the rind, which makes a thick, solid outer wall about the central chamber, where are contained six rows of crowded seeds, attached by their pointed tips and supported by a network of yellow, coarse fibers — like babies supported in hammocks. All this network, making a loose and fibrous core, allows the seeds to fall out in a mass when the pumpkin is broken. If we observe where the cattle have been eating pumpkins we find these masses of seeds left and trampled into the mud, where, if our winter climate permitted, they could grow into plants next year.

The pumpkin seed is attached by its pointed end; it is flat, oblong, and has a rounded ridge at its edge, within which is a delicate " beading." The outside is very mucilaginous; but when it is wiped dry, we can see that it has an outer, very thin, transparent coat; a thicker white, middle coat; while the meat of the seed is covered with a greenish, membranous coat. The meat falls apart lengthwise and flatwise, the two halves forming later the seed leaves and containing the food laid up by the " pumpkin mother " for the nourishment of the young plant. Between these two halves, at the pointed end, is the embryo, which will develop into a new plant.

When sprouting, the root pushes out through the pointed end of the seed and grows downward. The shell of the seed is forced open by a little wedge-shaped projection, while the seed leaves are pulled from their snug quarters. If the seed leaves are not released, the seed shell clamps them together like a vise, and the little plant is crippled.

Both squashes and pumpkins figure in the spicy Thanksgiving pies, but the chief value of the pumpkin crop in America is as food for milch cows; it causes a yield of milk so rich that the butter made from it is as golden as its flesh. But the Hal-



Section of a pumpkin just after the blossom has fallen. Note how the seeds are borne lowe'en jack-o'-lantern appeals to the children. In this connection, a study of expression might be made interesting; the turning of the corners of the mouth up or down, and the angles of the eyebrows, making all the difference between a jolly grin and an "awful face."

SUGGESTED READING — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 3, *Surprises*; also, readings on pages 459 and 594.

LESSON 171

THE PUMPKIN

LEADING THOUGHT — The pumpkin and squash were cultivated by the American Indians in their cornfields long before Columbus discovered the new world. Insects carry the pollen for the flowers of these plants, which must be cross-pollinated in order to develop their fruit.

METHOD — This work may be done in the garden or field in September or early October; or a vine bearing both kinds of flowers, leaves, and tendrils may be brought to the schoolroom for observation. The lesson on the pumpkin fruit may be given later. A small green pumpkin should be studied with the ripe one, and also with the blossoms, so as to show the position of the seeds during development. This lesson can be modified to fit the cucumber, the melon, the squash, and the gourd.

THE PUMPKIN VINE AND FLOWERS

OBSERVATIONS — 1. How many different forms of flowers do you find on a pumpkin vine? What are the chief differences in their shape?

2. Look first at the flowers with the long slender stalks. What is the shape and color of the blossom? How many lobes has it? Is each lobe distinctly ribbed or veined? Is the flower smooth on the inner and the outer surface? Are the edges of the lobes scalloped or ruffled?

3. What do you see at the bottom of the golden vase of this flower? This yellow club, or knob, is formed by the joining of three anthers, one of which is smaller than the others. Do all the pumpkin flowers have this knob at the center? Look at the base of the standard which bears the anther-knob, and note if there are some openings; how many? Cut off the anther pedestal, and describe what is hidden beneath it. Note if the bees find the openings to the nectar-well and probe there for the nectar. Do they become dusted with pollen while seeking the nectar?

Verne Morton

Pistillate flowers of the squash in various stages

4. What color is the pollen which is clinging to the anther? Is it soft and light, or moist and sticky? Do you think that the wind would be able to lift it from its deep cup and carry it to the cup of another flower?

5. Describe the calyx behind this pollen-bearing flower. How many lobes has it? Are the lobes slender and pointed?

6. Find one of the flowers which has below it a little green globe, which will later develop into a pumpkin. How does this flower differ from the one that bears the pollen?

7. Describe or sketch the pistil which is at the bottom of this flower vase. Into how many lobes does it divide? Do these three stigmas face outward or toward each other? Are the styles which uphold the stigmas short or long? Describe the cup

Verne Morton

A pumpkin vine showing tendrils, a flower, and an immature pumpkin

in which they stand. Break away a bit of this little yellow cup and taste it. Why do you think the pumpkin flowers need such a large and well-filled nectary? Could insects get the nectar from the cup without rubbing against the stigmas the pollen with which they became so thoroughly dusted when they visited the staminate flowers?

8. Cut through the center of one of the small green pumpkins. Can you see into how many sections it is divided? Does the number of seed-clusters correspond with the number of stigmas in the flower? Make a sketch of a cross section, showing where the seeds are placed.

9. What insects do you find visiting the pumpkin flowers?

10. Carefully unfold a flower bud which is nearly ready to open, and note how it is folded. Then notice late in the afternoon how the flower closes. What part is folded over first? What next? How does it look when closed?

11. Describe the stems of the pumpkin vine; how are they protected? Sketch or describe a pumpkin leaf.

12. Describe one of the tendrils of the pumpkin vine. Do you think that these tendrils could help the vine in climbing? Have you ever found a pumpkin vine climbing up any object?

The Pumpkin Fruit

Observations — 1. Do you think the pumpkin is a beautiful fruit? Why? Describe its shape and the way it is creased. Describe the rind, its color and its texture. Describe the stalk; does it cling to the pumpkin? How many ridges in the stalk where it joins the vine? How many where it joins the pumpkin? Which part of the stalk is larger? Does this give it a firmer hold?

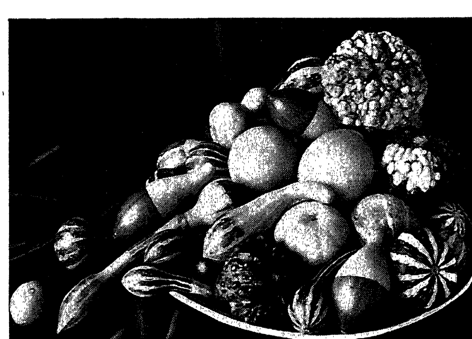
2. Cut in halves crosswise a small green pumpkin and a ripe one. Which is more solid? Can you see how the seeds are borne in the green pumpkin? How do they look in the ripe pumpkin? What is next to the rind in the ripe fruit? What part of the pumpkin do we use for pies?

3. Can you see in the ripe pumpkin where the seeds are borne? How are they suspended? How many rows of seeds lengthwise of the pumpkin? What is left of a pumpkin after the cattle have eaten it? Might the seeds thus left plant themselves?

4. Is the pumpkin seed attached at the round end or at the pointed end? Describe the pumpkin seed, its shape, and its edges. How does it feel when first taken from the pumpkin? How many coats has the seed?

5. Describe the meat of the seed. Does it divide naturally into two parts? Can you see the little embryo plant? Have you ever tried roasting and salting pumpkin and squash seeds, to prepare them for food as almonds and peanuts are prepared?

6. Plant a pumpkin seed in damp sand and give it warmth and light. From which end does it sprout? What comes first, the



Bodger Seeds, Ltd.

Gourds of many varieties are grown for ornamental purposes. Pumpkins, squashes, and cucumbers are all members of the gourd family root or the shoot? What part of the seed forms the seed leaves?

7. Describe how the pumpkin sprout pries open the shell to its seed in order to get its seed leaves out. What happens if it does not pull them out? Which part of the seedling pumpkin appears above ground first?

8. How do the true leaves differ in shape from the seed leaves? In what ways are the seed leaves useful to the plant?

Ah! on Thanksgiving day, when from East
and from West,
From North and from South come the pil-
grim and guest,
When the gray-haired New-Englander
sees round his board
The old broken lines of affection restored,
When the care-wearied man seeks his
mother once more,
And the worn matron smiles where the
girl smiled before,
What moistens the lip and brightens the
eye?
What calls back the past, like the rich
Pumpkin pie?

Oh, fruit loved of boyhood! the old days
recalling,
When wood-grapes were purpling and
brown nuts were falling,
When wild, ugly faces we carved in its
skin,
Glaring out through the dark with a can-
dle within!
When we laughed round the corn-heap,
with hearts all in tune,
Our chair a broad pumpkin — our lantern
the moon,
Telling tales of the fairy who travelled like
steam,
In a pumpkin-shell coach, with two rats
for her team!

— J. G. Whittier

TREES

W. C. Muenscher

Douglas firs, San Juan Island, Washington. These trees show the effects of strong prevailing winds from one direction

I wonder if they like it — being trees?
I suppose they do.
It must feel so good to have the ground so flat,
And feel yourself stand straight up like that.
So stiff in the middle, and then branch at ease,
Big boughs that arch, small ones that bend and blow,
And all those fringy leaves that flutter so.
You'd think they'd break off at the lower end
When the wind fills them, and their great heads bend.
But when you think of all the roots they drop,
As much at bottom as there is on top,
A double tree, widespread in earth and air,
Like a reflection in the water there.

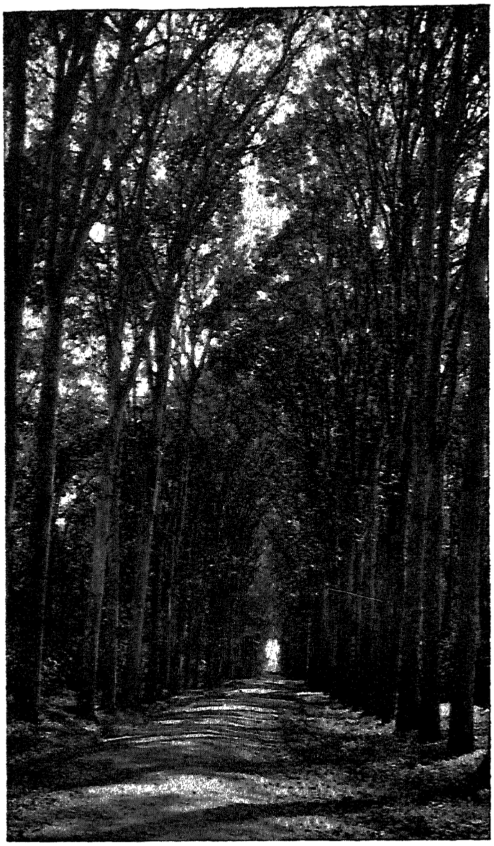
— "Tree Feelings," Charlotte Perkins Stetson

Natural is our love for trees! A tree is a living being, with a life comparable to our own. In one way it differs from us greatly: it is stationary, and it has roots and trunk instead of legs and body; it is obliged to wait to have what it needs come to it, instead of being able to search the wide world over to satisfy its wants.

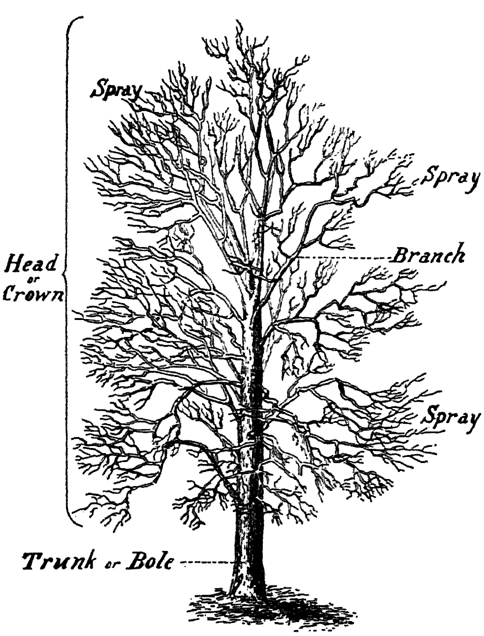
The Parts of the Tree

The *head*, or *crown*, is composed of the branches as a whole, which in turn are composed of the larger and smaller branches and twigs. The *spray* is the term given to the outer twigs, the finest divisions of the trunk, which bear the leaves and fruit. The branches are divisions of the *bole* or *trunk*, which is the body or stem of the tree. The bole, at the base, divides into roots, and the roots into rootlets, which are covered with root hairs. It is important to understand what each of the parts of a tree's anatomy does to help carry on the life of the tree.

The roots, which extend out in every direction beneath the surface of the ground, have two quite different offices to perform: first, they absorb the water and minerals from the soil; second, they hold the tree in place against the onslaught of the winds. If we could see a tree standing on its head with its roots spread in the air in the same manner as they are in the ground, we could then better understand that there is as much of the tree hidden below ground as there is in sight above ground; although the part beneath the ground is of quite different shape, being flatter and in a more dense mass. The roots seem to know in which direction to grow to reach water; thus, the larger number of the roots of a tree are often found to extend out toward a stream flowing perhaps some distance from the tree; when they find plenty of food and water the rootlets interlace forming a solid mat. On the Cornell University campus are certain elms whose roots, every six or seven years, fill and clog the nearby sewers; these trees send most of their roots in the direction of the sewer pipe. The fine rootlets upon the tree roots are covered with root hairs, which really form the mouths by which liquids are taken into the tree.



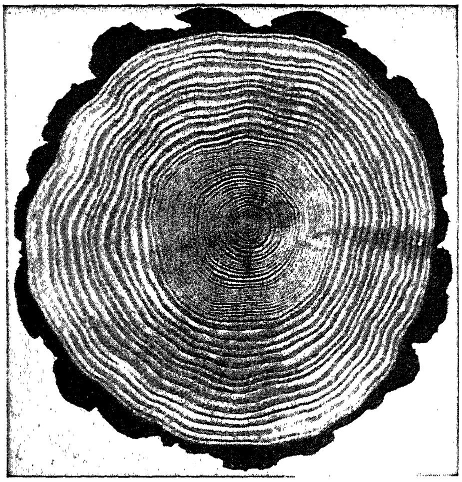
Avenue of trees



A tree with parts named

To understand how firm a base the roots form to hold up the tall trunk, we need to see an uprooted tree. The great roots seem to be molded to take firm grasp upon the soil. It is interesting to study some of the " stump fences " which were made by our forefathers, who uprooted the white pines when the land was cleared of the primeval forest, and made fences of their widespreading but rather shallow extending roots. Many of these fences stand today with branching, out-reaching roots, white and weatherworn, but still staunch and massive as if in memory of their strong grasp upon the soil of the wilderness.

The trunk, or bole, or stem of the tree has also two chief offices: it holds the branches aloft, rising to a sufficient height in the forest so that its head shall push



U. S. Forest Service

Loblolly pine. Annual rings near the center are narrow, but they become much wider. This increased rate of growth was due to thinning of the stand

through the leaf canopy and expose the leaves to the sunlight. It also is a channel by which the sap surges from root to leaf and back again through each growing part. The branches are divisions of the trunk, and have the same work to do.

In cross section, the tree trunk shows on the outside the layer of protective bark; next to this comes the cambium layer, which is the vital part of the trunk; it builds on its outside a layer of bark, and on its inside a layer of wood around the trunk. Just within the cambium layer is a lighter colored portion of the trunk, which is called the sapwood because it is filled with sap, which moves up and down its cells in a mysterious manner; the sapwood consists of the more recent annual rings of growth. Within the sapwood are concentric rings to the very center or pith; this portion is usually darker in color and is called the heartwood; it no longer has anything to do with the life of the tree, but simply gives to it strength and staunchness. The larger branches, if cut across, show a structure similar to that of the trunk — the bark on the outside, the cambium layer next, and within this the rings of annual growth. Even the smaller branches and twigs show similar structure, but they are young and have not attained many annual rings.

The leaves are borne usually on the outermost parts of the tree. A leaf would be of little use, unless it could be reached by the sunlight. Therefore the trunk lifts the branches aloft, and the branches hold the twigs far out, and the twigs divide into the fine spray, so as to spread the leaves and hold them out into the sunshine. In structure, the leaf is made up of the petiole and the blade, or widened portion of the leaf, which is sustained usually with a framework of many ribs or veins. The petioles and the veins are sap channels like the branches and twigs.

WOOD-GRAIN

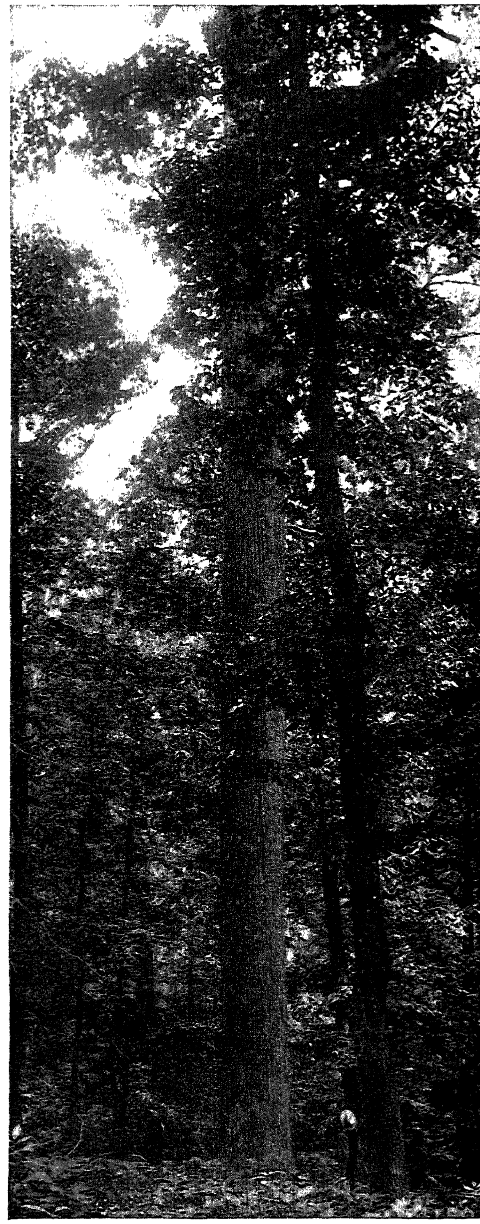
This is the way that the sap-river ran
From the root to the top of the tree
Silent and dark,
Under the bark,
Working a wonderful plan
That the leaves never know,
And the branches that grow
On the brink of the tide never see.

— John B. Tabb

The Way a Tree Grows

The places of growth on a tree may be found at the tips of the twigs and the tips of the rootlets; each year through this growth the tree pushes up higher, down deeper, and out farther at the sides. But in addition to all of these growing tips, there is a layer of growth over the entire tree — over every root, over the trunk, over the limbs, and over each least twig, just as if a thick coat of paint had been put over the complete tree. It is a coat of growth instead, and these coats of growth make the concentric rings which we see when the trunks or branches are cut across. Such growth as this cannot be made without food; but the tree can take only water and minerals from the soil; the root hairs take up the water in which the " fertilizer " is dissolved, and it is carried up through the larger roots, up through the sapwood of the trunk, out through the branches to the leaves, where in the leaf-factories the water and free oxygen are given off to the air, and the nourishing elements retained and mixed with certain chemical elements of the air, thus becoming tree food. The leaf is a factory; the green pulp in the leaf cells is part of the machinery; the machinery is set in motion by sunshine power; the raw materials are taken from the air and from the sap containing minerals from the soil; the finished product is largely starch. Thus, it is well, when we begin the study of the tree, to notice that the leaves are so arranged as to gain all the sunlight possible, for without sunlight the starch factories would be obliged to "shut down." It has been estimated that on a mature maple of vigorous growth there is exposed to the sun nearly a half acre of leaf surface. Our tree appears to us in a new phase when we think of it as a starch factory covering half an acre.

Starch is plant food in a convenient form for storage, and it is stored in sapwood of the limbs, the branches, and trunk, to be used for the growth of the next year's leaves. But starch cannot be assimilated by plants in this form; it must be changed to sugar before it may be used to build up the plant tissues. So the leaves are obliged to perform the office of stomach and digest the food they have made for the tree's use. In the mysterious laboratory of the leaf cells, the starch is changed to sugar; and nitrogen, sulphur, phosphorus, and other substances are taken from the sap and starch added to them, and thus are made the proteids which form another part of the tree's diet. It is interesting to note that while the starch factories can operate only in the sunlight, the leaves can digest the food and it can be transported and used in the growing tissues in the *dark*. The leaves are also an aid to the tree in breathing, but they are not especially the lungs of the tree. The tree breathes in certain respects as we do; it takes in oxygen and gives off carbon dioxide; but the air containing the oxygen is taken in through the numerous pores in the leaves called stomata, and also through lenticels in the bark; so the tree really breathes all over its active surface.



A big tulip poplar, in Jackson County, North Carolina

The tree is a rapid worker and achieves most of its growth and does most of its work by midsummer. The autumn leaf which is so beautiful has completed its work.The green starch-machinery or chlorophyl, the living protoplasm in the leaf cells, has been withdrawn and is safely secluded in the woody part of the tree. The


Verne Morton

Trees in winter

autumn leaf which glows gold or red, has in it only the material which the tree can no longer use. It is a mistake to believe that the frost causes the brilliant colors of autumn foliage; they are caused by the natural old age and death of the leaves — and where is there to be found old age and death more beautiful? When the leaf assumes its bright colors, it is making ready to depart from the tree; a thin, corky layer is being developed between its petiole and the twig, and when this is perfected, the leaf drops from its own weight or the touch of the slightest breeze.

A tree, growing in open ground, records in its shape the direction of the prevailing winds. It grows more luxuriantly on the leeward side. It touches the heart of the one who loves trees to note their sturdy endurance of the onslaughts of this, their most ancient enemy.

Suggested Reading — *Field Book of American Trees and Shrubs*, by F. Schuyler Mathews; *The Forest: A Handbook for Teachers*, by Mrs. Priscilla D. Edgerton; *Forest Facts for Schools*, by Charles L. Pack and Tom Gill; *A Guide to the Trees*, by Alice Lounsberry; *How a Tree Grows*, by William Somerville; *Our Native Trees and How to Identify Them*, by Harriet L. Keeler; *Our Northern Shrubs and How to Identify Them*, by Harriet L. Keeler; *Our Trees, How to Know Them*, by A. I. Emerson and C. M. Weed; *The Tree Book*, by Julia Ellen Rogers; *Trees*, by Julia Ellen Rogers; *Trees; A Simple Guide for Quick Identification of Forest Trees*, by O. L. Sponsler; *Trees in Winter*, by A. F. Blakeslee and C. D. Jarvis; *Trees of Northeastern United States*, by H. P. Brown; additional references are to be found in the bibliography in the back of this Handbook, under Plant Life, Nature-Study in General, Textbooks and Readers; also, readings on page 459.

HOW TO BEGIN TREE STUDY

During autumn the attention of the children should be attracted to the leaves by their gorgeous colors. It is well to use this interest to cultivate their knowledge of the forms of leaves of trees; but the teaching of the tree species to the young child should be done quite incidentally and guardedly. If the teacher says to the child bringing a leaf, " This is a white-oak leaf," the child will soon quite unconsciously learn that leaf by name. Thus, tree study may be begun in the kindergarten or the primary grades.

1. Let the pupils use their leaves as a

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Mt. Baker from Table Mountain, Washington. Trees growing near timberline are stunted

color lesson by classifying them according to color, and thus train the eye to discriminate tints and color values.

2. Let them classify the leaves according to form, selecting those which resemble each other.

3. Let each child select a leaf of his own choosing and draw it. This may be done by placing the leaf flat on paper and outlining it with pencil or with colored crayon.

4. Let the pupils select paper of a color similar to the chosen leaf and cut a paper leaf like it.

5. Let each pupil select four leaves which are similar and arrange them on a card in a symmetrical design. This may be done while the leaves are fresh, and the card with leaves may be pressed and thus preserved.

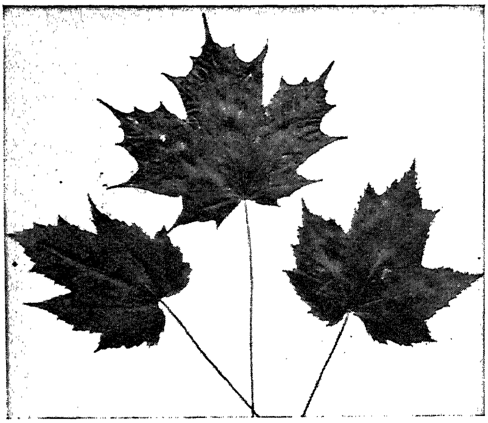
In the fourth grade, begin with the study of a tree which grows near the schoolhouse. In selecting this tree and in speaking of it, impress upon the children that it is a living being, with a life and with needs of its own. I believe so much in making this tree seem an individual, that I would if necessary name it Pocahontas or Martha Washington. First, try to ascertain the age of the tree. Tell an interesting story of who planted it and who were children and attended school in the school building when the tree was planted. To begin the pupils' work, let each have a little notebook in which shall be written, sketched, or described all that happens to this particular tree for a year. The following words with their meanings should be given in the reading and spelling lessons: *Head, bole, trunk, branches, twigs, spray, roots, bark, leaf, petiole, foliage, sap.*

LESSON 172

Tree Study

Autumn Work — 1. What is the color of the tree in its autumn foliage? Sketch it in water colors or crayons, showing the shape of the head, the relative proportions of head and trunk.

2. Describe what you can see of the tree's roots. How far do you suppose the roots reach down? How far out at the sides? In how many ways are the roots useful to the tree? Do you suppose, if the tree were turned bottomside up, that it



Mountain maple, sugar maple, and red maple

would show as many roots as it now shows branches?

3. How high on the trunk from the ground do the lower branches come off? How large around is the trunk three feet from the ground? If you know how large around it is, how can you get the distance through? What is the color of the bark? Is the bark smooth or rough? Are the ridges fine or coarse? Are the furrows between the ridges deep or shallow? Of what use is the bark to the tree?

4. Describe the leaf from your tree, paying special attention to its shape, its edges, its color above and below, its veins or ribs, and the relative length and thickness of its petiole. Are the leaves set opposite or alternate upon the twigs? As the leaves begin to fall, can you find two which are exactly the same in size and shape? Draw in your notebook the two leaves which differ most from each other of any that grew on your tree. At what date do the leaves begin to fall from your tree? At what date are they all off the tree?

5. Do you find any fruit or seed upon your tree? If so describe and sketch it, and tell how you think it is scattered and planted.

Winter Work — 1. Make a sketch of the tree in your notebook, showing its shape as it stands bare. Does the trunk divide into branches, or does it extend through the center of the tree and the branches come off from its sides? Of what use are the branches to a tree? Is the spray — the twigs at the end of the branches — coarse or fine? Does it lift up or droop? Is the bark on the branches like that on the trunk? Is the color of the spray the same as that of the large branches?

2. Study the cut end of a log or stump and also study a slab. Which is the heartwood and which is the sapwood? Can you see the rings of growth? Can you count these rings and tell the age of the tree from which this log came? Describe, if you can, how a tree trunk grows larger each year. What is it that makes the grain in the wood which we use for furniture? If we girdle a tree why may it die? If we place a nail in a tree three feet from the ground this winter, will it be any higher from the ground ten years from now? How does the tree grow tall?

3. Take a twig of a tree in February and look carefully at the buds. What is their color? Are they shiny, rough, sticky, or downy? Are they arranged on the twigs opposite or alternate? Can you see the scar below the buds where the last year's leaf was borne? Place the twig in water and put it in a light, warm place, and see what happens to the buds. As the leaves push out, what happens to the scales which protected the buds?

4. What birds do you find visiting your tree during winter? Tie some strips of

Trunks of young birches, black on left, yellow on right beef fat upon its branches, and note all of the kinds of birds which come to feast upon it.

SPRING WORK — 1. At what date do the young leaves appear upon your tree? What color are they? Look carefully to see how each leaf was folded in the bud. Were all the leaves folded in the same way? Are the young leaves thin, downy, and tender? Do they stand out straight as did the old leaves last autumn, or do they droop? Why? Will they change position and stand out as they grow stronger? Why do the leaves stand out from the twigs in

Ralph W. Curtis

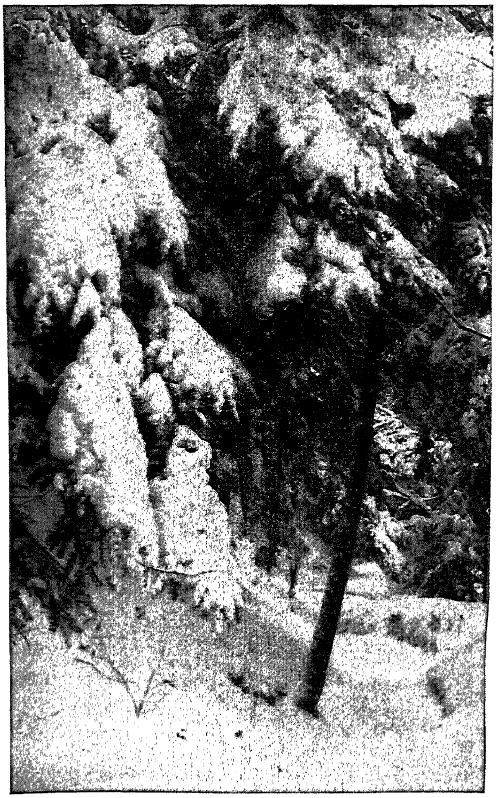
Tamarack

Verne Morton

Sycamore in winter

order to get sunshine? What would happen to a tree if it lost all its leaves in spring and summer? Tell all of the things you know which the leaves do for the tree?

2. Are there any blossoms on your tree in the spring? If so, how do they look?



Hemlocks under a load of snow

Are the blossoms which bear the fruit on different trees from those that bear the pollen, or are these flowers placed separately on the same tree? Or does the same flower which produces the pollen also produce the seed? Do the insects carry the pollen from flower to flower, or does the wind do this for the tree? What sort of fruits are formed by these flowers? How are the fruits scattered and planted?

3. At what date does your tree stand in full leaf? What color is it now? What birds do you find visiting it? What insects? What animals seek its shade? Do the squirrels live in it?

4. Measure the height of your tree as follows: Choose a bright, sunny morning for this. Take a stick $3\frac{1}{2}$ feet long and thrust it in the ground so that three feet will project above the soil. Immediately measure the length of its shadow and the length of the shadow which your tree makes from its base to the shadow of its topmost twigs. Supposing that the shadow from the stick is 4 feet long and the shadow from your tree is 80 feet long, then your example will be: 4 ft.: 3 ft.:: 80 ft.:(?), which will make the tree 60 feet high.

To measure the circumference of the tree, take the trunk three feet from the ground and measure it exactly with a tape measure. To find the thickness of the trunk, divide the circumference just found by 3.14.

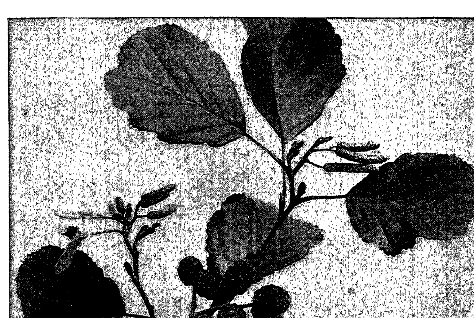
LESSON 173

How to Make Leaf Prints

A very practical help in interesting children in trees is to encourage them to make portfolios of leaf prints of all the trees of the region. Although the process is mechanical, yet the fact that every print must be correctly labeled makes for useful knowledge. One of my treasured possessions is such a portfolio made by the lads of St. Andrews School of Richmond, Virginia, who were guided and inspired in this work by their teacher, Professor W. W. Gillette. The impressions were made in green ink and the results are as beautiful as works of art. Professor Gillette gave me my first lesson in making leaf prints.

Material — 1. A smooth surface such as a slate, a thick plate of glass, or a marble slab about 12 × 15 inches.

2. A tube of printer's ink, either green or black; one tube contains a sufficient supply of ink for making several hundred



Alder showing staminate catkins of current year, and fruits matured from pistillate catkins of preceding year prints. Or a small quantity of printer's ink may be purchased at any printing office.

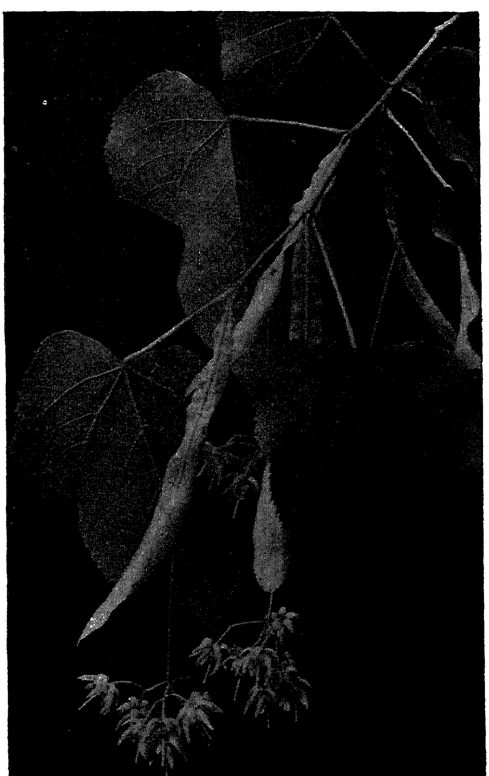
3. Two six-inch rubber rollers, such as photographers use in mounting prints. A letter press may be used instead of one roller.

4. A small bottle of kerosene to dilute the ink, and a bottle of gasoline for cleaning the outfit after using, care being taken to store them safe from fire.

5. Sheets of paper; $8\frac{1}{2} \times 11$ inches is a good size. The paper should be of good quality, with smooth surface, in order that it may take and hold a clear outline. The ordinary paper used in printers' offices for printing newspapers works fairly well.

To make a print, place a few drops of ink upon the glass or slate, and spread it about with the roller until there is a thin coat of ink upon the roller and a smooth patch in the center of the glass or slate. It should never be so liquid as to "run," for then the outlines will be blurred. Ink the leaf by placing it on the inky surface of the glass and passing the inked roller over it once or twice until the veins show that they are smoothly filled. Now place the inked leaf between two sheets of paper and roll once with the *clean* roller, bearing down with all the strength possible; a second passage of the roller blurs the print. Two prints are made at each rolling, one of the upper, and one of the under side of the leaf. Dry and wrinkled leaves may be made pliant by soaking in water, and drying between blotters before they are inked.

Leaf print of a sycamore maple



Linden in blossom

Prints may also be made a number at a time by pressing them under weights, being careful to put the sheets of paper with the leaves between the pages of old magazines or folded newspapers, in order that the impression of one set of leaves may not mar the others. If a letter press is available for this purpose, it does the work quickly and well.

SAP

Strong as the sea and silent as the grave,
It flows and ebbs unseen,
Flooding the earth, a fragrant tidal wave,
With mists of deepening green.

—John B. Tabb

Troy Studio

Sugar bush in spring

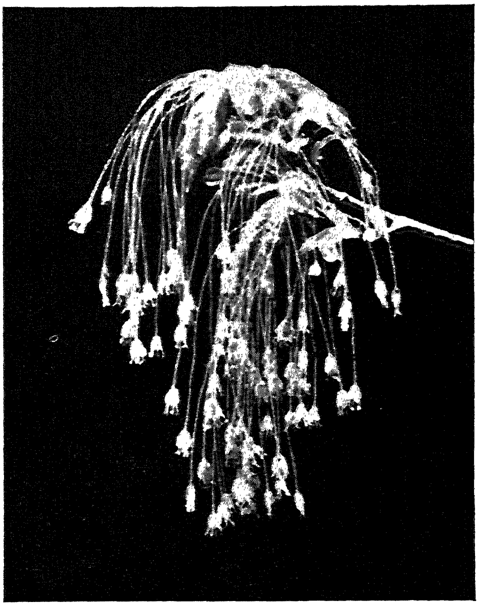
THE MAPLES

The sugar maple, combining beauty with many kinds of utility, is dear to the American heart. Its habits of growth are very accommodating; when planted where it has plenty of room, it shows a short trunk and oval head, which, like a dark green period, prettily punctuates the summer landscape; but when it occurs in the forest, its noble bole, a pillar of granite gray, rises to uphold the arches of the forest canopy; and it often attains there the height of one hundred feet. It grows rapidly and is a favorite shade tree, twenty years being long enough to make it thus useful. The foliage is deep green in the summer, the leaf being a glossy, dark green above and paler beneath. It has five main lobes, the two nearest the petiole being smaller; the curved edges between the lobes are marked with a few smoothly cut, large teeth; the main veins extend directly from the petiole to the sharp tips of the lobes; the petiole is long, slender, and occasionally red. The leaves are placed opposite. The shade made by the foliage of the maple is so dense that it shades down the plants beneath it; even grass grows but sparsely there. If a shade tree stands in an exposed position, it grows luxuriously to the leeward of the prevailing winds, and thus makes a one-sided record of their general direction.

It is its autumn transfiguration which has made people observant of the maple's beauty; yellow, orange, crimson, and scarlet foliage makes these trees gorgeous when October comes. Nor do the trees get their color uniformly; even in September, the maple may show a scarlet branch in the midst of its green foliage. I believe this is a hectic flush and a premonition of death to the branch which, less vigorous than its neighbors, is being pruned out by Nature's slow but sure method. After the vivid color is on the maple, it begins to shed its leaves. This is by no means the sad act which the poets would have us believe; the brilliant colors are an evidence that the trees have withdrawn from the leaves much of the manufactured food and have stored it snugly in trunk and branch for winter keeping. Thus, only the mineral substances and waste materials are left in the leaf, and they give the vivid hues. It is a mistake to think that frost causes this brilliance; it is caused by the natural, beautiful, old age of the leaf. When the leaves finally fall, they form a mulch-carpet, and add their substance to the humus from which trees and other plants draw new powers for growth.

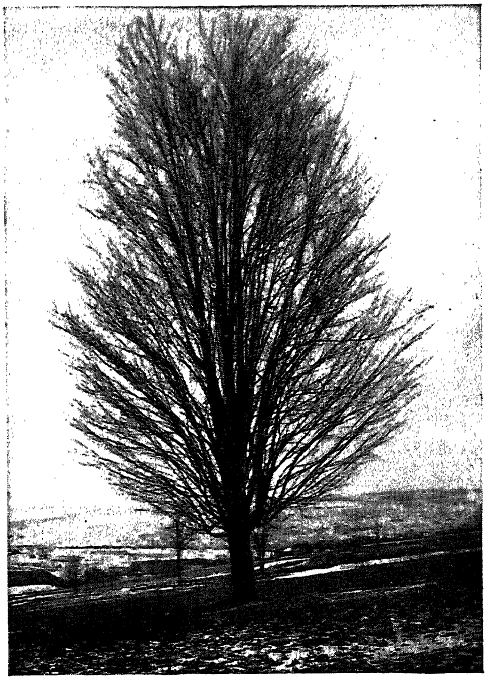
After every leaf has fallen, the maple shows why its shade is dense. It has many branches set close and at sharp angles to the trunk, dividing into fine, erect spray, giving the tree a resemblance to a giant whisk broom. Its dark, deep-furrowed bark smoothes out and becomes light gray on the larger limbs, while the spray is purplish, a color given it by the winter buds. These buds are sharp-pointed and long. In late winter, their covering of scales shows premonitions of spring by enlarging, and as if due to the soft influence, they become downy, and take on a sunshine color before they are pushed off by the leaves. The leaves and the blossoms appear together. The leaves are at first yellowish, downy, and drooping. The flowers appear in tassel-like clusters, each downy, drooping thread of the tassel bearing at its tip a five-lobed calyx, which may hold seven or eight long, drooping stamens or a pistil with long, double stigmas. The flowers are greenish yellow, and those that bear pollen and those that bear the seeds may be borne on separate trees or on the same tree, but they are always in different clusters. If on the same tree, the seed-bearing tassels are at the tips of the twigs, and those bearing pollen are along the sides.

Sugar maple leaves



Sugar maple blossoms

The ovary is two-celled, but there is usually only one seed developed in the pair which forms a " key "; to observe this, however, we have to dissect the fruits; they have the appearance of two seeds joined together, each provided with a thin, closely veined wing and the two attached to the tree by a single long, drooping stem. This twin-winged form is well fitted to be whirled off by the autumn winds, for the



Sugar maple growing in the open

seeds ripen in September. I have seen seedlings growing thickly for rods to the leeward of their parent tree, which stood in an open field. The maples may bear blossoms and produce seeds every year.

There are six species of native maples which are readily distinguishable. The silver and the red maples and the box elder are rather large trees; the mountain and the striped (or goosefoot) maples are scarcely more than shrubs, and mostly grow in woods along streams. The Norway and the sycamore maples have been introduced from Europe for ornamental planting. The cut-leaf silver maple comes from Japan.

The maple wood is hard, heavy, strong, tough, and fine-grained; it is cream color, the heartwood showing shades of brown; it takes a fine polish and is used as a finishing timber for houses and furniture. It is used in construction of ships, cars, piano action, and tool handles; its fine-grained quality makes it good for wood carving; it is an excellent fuel and has many other uses.

Maple Sugar Making

Although we have tapped the trees in America for many hundred years, we do not as yet understand perfectly the mysteries of the sap flow. In 1903, the scientists at the Vermont Experiment Station did some very remarkable work in clearing up the mysteries of sap movement. Their results were published in their Bulletins 103 and 105, which are very interesting and instructive.

The starch which is changed to sugar in the sap of early spring was made the previous season and stored within the tree. If the foliage of the tree is injured by caterpillars one year, very little sugar can be made from that tree the next spring, because it has been unable to store enough starch in its sapwood and in the outer ray cells of its smaller branches to make a good supply of sugar. During the latter part of winter, the stored starch disappears, being converted into tree-food in the sap, and then begins that wonderful surging up and down of the sap tide. During the first part of a typical sugar season, more sap comes from above down than from below up; toward the end of the season, during poor sap days, there is more sap coming up from below than down from above. The ideal sugar weather consists of warm days and freezing nights. This change of temperature between day and night acts as a pump. During the day when the branches of the tree are warmed, the pressure forces into the hole bored into the trunk all the sap located in the adjacent cells of the wood. Then the suction which follows a freezing night drives more sap into those cells, which is in turn forced out when the top of the tree is again warmed. The tree is usually tapped on the south side, because the action of the sun and the consequent temperature-pump more readily affects that side.

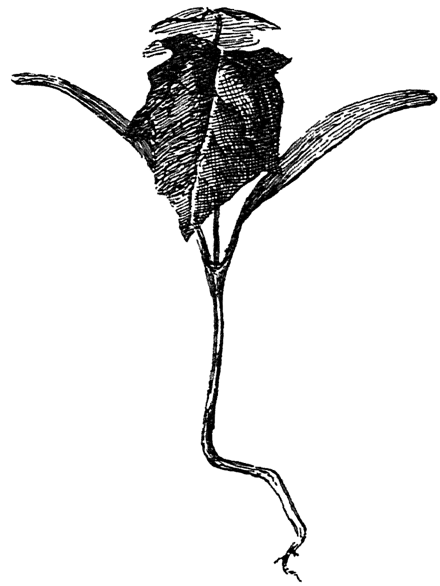
"Tapping the sugar bush" are magical words to the country boy and girl. Well do we older folk remember those days in March when the south wind settled the snow into hard, marble-like drifts, and the father would say, "We will get the sap buckets down from the stable loft and wash them, for we shall tap the sugar bush soon." In those days the buckets were made of staves and were by no means so easily washed as are the metal buckets of today. Well do we recall the sickish smell of musty sap that greeted our nostrils when we poured in the boiling water to clean those old brown buckets. Previously during the winter evenings, we all had helped fashion sap spiles from stems of sumac. With buckets and spiles ready when the momentous day came, the large, iron caldron kettle was loaded on a stoneboat together with a sap cask, log chain, ax, and various other utensils, and as many children as could find standing room; then the oxen were hitched on and the procession started across the rough pasture to the woods, where it eventually arrived after numerous stops for reloading almost everything but the kettle.

When we came to the boiling place, we lifted the kettle into position and flanked it with two great logs against which the fire was to be kindled. Meanwhile the oxen and stoneboat returned to the house for a load of buckets. The oxen, blinking, with bowed heads, or with noses lifted aloft to keep the underbrush from striking their faces, " gee'd and haw'd " up hill and down dale through the woods, stopping here and there while the men with augers bored holes in certain trees near other holes which had been made in years

Verne Morton

A foretaste. An old-fashioned sugar bush

gone by. When the auger was withdrawn, the sap followed it, and enthusiastic young tongues met it half way, though



Maple seedling

they received more chips than sweetness therefrom; then the spiles were driven in with a wooden mallet.

The next day after " tapping," those of us large enough to wear the neck yoke donned cheerfully this badge of servitude and with its help brought pails of sap to the kettle, and the " boiling " began. As the evening shades gathered, how delicious was the odor of the sap steam, permeating the woods farther than the shafts of firelight pierced the gloom! How weird and delightful was this night experience in the woods! And how cheerfully we swallowed the smoke which the contrary wind seemed ever to turn toward us! We poked the fire to send the sparks upward, and now and then added more sap from a barrel, and removed the scum from the boiling liquid with a skimmer thrust into the cleft of a long stick for a handle. As the evening wore on, we drew closer to each other as we told stories of the Indians, bears, panthers, and wolves which had roamed these woods when our father was a little boy; and came to each of us a

M. V. Slingerland

Leaves of silver maple

disquieting suspicion that perhaps they were not all gone yet, for everything seemed possible in those night-shrouded woods; and our hearts suddenly " jumped into our throats " when nearby there sounded the tremulous, blood-curdling cry of the screech owl.

After about three days of gathering and boiling sap, came the " siruping down." During all that afternoon we added no more sap and we watched carefully the tawny, steaming mass in the kettle; when it threatened to boil over, we threw in a thin slice of fat pork which seemed to have some mysterious calming influence. The odor grew more and more delicious and presently the sirup was pronounced sufficiently thick. The kettle was swung off the logs and the sirup dipped through a cloth strainer into a carrying-pail. Oh, the blackness of the residue left on that strainer! But it was clean woods-dirt and never destroyed our faith in the maple sugar, any more than did the belief that our friends were made of dirt destroy our friendship for them. The next day our interests were transferred to the house, where we " sugared off." There we boiled the sirup to sugar on the stove and pouring it thick and hot upon snow made that most delicious of all sweets — the maple wax; or we stirred it until it " grained," before we poured it into the tins to make the " cakes " of maple sugar.

Now the old stave bucket and the sumac spile are gone; in their place the patent galvanized spile not only conducts the sap but holds in place a tin bucket carefully covered. The old caldron kettle is broken, or lies rusting in the shed. In its place, in the newfangled sugar-houses, are evaporating vats, set over furnaces with chimneys. But we may as well confess that the maple sirup of today seems to us a pale and anemic liquid, lacking the delicious flavor of the rich, dark nectar which we, with the help of cinders, smoke, and various other things, brewed of yore in the open woods.

Suggested Reading — *Maple Sugar Time*, by Royce S. Pitkin; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons; Our Plant Friends and Foes*, by William A. DuPuy; also, readings on page 622.

LESSON 174

The Sugar Maple

Leading Thought — The sugar maple grows very rapidly, and is therefore a useful shade tree. Its wood is used for many purposes, and from its sap is made a delicious sugar.

Method — This study of the maple should be done by the pupils out of doors, with a tree to answer the questions. The

Ralph W. Curtis

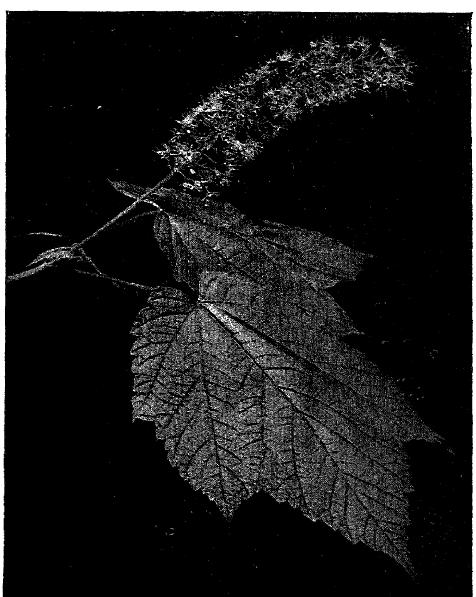
Blossoms of the silver maple

study of the leaves, blossoms, and fruit may be made in the schoolroom. The maple is an excellent subject for Lesson 172. The observations should begin in the fall and continue at intervals until June.

OBSERVATIONS. FALL WORK — 1. Where is the maple you are studying? Is it near other trees? What is the shape of the head? What is the height of the trunk below the branches? What is the height of the tree? How large around is the trunk three feet from the ground? Can you find when the tree was planted? Can you tell by the shape of the tree from which direction the wind blows most often?

2. Can you find fruits on your tree? Each fruit is called a key. Sketch a key, showing the way the seeds are joined and the direction of the wings. Sketch the stem which holds the key to the twig. Are both halves of the key good or is one empty? How are the fruits scattered and planted? How far will a maple key fly on its wings? Plant a maple fruit where you can watch it grow next year.

3. Make leaf prints and describe a leaf of the maple, showing its shape, its veins,



Ralph W. Curtis

Blossoms of mountain maple

Ralph W. Curtis

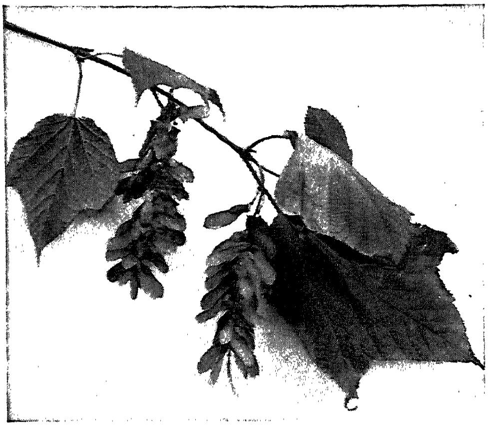
Blossoms of striped maple

and petiole. Are the leaves arranged opposite or alternate on the twig? Make leaf prints or sketches of the leaves of all the other kinds of maples which you can find. How can you tell the different kinds of maples by their leaves?

4. If your tree stands alone, measure the ground covered by its shadow from morning until evening. Mark the space by stakes. What grows beneath the tree? Do grass and other plants grow thriftily beneath the tree? Do the same plants grow there as in the open field?

5. Does your maple get its autumn colors all at once, or on one or two branches first? At what time do you see the first autumn colors on your tree? When is it completely clothed in its autumn dress? Is it all red or all yellow, or mixed? If it is yellow this year do you think it will be red next year? Watch and see. Sketch your maple in water colors.

6. At what time do the leaves begin to fall? Do those branches which first colored brightly shed their leaves before the



Ralph W. Curtis

Leaves and fruit of striped maple

others? At what date does your tree stand bare?

7. Find a maple tree in the forest and compare it with one that grows as a shade tree in a field. Why this difference?

WINTER WORK — 8. Make a sketch of your maple with the leaves off. What sort of bark has it? Is the bark on the branches like that on the trunk? Are the main branches large? At what angle do they come off the trunk? Does the trunk extend up through the entire tree? Is the spray fine or coarse? Is it straight or crooked?

9. Study the winter buds. Are they alternate or opposite on the twigs? Are they shining or dull?

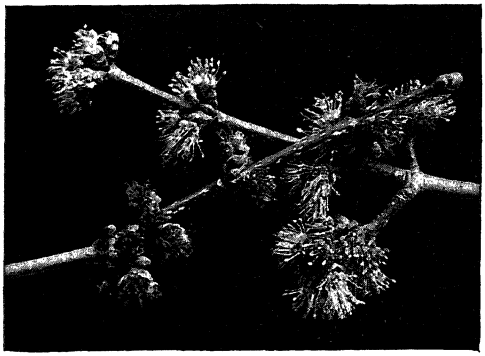
SPRING WORK — 10. At what time do we tap maple trees for sap? On which side of the tree do we make the hole? If we tapped the tree earlier would we get any sap? What kind of weather is the best for causing sap flow? Do you suppose that it is the sap going up from the root to the tree and the branches, or that coming down from the branches to the root which flows into the bucket? Why do we not make maple sugar all summer? Do you suppose the sap ceases to run because there is no more sap in the tree?

11. Write a story telling all you can find in books or that you know from your own experience about the making of maple sugar.

12. When do the leaves of your maple first appear? How do they then look? Do they stand out or droop?

13. Do the blossoms appear with the leaves or after them? How do the blossoms look? Can you tell the blossoms with stamens from those with pistils? Do you find them in the same cluster? Do you find them on the same tree?

14. What uses do we find for maple wood? What is the character of the wood?



Ralph W. Curtis

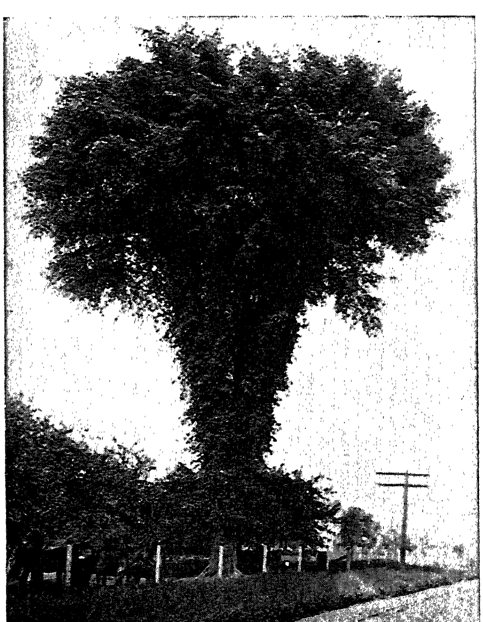
Blossoms of red maple

THE AMERICAN ELM

Although the American elm loves moist woods, it is one of those trees that enjoy gadding; and without knowing just how it has managed to do it, we can see plainly that it has planted its seeds along fence corners, and many elms now grace our fields on sites of fences long ago laid low. Because of its beautiful form and its rapid growth, the elm has been from earliest times a favorite shade tree in the Eastern and Middle States. Thirty years after being planted, the elms on the Cornell University campus clasped branches across the avenues; and the beauty of many a village and city is due chiefly to these graceful trees of bounteous shade. Moreover, the elm is at no time more beautiful than when it traces its flowing lines against the background of snow and gray horizon. Whether the tree be shaped like a vase or a fountain, the trunk divides into great uplifting branches, which in turn divide into spray that oftentimes droops gracefully, as if it were made purposely to sustain from its fine tips the woven pocket-nest of the oriole. No wonder this bird so often chooses the elm for its rooftree!

In winter, the dark, coarsely-ridged bark and the peculiar, wiry, thick spray, as well as the characteristic shape of the tree reveal to us its identity; some elms have a peculiar habit of growing their short branches all the way down their trunk, making them look as if they were entwined with a vine. The elm leaf, although its ribs are straight and simple, shows a little quirk of its own in the uneven sides of its base where it joins the petiole; it is dark green and rough above, light green and somewhat rough below; but this leaf is rough only when stroked in certain directions, while the leaf of the slippery elm is rough whichever way it may be stroked. The edges of the leaf have saw teeth, which are in turn toothed; the petiole is short. The leaf comes out of the bud in the spring folded like a little fan; but before the fans are opened to the spring breezes, the elm twigs are furry with reddish green blossoms. The blossom consists of a calyx with an irregular number of lobes, and for every lobe, a stamen which consists of a threadlike filament from which hangs a bright red anther; at the center is a two-celled pistil with two light green styles. These blossoms appear in March or early April, before the leaves.


Ralph W. Curtis
Blossoms of slippery elm


Ralph W. Curtis
American elm, vase type

When full-grown the fruit hangs like beaded fringe from the twigs. The fruit is flat and has a wide, much-veined margin or wing, notched at the tip and edged with a white silken fringe; the seed is at the center, wrinkled and flat. Each fruit shows at its base the old calyx and is attached by a slender threadlike stem to the twig at the axils of last year's leaves. A little later the lusty breezes of spring break the frail threads and release the fruits, al-

G. F. Morgan

Elm fruit

though few of them find places fit for growth of seeds.

The elm roots are water hunters and extend deep into the earth; most of them grow toward water, seeming to know the way. The elm heartwood is reddish, the sapwood being broad and whitish in color; the wood is very tough because of the interlaced fibers, and therefore very hard to split. It is used for cooperage, wheel hubs, saddlery, and is now used more extensively for furniture; its grain is most ornamental. It is fairly durable as posts, but perhaps the greatest use of all for the tree is for shade. The slippery elm is much like the white elm, except that its inner bark is very mucilaginous, and children love to chew it. The cork elm has a peculiar corky growth on its branches, giving it a very unkempt look. The wahoo, or winged elm, is a small tree, and its twigs are ornamented on each side by a corky layer. The English elm has a solid, round head, very different from that of our graceful species. The elms are long-lived, unless attacked by insects or disease; some elm trees have lived for centuries. The Washington elm in Cambridge, and the William Penn elm in Philadelphia, which now has a monument to mark its place, were famous trees.

Lovers of the elm are at present much alarmed at the inroads made by the Dutch elm disease, so called because it was first discovered in Holland. It first appeared in this country in Ohio in 1930, and many hundreds of infected trees have since been discovered in northern New Jersey and southeastern New York. The disease is caused by a fungus, *Ceratostomella ulmi*, the spores of which are carried from tree to tree by the European elm bark-beetle.

A tree seriously infected is doomed, and will serve as a focal point of infection to healthy trees. Dead branches should be cut and burned as soon as seen, and thoroughly infected trees should be completely destroyed, root and branch. Any competent plant pathologist can from a study of infected twigs identify the disease, which in its early stages resembles less serious disorders.

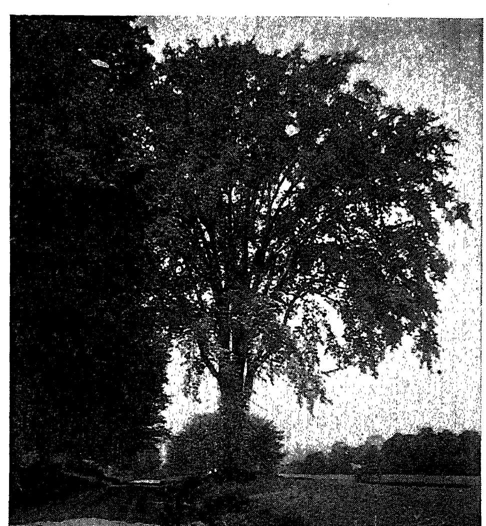
Unless the disease is eradicated by these drastic measures, our beautiful elms may succumb as did the chestnuts to the chestnut blight. No one would willingly picture America without its elms.

SUGGESTED READING — *Holiday Hill*, by Edith M. Patch; *Our Plant Friends and Foes*, by William A. DuPuy; *Under These Trees*, by Grace Humphry; also, readings on page 622.

LESSON 175

THE ELM

LEADING THOUGHT — The elm has a peculiarly graceful form, which makes it of



Ralph W. Curtis

American elm

value as a shade tree. It grows best in moist locations. Its wood is very tough.

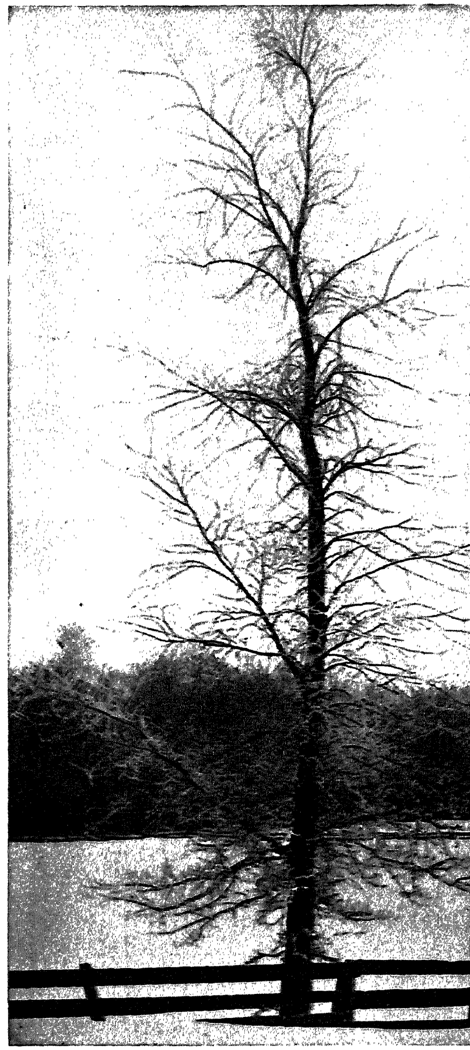
METHOD — This work should be begun in the fall with the study of the shape of the tree and its foliage. Sketches should be made when the tree is clothed in autumn tints, and later it should be sketched again when its branches are naked. Its blossoms should be studied in March and April and its fruits in May.

OBSERVATIONS — 1. Where does the elm grow? Does it thrive where there is little water? What is the usual shape of the elm? How does the trunk divide into branches to make this shape possible? What is the shape of the larger elms? Describe the spray. Describe the elm bark. How can you tell the elm from other trees in winter?

2. Study the elm leaf. What is its form? What kind of edges has it? How large is it? What is the difference in appearance and feeling between the upper and lower sides? Are the leaves rough above whichever way you stroke them? If a leaf is folded lengthwise are the two halves exactly alike? How are the leaves arranged on the twig? What is their color above and below? Describe the leafy growth along the trunk.

3. What is the color of the elm tree in autumn? Make a sketch of the elm tree you are studying.

American elm



Verne Morton

American elm in winter

4. What sort of roots has the elm? Do they grow deep into the earth? What is the character of its wood? Is it easy to split? Why? What are the chief uses of the elm?

5. Do you know what distinguishes the slippery elm, the cork elm, the winged elm or wahoo, and the English elm from the common American or white elm which you have been studying?

6. Write an essay on two famous American elms.

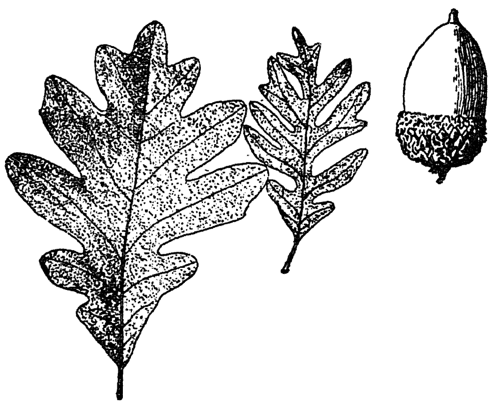
7. What birds love to build in the elm trees?

8. What disease threatens our elms? What steps should be taken to save the elms?

SPRING WORK — 9. Which appear first, the blossoms or the leaves? Describe the elm blossom. How long before the fruits ripen? How are the fruits attached to the twig? Describe an elm fruit. How are the fruits scattered? How are the young leaves folded as they come out of the bud?

THE OAKS

The symbol of rugged strength since man first gazed upon its noble proportions, the oak more than other trees has

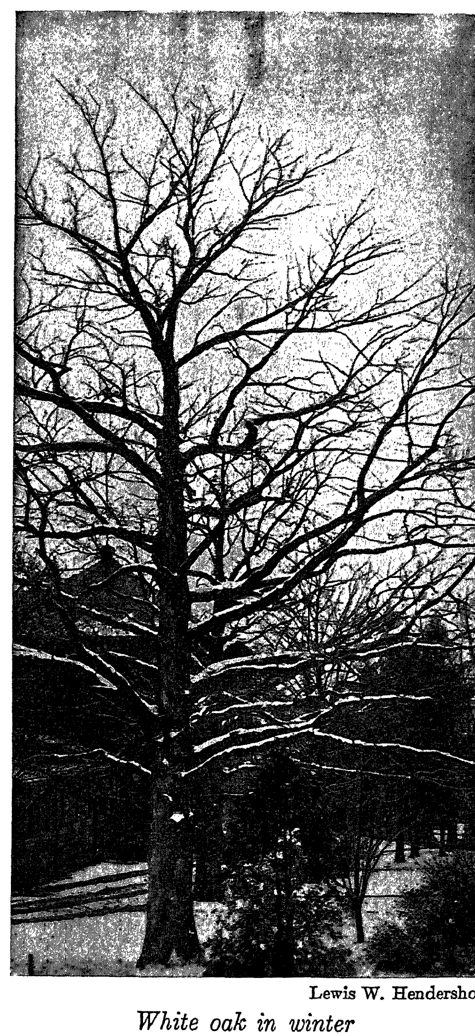


White-oak leaves and acorn

been entangled in human myth, legend, and imagination. It was regarded as the special tree of Zeus by the Greeks; while in primitive England the strange worship of the Druids centered on it. Virgil sang of it thus:

Full in the midst of his own strength he stands
Stretching his brawny arms and leafy hands,
His shade protects the plains, his head the hills commands.

Although the oak is a tree of grandeur when its broad branches are covered with leafage, yet it is only in winter when it stands stripped like an athlete that we realize wherein its supremacy lies. Then only can we appreciate the massive trunk and the strong limbs bent and gnarled with combating the blasts of centuries. But there are oaks and oaks, and each species fights time and tempest in his own peculiar armor and in his own way. Many of the oaks achieve the height of eighty to one hundred feet. The great branches come off the sturdy trunk at wide angles, branches crooked or gnarled but which may be long and strong; the smaller

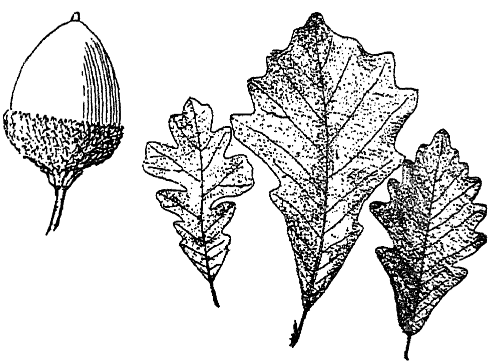


Lewis W. Hendershot

White oak in winter

branches also come off at wide angles, and in turn bear angular individual spray — all of which, when covered with leaves, make the broad, rounded head which characterizes this tree. The oaks are divided into two classes which the children soon learn to distinguish, as follows:

A. *The white oak group,* the leaves of which have rounded lobes and are rough and light-colored below; the wood is light-colored, the acorns have sweet kernels and mature in one year, so that there are no acorns on the branches in winter. To this class belong the white, chestnut, bur, post, and chinquapin oaks.

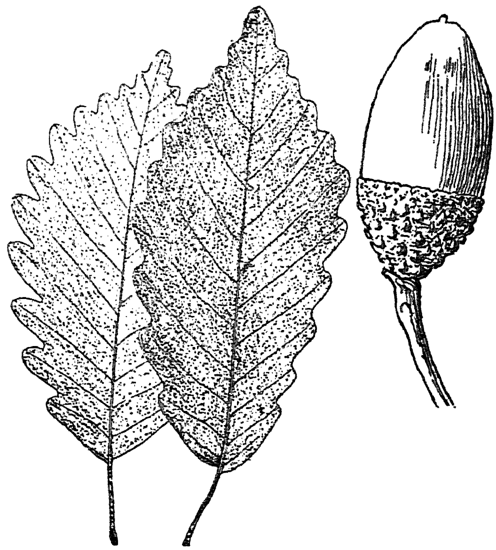


Leaves and acorn of swamp white oak

AA. *The black oak group,* the leaves of which are nearly as smooth below as above, and have angular lobes ending in sharp points. The bark is dark in color, the acorns have bitter kernels and require two years for maturing, so that they may be seen on the branches in winter. To this group belong the black, red, scarlet, Spanish, pin, scrub, blackjack, laurel, and willow oaks.

There is a great variation in the shape of the leaves on the same tree, and while the black, the red, and the scarlet oaks are well-marked species, it is possible to find leaves on these three different trees which are similar in shape. Oaks also hybridize, and thus their leaves are a puzzle to the botanist; but in general, the species can be determined by tree books, and the pupils may learn to distinguish some of them.

The acorns and their scaly saucers are varied in shape, and are a delight to children as well as to pigs. The great acorns of the red oak are made into cups and saucers



Leaves and acorn of chestnut oak

by the girls, and those of the scarlet oak into tops by the boys. The white oaks turn

Ralph W. Curtis

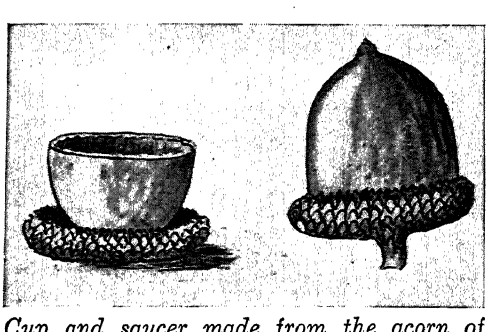
Blossoms of chestnut oak. Compare with chestnut blossoms, p. 646 a rich wine-color in the autumn, while the bur and the chestnut are yellow. The red oak is a dark, wine-red; the black oak russet, and the scarlet a deep and brilliant red.

W. C. Baker

White oak in winter

When the oak leaves first come from the buds in the spring, they are soft and downy and drooping, those of the red and scarlet being reddish, and those of the white, pale green with red tints. Thoreau says of them, " They hang loosely, flacidly down at the mercy of the wind, like a new-born butterfly or dragonfly."

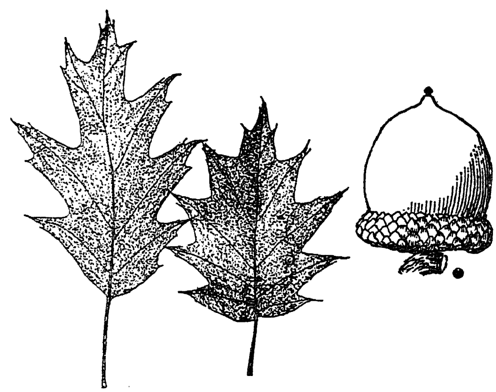
The pollen-bearing flowers are like beads on a string, several strings hanging down from the same point on the twig, making a fringe, and they are attractive to the eye that sees. The pistillate flowers



Cup and saucer made from the acorn of red oak

are inconspicuous, at the axils of the leaves, and have irregular or curved stigmas; they are on the same branch as the pollen-bearing flowers.

The oak is long-lived; it does not produce acorns until about twenty years of age and requires about a century to mature. Although from two to three hundred years is the average age of most oaks, yet a scarlet oak of my acquaintance is about four hundred years old, and there are oaks still living in England which were there when William the Conqueror came. The famous Wadsworth Oak at Geneseo,

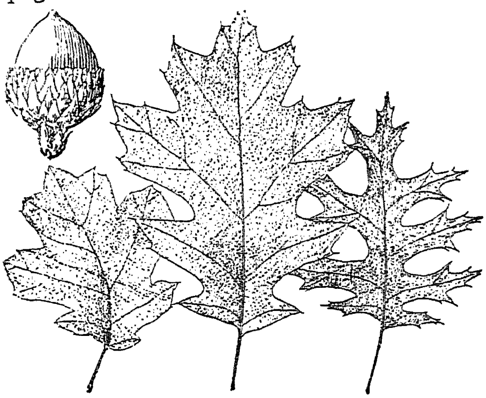


Leaves and acorn of red oak

New York, had a circumference of twenty-seven feet. This was a swamp white oak. One reason for their attaining great age is long, strong, taproots which plant them deep; doubtless the great number of roots near the surface which act as braces, and their large and luxurious heads, also help the oaks to survive.

Oak wood is usually heavy, very strong, tough, and coarse. The heart is brown, the sapwood whitish. It is used for many purposes — ships, furniture, wagons, cars, cooperage, farm implements, piles, wharves, railway ties, etc. The white and live oaks give the best wood. Oak bark is used extensively for tanning.

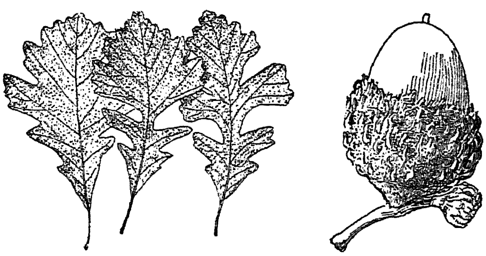
Suggested Reading — *First Studies of Plant Life*, by George F. Atkinson; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; Our Plant Friends and Foes*, by William A. DuPuy; *Under These Trees*, by Grace Humphry; also, readings on page 622.



Leaves and acorn of black oak

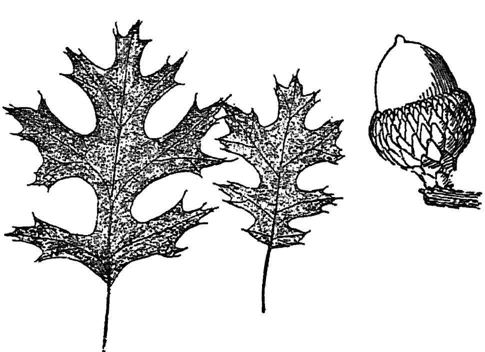
LESSON 176
The Oaks

Leading Thought — The oak tree is the symbol of strength and loyalty. Let us study it and see what qualities in it have thus distinguished it.

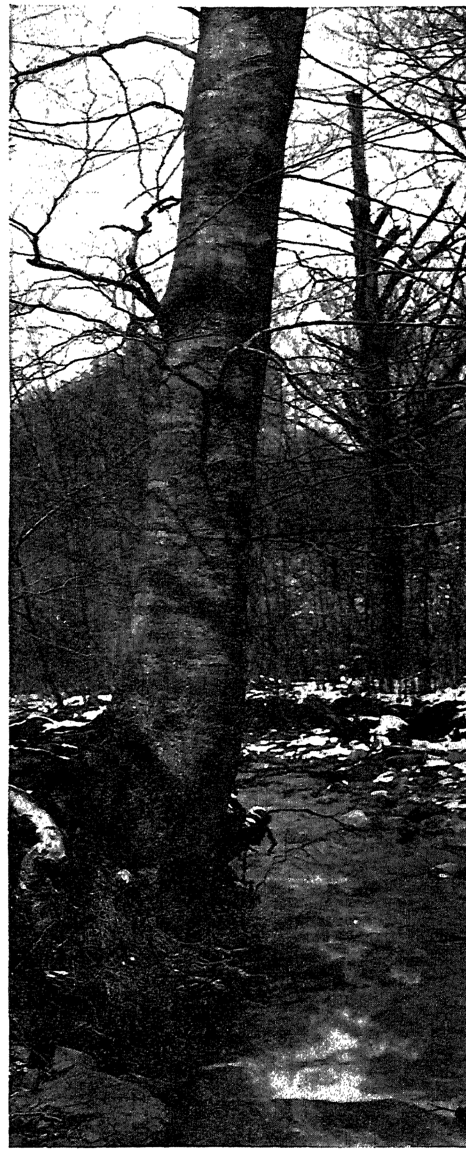


Leaves and acorn of bur oak

Method — Any oak tree may be used for this lesson; but whatever species is used, the lesson should lead to the knowledge of all the species of oaks in the neighborhood. The tree may be sketched, essays concerning the connection of the oak with human history may be written, while the leaves and acorns may be brought into the schoolroom for study. Use Lesson 173 for a study of leaves of all the oaks of the neighborhood.



Leaves and acorn of scarlet oak



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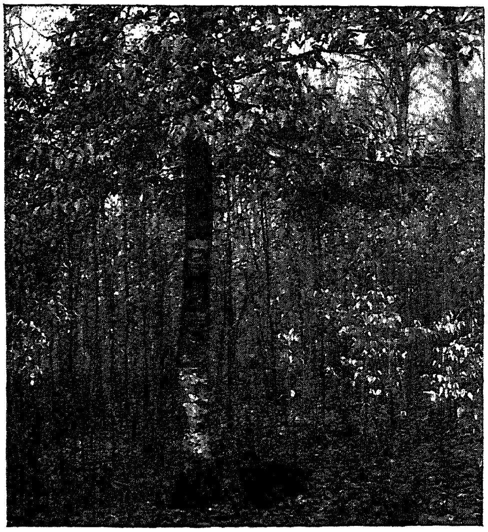
Beech, a near relative of the oak

Observations — 1. Describe the oak tree which you are studying. Where is it



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Beech photographed in April showing last year's leaves

growing? What shape is its head? How high in proportion to the head is the trunk? What is the color and character of its bark? Describe its roots as far as you can see. Are the branches straight or crooked? Delicate or strong? Is the spray graceful or angular?

2. What is the name of your oak tree? What is the color of its foliage in autumn? Find three leaves from your tree which differ most widely in form, and sketch them or make leaf prints of them for your notebook. Does the leaf have the lobes rounded, or angular and tipped with sharp points? Is the leaf smooth on the lower side or rough? Is there much difference in color between the upper and the lower side?

3. Describe the acorns which grow on your oak. Has the acorn a stem, or is it set directly on the twig? How much of the acorn does the cup cover? Are the scales on the cup fine or coarse? Is the cup rounded inwards at its rim? What is the length of the acorn including the cup? The diameter? Are there acorns on your oak in winter? Is the kernel of the acorn sweet or bitter? Plant an acorn and watch it sprout.

4. Read stories about oak trees, and write them in your notebook in your own words.

5. How great an age may the oak attain? Describe how the country round about looked when the oak you are studying was planted.

6. How many kinds of oaks do you know? What is the difference in leaves between the white and the black oak groups? What is the difference in the length of time required for the acorns to mature in these two groups? The difference in taste of the acorns? The difference in the general color of the bark?

7. How do the oak leaves look when they first come out of the bud in spring? What is the color of the tree covered with new leaves? When does your oak blossom? Find the pollen-bearing blossoms, which are hung in long, fuzzy, beady strings. Find the pistillate flower which is to form the acorn. Where is the pistillate flower situated in relation to the pollen-bearing flower?

8. Make a sketch of your oak tree in the fall, and another in the winter. Write the autobiography of some old oak tree in your neighborhood.

9. For what is the oak wood used? How is the bark used?

Beech nuts and "husks"

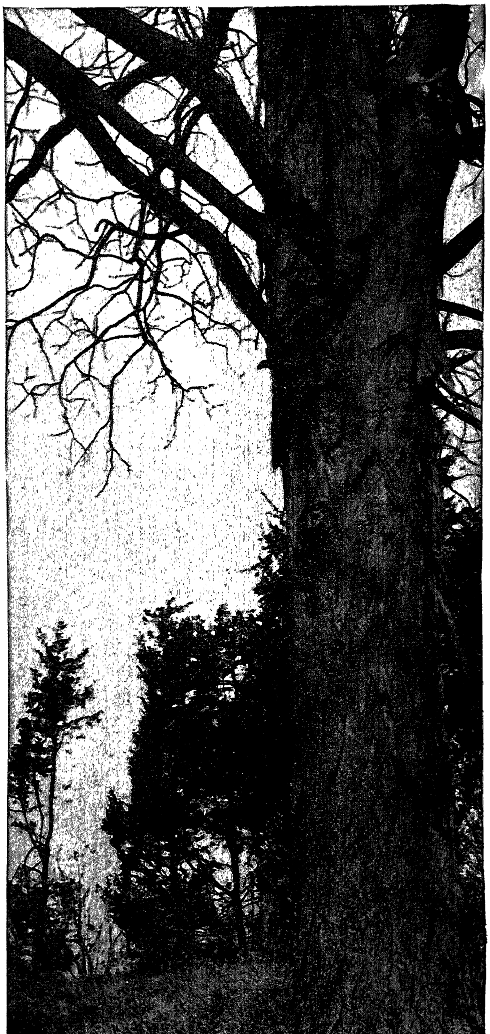
THE SHAGBARK HICKORY

How pathetically the untidy bark of this dignified tree suggests the careless raiment of a great man! The shagbark is so busy being something worth while that it does not seem to have time or energy to clothe itself in tailor-made bark, like the beech, the white ash, and the basswood. And just as we may like a great man more because of his negligence of fashion's demands, so do we esteem this noble tree, and involuntarily pay it admiring tribute as we note its trunk with the bark scaling off in long, thin plates that curve outward at the top and bottom and seem to be only slightly attached at the middle.

In general shape, the shagbark resembles the oak; the lower branches are large and, although rising as they leave the bole, their tips are deflected; and, for their whole length, they are gnarled and knotted as if to show their strength. The bark on the larger branches may be scaly toward their bases but above is remarkably smooth. The spray is angular and extends in almost every direction. The leaves, like those of other hickories, are compound. There are generally five leaflets, but sometimes only three and sometimes seven. The basal pair is smaller than the others. The hickory leaves are borne alternately on the twig, and from this character the hickory may be distinguished from the ashes, which have leaves of similar type, but which are placed opposite on the twigs. The shagbark usually has an unsymmetrical oblong head; the lower branches are usually shorter than the upper ones, and the latter are irregularly placed, causing gaps in the foliage.

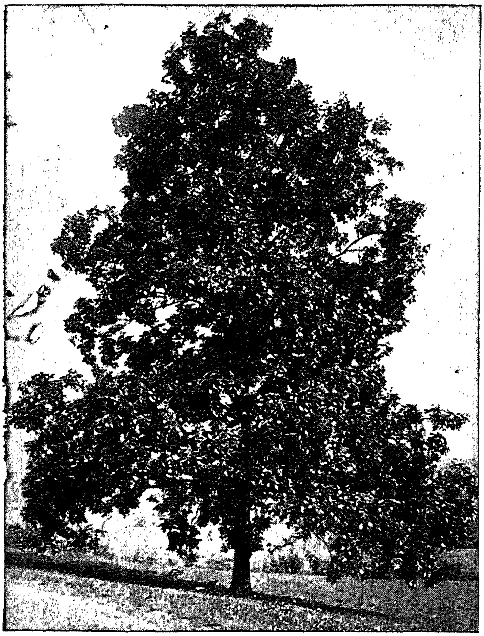
The nut is large, with a thick, smooth outer husk channeled at the seams and separating readily into sections; the inner shell is sharply angled and pointed and slightly flattened at the sides; the kernel is sweet. The winter buds of the shagbark are large, light brown, egg-shaped, and downy; they swell greatly before they expand. There are from eight to ten bud scales; the inner ones, which are red, increase to two or three inches in length before the leaves unfold, after which they fall away. The young branches are smooth, soft, delicate in color, and with conspicuous leaf scars.

The hickory bears its staminate and pistillate flowers on the same tree. The pollen-bearing flowers grow at the base of the season's shoots in slender, pendulous



Ralph W. Curtis

Shagbark hickory. Note loose strips of bark



Ralph W. Curtis

Shellbark or shagbark hickory

green catkins, which occur usually in clusters of three swinging from a common stem. The pistillate flowers grow at the tips of the season's shoots singly or perhaps two or three on a common stem. In the shagbark the middle lobe of the staminate calyx is nearly twice as long as the other two, and is tipped with long bristles; it usually has four stamens with yellow anthers; its pistillate calyx is four-toothed and hairy, and has two large, fringed stigmas.

The big shagbark, or king nut, is similar to the shagbark in height, manner of growth, and bark. However, its leaves have from seven to nine leaflets, which are more oblong and wedgelike than are those of the shagbark; they are also more downy when young and remain slightly downy beneath. The nut is very large, thick-shelled, oblong, angled, and pointed at both ends. The kernel is large and sweet but inferior in flavor to that of the smaller shagbark. The big shagbark has larger buds than has the other. Their fringy, reddish purple inner scales grow so large that they appear tulip-like before they fall away at the unfolding of the leaves.

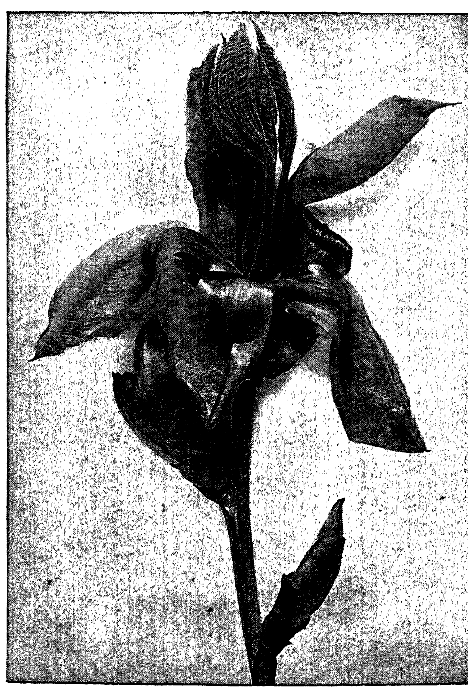
Hickory wood ranks high in value; it is light-colored, close-grained, heavy, and very durable when not exposed to moisture. It is capable of resisting immense strain, and therefore it is used for the handles of spades, plows, and other tools. As a fuel, it is superior to most woods, making a glowing, hot, and quite lasting fire.

LESSON 177

The Shagbark

Leading Thought — The hickories are important trees commercially. They have compound leaves which are set alternately upon the twig. The shagbark can be told from the other hickories by its ragged, scaling bark.

Method — This lesson may be begun in the winter when the tree can be studied carefully as to its shape and method of branching. Later, the unfolding of the leaves from the large buds should be watched, as this is a most interesting process; and a little later the blossoms may be studied. The work should be taken up again in the fall, when the fruit is ripe.



Opening leaf bud of shagbark hickory

Observations. Winter Work — 1. What is the general shape of the whole tree? Are the lower branches very large? At what angle do the branches, in general, grow from the trunk? Are there many large branches?

2. Where is the spray borne? What is its character — that is, is it fine and smooth, or knotted and angled? What is its color?

3. Describe the bark. Is the bark on the limbs like that on the trunk?

4. What is the size and shape of the buds? Are the buds greenish-yellow, yellowish-brown, or do they have a reddish tinge?

5. Count the bud scales. Are they downy or smooth?

Spring Work — 6. Describe how the hickory leaf unfolds from its bud. How is each leaflet folded within the bud?

7. Describe the long greenish catkins which bear the pollen. On what part of the twigs do they grow? Do they grow singly or in clusters?

8. Take one of the tiny, pollen-bearing flowers and hold it under a lens on the point of a pin. How many lobes has the calyx? Count the stamens, and note the color of the anthers.

9. Upon what part of the twigs do the pistillate flowers grow? How many points or lobes has the pistillate calyx? Describe the growth of the nut from the flower.

Autumn Work — 10. Does the hickory you are studying grow in an open field or in a wood?

11. Are the trunk and branches slender and lofty, or sturdy and wide spreading?

12. Note the number and shape of the leaflets. Are they slim and tapering, or do they swell to the width of half their length? Are they set directly upon or are they attached by tiny petioles or petiolules to the mid-stem or petiole? Are they smooth or downy on the underside? Are the leaves set upon the twigs alternately or opposite each other? How are the leaflets set upon the mid-stem?

13. Describe the outer husk of the nut. Into how many sections does it open? Does it cling to the nut and fall with it to the ground? Is the nut angled and pointed, or is it roundish and without angles? Is the taste of the kernel sweet or bitter?

THE CHESTNUT

The chestnut, formerly one of the most useful and valuable trees in the eastern United States, has been eliminated over most of its natural range by the deadly chestnut bark disease. In the Southeast live chestnut trees are still to be found, but over most of the land, where they grew originally, growing chestnut exists only as small sprouts. These sprouts are almost always badly diseased and able to live for only a few years. It is almost certain that within a short span of time, all mature chestnut trees will disappear.

The interest in native chestnut, even though most of it is gone, and not likely to reappear, is still so great that a discussion of it is included here.

This splendid tree, sometimes reaching the height of one hundred feet, seldom receives the admiration due to it, simply because humanity is so much more interested in food than in beauty. The fact that the chestnuts are sought so eagerly has taken away from interest in the appearance of the tree. The chestnut has a great round head set firmly on a handsome bole, which is covered with grayish brown bark divided into rather broad, flat, irregular ridges. The foliage is superb; the long, slender, graceful leaves, tapering at both ends, are glossy, brilliant green above and paler below; and they are placed near the ends of the twigs, those of the fruiting twigs seeming to be arranged in rosettes to make a background for blossom or fruit. The leaves are placed alternately and have deeply notched edges, the veins extending straight and unbroken from midrib to margin; the petiole is short. The leaf is like that of the beech, except

Verne Morton

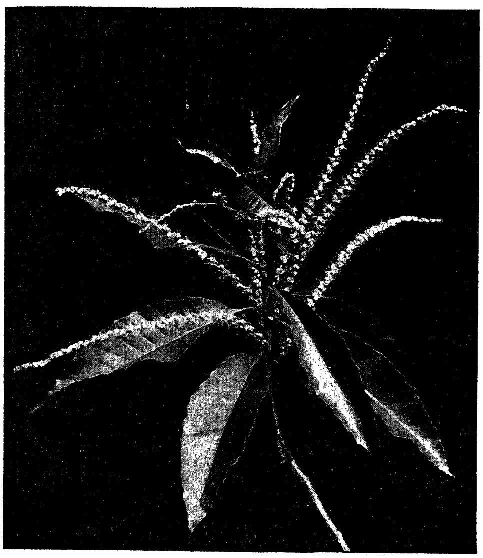
Not long ago these chestnuts were living and flourishing. Now, as is true of most of the other chestnuts in the United States, only their gaunt skeletons remain

that it is much longer and more pointed; it resembles in general shape the leaf of the chestnut oak, except that the edges of the latter have rounded scallops instead of being sharply toothed. The burs appear at the axils of the leaves near the end of the twig. Thoreau has given us an admirable description of the chestnut fruit:

"What a perfect chest the chestnut is packed in! With such wonderful care Nature has secluded and defended these nuts as if they were her most precious fruits, while diamonds are left to take care of themselves. First, it bristles all over with sharp, green prickles, some nearly a half inch long, like a hedgehog rolled into a ball; these rest on a thick, stiff, barklike rind one-sixteenth to one-eighth of an inch thick, which again is most daintily lined with a kind of silvery fur or velvet plush one-sixteenth of an inch thick, even rising into a ridge between the nuts, like the lining of a casket in which the most precious commodities are kept. At last frost comes to unlock this chest; it alone holds the true key; and then Nature drops to the rustling leaves a 'done' nut, prepared to begin a chestnut's course again. Within itself again each individual nut is lined with a reddish velvet, as if to preserve the seed from jar and injury in falling, and perchance from sudden damp and cold; and within that a thin, white skin envelops the germ. Thus, it has lining within lining and unwearied care, not to count closely, six coverings at least before you reach the contents."

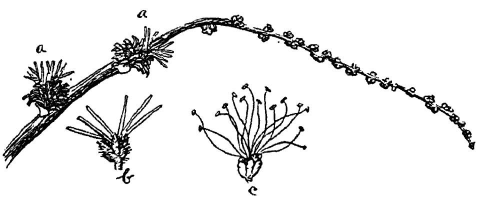
The red squirrels, as if to show their spite because of the protection of this treasure chest, have the reprehensible habit of cutting off the young burs and thus robbing themselves of a rich later harvest — which serves them right. There are usually two nuts in each bur, set with flat sides together; but sometimes there are three and then the middle one is squeezed so that it has two flat sides. Occasionally there is only one nut developed in a bur, and it grows to be almost globular. The color we call chestnut is derived from the beautiful red-brown of the polished shell of the nut, polished except where the base joins the bur, and at the apex, which is gray and downy.

The chestnut is a beautiful tree,



Leaves and blossoms of the chestnut

whether green in summer or glowing golden yellow in autumn, or bare in winter; but it is most beautiful during late June and July, when covered with constellations of pale yellow stars. Each of these stars is a rosette of the pollen-bearing blossoms; each ray consists of a catkin often six or eight inches in length, looking like a thread of yellowish chenille fringe; clothing this thread in tufts for its whole length are the stamens, standing out like minute threads tipped with tiny anther balls. If we observe the blossom early enough, we

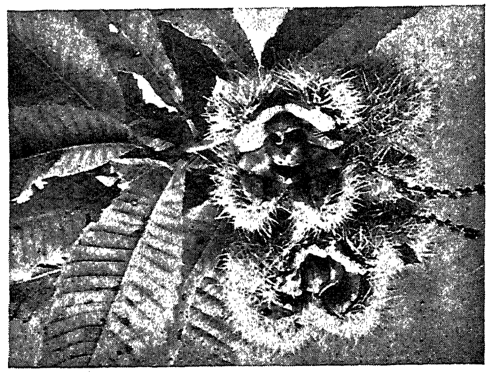


Detail of chestnut blossoms

a, a, pistillate flowers set in a base of scales; b, pistillate flower enlarged; c, staminate flower enlarged

can see these stamens curled up as they come forth from the tiny, pale yellow, six-lobed calyx. One calyx, although scarcely one-sixteenth of an inch across, develops from ten to twenty of these stamens; these tiny flowers are arranged in knots along the central thread of the catkin. No wonder it looks like chenille! There are often as many as thirty of these catkin rays in the star rosette; the lower ones come from the axils of the leaves; but toward the tips of the twig, the leaves are ignored and the catkins have possession. In one catkin I estimated that there were approximately 2,500 stamens developed, each anther packed with pollen. When we think that there may be thirty of the catkins in a blossom star, we get a glimmering of the amount of pollen produced.

And what is all this pollen for? Can it be simply to fertilize the three or four inconspicuous flowers at the tip of the twig beyond and at the center of the star? These pistillate flowers are little bunches of green scales with some short, white threads projecting from their centers; and beyond them a skimpy continuation of the stalk with more little green bunches scattered along it, which are undeveloped pistillate blossoms. The one or two flow-



Verne Morton

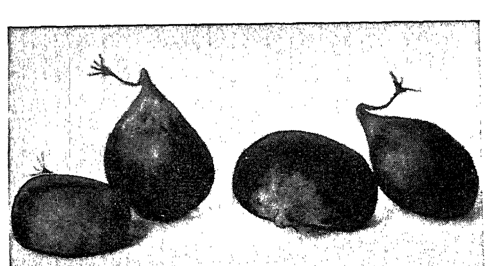
Chestnuts in burs

ers at the base of the stalk seem to get all the nourishment and the others do not develop. If we examine one of these nests of green scales, we find that there are six threads belonging to one tiny, green flower with a six-lobed calyx; the six threads are the stigmas, each one reaching out and asking for no more than one grain of the rich shower of pollen.

Whereas the chestnut blooms in the summer, the blossoms of the other members of its family appear earlier; and their fruit has formed when the chestnut comes into bloom.

Chestnut wood is light, rather soft, stiff, coarse, and not strong. It is used in cabinet work, cooperage, and for telegraph poles and railway ties. When burned as fuel, it snaps and crackles almost as much as hemlock.

Suggested Reading — Readings on page 622.



O. L. Foster

Chestnuts

THE HORSE CHESTNUT

Ralph W. Curtis

Horse chestnut in blossom

The wealth of children is, after all, the truest wealth in this world; and the horse chestnuts, brown and smooth, looking so appetizing and so belying their looks, have been used from time immemorial by boys as legal tender — a fit use, for these handsome nuts seem coined purposely for boys' pockets.

The horse chestnut is a native of Asia Minor. It has also a home in the high mountains of Greece. In America, it is essentially a shade tree. Its head is a broad cone, its dark green foliage is dense, and, when in blossom, the flower clusters stand out like little white pyramids against the rich background in a most striking fashion. "A pyramid of green supporting a thousand pyramids of white" is a clever description of this tree's blossoming. The brown bark of the trunk has a tendency to break into plates, and the trunk is just high enough to make a fitting base for the handsome head.

The blossom panicle is at the tip end of the twig and stops its growth at that point; the side buds continue to grow thus making a forking branch. Each blossom panicle stands erect like a candle flame, and the flowers are arranged spirally around the central stem, each pedicel carrying from four to six flowers. The calyx has five unequal lobes, and it and the stem are downy. Five spreading and unequal petals with ruffled margins are raised on short claws, to form the corolla; seven stamens with orange colored anthers are thrust far out and up from the flower. The blossoms are creamy or pinkish white and have purple or yellow blotches in their throats. Not all the flowers have perfect pistils. The stigmas ripen before the pollen, and are often thrust forth from the unopened flower. The flowers are fragrant and are eagerly visited by bumblebees, honeybees, and wasps.

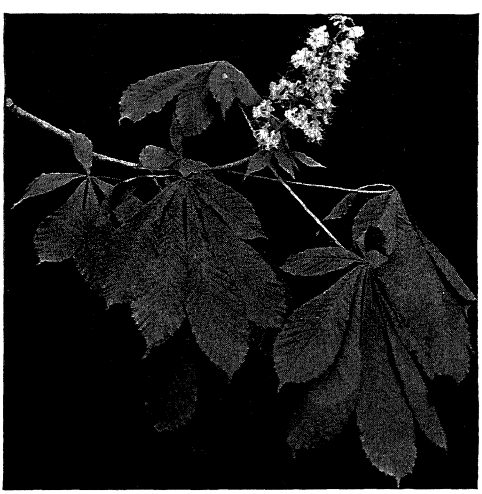
Very soon after the blossom falls, there may be seen one or two green, prickly balls, which contain the fruits. By October the green, spherical husk breaks open in three parts, showing its white satin lining and the roundish, shining, smooth nut at its center. At first there were six little nuts in this husk, but all except one gave up to the single burly occupant that is there when the husk opens. The great, round, pale scar on the nut is where it

a, Blossom of the sweet buckeye and young fruit; b, Blossom and young fruit of horse chestnut joined the husk. Very few American animals will eat the nut; the squirrels scorn it and horses surely disown it.

In winter, the horse chestnut twig has at its tip a large bud and looks like a knobbed antenna thrust forth to test the safety of the neighborhood. There are, besides the great varnished buds at the ends of the twigs, smaller buds opposite to each other along the sides of the twig, standing out stiffly. On each side of the end bud, and below each of the others, is a horseshoe-shaped scar left by the falling leaf of last year. The " nails " in this horseshoe are formed by the leafy fibers which joined the petiole to the twig. The great terminal buds hold both leaves and flowers. The buds in winter are brown and shining as if varnished; when they begin to swell, they open, displaying the silky gray floss which swaddles the tiny leaves. The leaves unfold rapidly and lift up their green leaflets, looking like partly opened umbrellas, and giving the tree a very downy appearance, which Lowell so well describes:

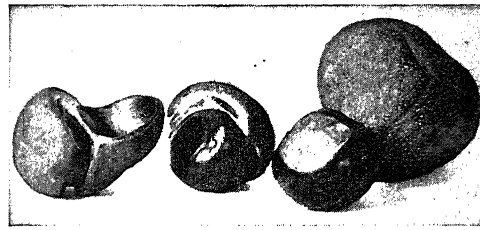
And gray hoss-chestnut's leetle hands unfold
Softer'n a baby's be at three days old.

The leaf, when fully developed, has seven leaflets, of which the central ones



Ralph W. Curtis

Horse chestnut blossoms and leaves



O. L. Foster

Buckeyes. They resemble horse chestnuts

are the larger. They are all attached around the tip of the petiole. The number of leaflets may vary from three to nine, but is usually seven. The leaflets are oval in shape, being attached to the petiole at the smaller end; their edges are irregularly toothed. The veins are large, straight, and lighter in color; the upper surface is smooth and dark green, the underside is lighter in color and slightly rough. The petiole is long and shining and enlarges at both ends; when cut across, it shows a woody outer part encasing a bundle of fibers, one fiber to each leaflet. The places where these fibers were attached to the twig make the nails in the horseshoe scar. The leaves are placed opposite on the twigs.

Very different from that of the horse chestnut is the flower of the yellow or sweet buckeye; the calyx is tubular, long, and five-lobed; the two side petals are on long stalks and are closed like spoons over the stamens and anthers; the two upper petals are also on long stalks, lifting themselves up and showing on their inner surfaces a bit of color to tell the wandering bee that here is a tube to be explored. The flowers are greenish yellow. The flowers of the Ohio buckeye show a stage between the sweet buckeye and the horse chestnut. The Ohio buckeye is our most common native relative of the horse chestnut. Its leaves have five leaflets instead of seven. The sweet buckeye is also an American species and grows in the Allegheny Mountains.

LESSON 178

The Horse Chestnut

Leading Thought — The horse chestnut has been introduced in America as a shade tree from Asia Minor and southern Europe. Its foliage and its flowers are both beautiful.

Method — This tree is almost always at hand for the village teacher, since it is so often used as a shade tree. Watching the leaves develop from the buds is one of the most common of the nature-study lessons. The study of the buds, leaves, and fruits may be made in school; but the children should observe the tree where it grows and pay special attention to its insect visitors when it is in bloom.

Observations — 1. Describe the horse chestnut tree when in blossom. At what time does this occur? What is there in its shape and foliage and flowers which makes it a favorite shade tree? Where did it grow naturally? What relatives of the horse chestnut are native to America?

2. Study the blossom cluster; are the flowers borne on the ends or on the sides of the twig? Describe the shape of the cluster. How are the flowers arranged on the main flowerstalk to produce this form? Do the flowers open all at once from top to bottom of the cluster? Are all the flowers in the cluster the same color? Are they fragrant? What insects visit them?

3. Take a single flower; describe the form of the calyx. Is it smooth or downy? Are the lobes all the same size? Are the petals all alike in size and shape? What gives them the appearance of Japanese paper? Are any connected together? Are they all splashed with color alike?

4. How many stamens are there? Where do you see them? What color are the anthers? Search the center of a flower for a pistil with its green style. Do you find one in every flower? Could a bee reach the nectar at the base of the blossom without touching the stigma? Could she withdraw without dusting herself with pollen?

5. How long after the blossom does the young fruit appear? How does it look? How many nuts are developed from each cluster of blossoms? What is the shape of the bur? Into how many parts does it open? Describe the outside; the inside. Describe the shape of the nuts, their color and markings. Open a nut. Can you find any division in the kernel? Is it good to eat?

Horse-Chestnut Twigs and Leaves in Spring — 6. Are the buds on the twigs nearly all the same size? Where are the larger ones situated? What is the color of the buds? How are the scales arranged on them? Are they shiny or dull? What do the scales enfold? Can you tell without opening them which buds contain flowers and which ones leaves?

7. Describe the scars below the buds. What caused them? What marks are on them? What made the "nails" in the horseshoe? Has the twig other scars? How do the ring-marks show the age of the twig? Do you see the little, light colored dots scattered over the bark of the twig? What are they?

8. Describe how the leaf unfolds from the bud. What is the shape of the leaf? Do all the leaves have the same number of leaflets? Do any of them have an even number? How are the leaflets set upon the petiole? Describe the leaflets, including shape, veins, edges, color above and below. Is the petiole pliant, or stiff and strong? Is it the same shape and size throughout its length? Break a petiole; is it green throughout? What can you see at its center? Are the leaves opposite or alternate? When they fall, do they drop entire or do the leaflets fall apart from the petiole?

9. Make a sketch of the horse-chestnut tree.

10. How do the flowers and leaves of the horse chestnut differ from those of the sweet buckeye and of the Ohio buckeye?

Ralph W. Curtis

Yellow-twigged and weeping willows

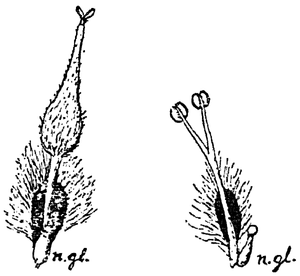
THE WILLOWS

They shall spring up among the grass, as willows by the water courses.
— Isaiah

When I cross opposite the end of Willow Row the sun comes out and the trees are very handsome, like a rosette, pale, tawny or fawn color at base and red-yellow or orange-yellow for the upper three or four feet. This is, methinks, the brightest object in the landscape these days. Nothing so betrays the spring sun. I am aware that the sun has come out of the cloud just by seeing it light up the osiers. — Thoreau

The willow Thoreau noted, is the golden osier, a colonial dame, a descendant from the white willow of Europe. It is the most common tree planted along streams to confine them to their channels, and affords an excellent subject for a nature-study lesson. The golden osier has a short though magnificent trunk, giving off tremendous branches, which in turn branch and uphold a mass of golden terminal shoots. But there are many willows besides this, and the one who tries to determine all the species and hybrids must conclude that of making willows there is no end. The species most beloved by children is the pussy willow, which is often a shrub, rarely reaching twenty feet in height. It loves moist localities, and on its branches in early spring are developed the silky, furry pussies, larger than the pussies of other willows. These are favorite objects for a nature-study lesson, and yet how little have the teachers or pupils known about these flowers!

The showy willow pussies are the pollen-bearing flowers; they are covered in winter by a brown, varnished, double, tentlike bract. The pussy in full bloom shows beneath each fur-bordered scale two stamens with long filaments and plump anthers; but there are no pistils in this blossom. The flowers which produce seed are borne on another tree entirely and in similar greenish gray catkins, but not so soft and furry. In the pistillate cat-



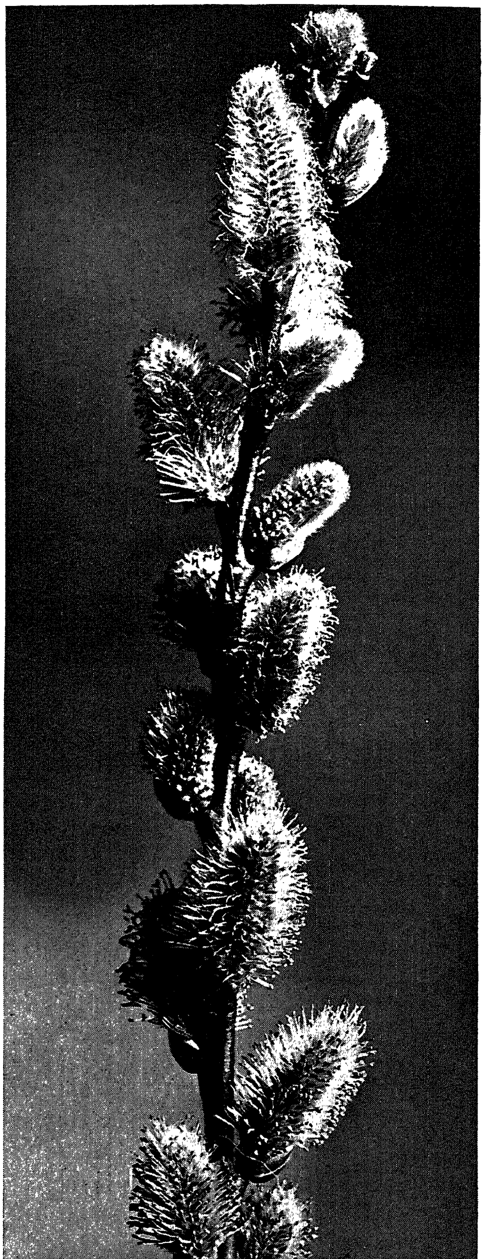
Enlarged willow blossoms

Pistillate blossom showing nectar-gland, (n.gl.) Staminate flower showing the nectar-gland (n.gl.)

kin each fringed scale has at its base a pistil which thrusts out a Y-shaped stigma. The question of how the pollen from one gets to the pistils of another is a story which the bees and the wind can best tell. The willow flowers give the bees almost their earliest spring feast, and when they are in blossom, the happy hum of the bees working in them can be heard for some distance from the trees. The pollen gives them bee bread for their early brood, and they get their honey supply from the nectar which is produced in little jug-shaped glands, at the base of each pollen-bearing flower on the " pussy " catkin, and in a long pocket at the base of each flower on the pistillate catkin. So they pass back and forth, carrying their pollen loads, which fertilize the stigmas on trees where there is no pollen.

In June the willow seed is ripe. The catkin then is made up of tiny pods, which open like milkweed pods and are filled with seed equipped with balloons. When these fuzzy seeds are being set free people say that the willows " shed cotton."

Although the seed of the willow is produced in abundance, it is hardly needed for preserving the species. Twigs which we place in water to develop flowers will also put forth roots; even if the twigs are placed in water wrong side up, rootlets will form. A twig lying flat on moist soil will push out rootlets along its entire length as though it were a root; and shoots will grow from the buds on its upper side. This habit of the willows and the fact that the roots are long, strong, and fibrous, make these trees of great use as soil binders. There are few things better than a thick hedge of willows to hold streams to their proper channels during floods; the roots



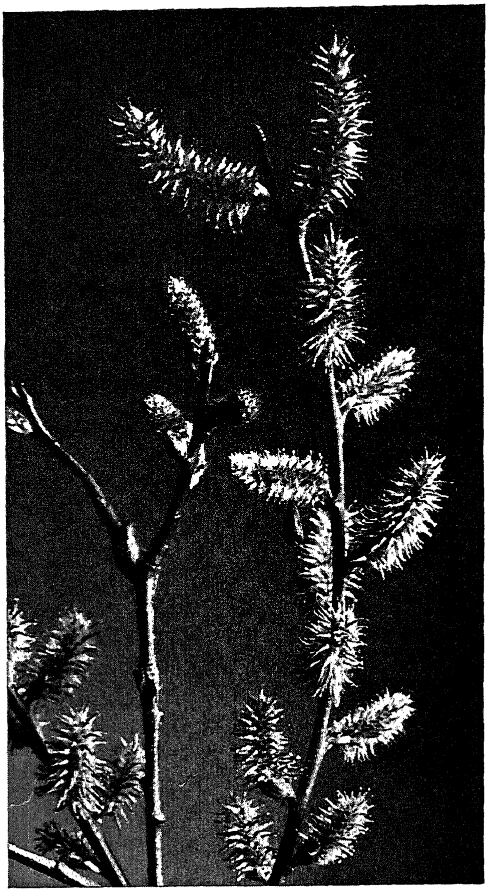
Verne Morton

Willow pussies; the staminate blossoms of the willow reach out in all directions, interlacing themselves in great masses, and thus hold the soil of the banks in place. The twigs of several of the species, notably the crack and sand-bar willows, are broken off easily by the wind and carried off down stream, and where they lodge, they take root; thus, many streams are bordered by self-planted willow hedges.

The willow foliage is fine and makes a beautiful, soft mass with delicate shadows. The leaf is long, narrow, pointed, and slender, with finely toothed edges and short petiole; the exact shape of the leaf, of course, depends upon the species, but all of them are much lighter in color below than above. The willows are, as a whole, water lovers and quick growers.

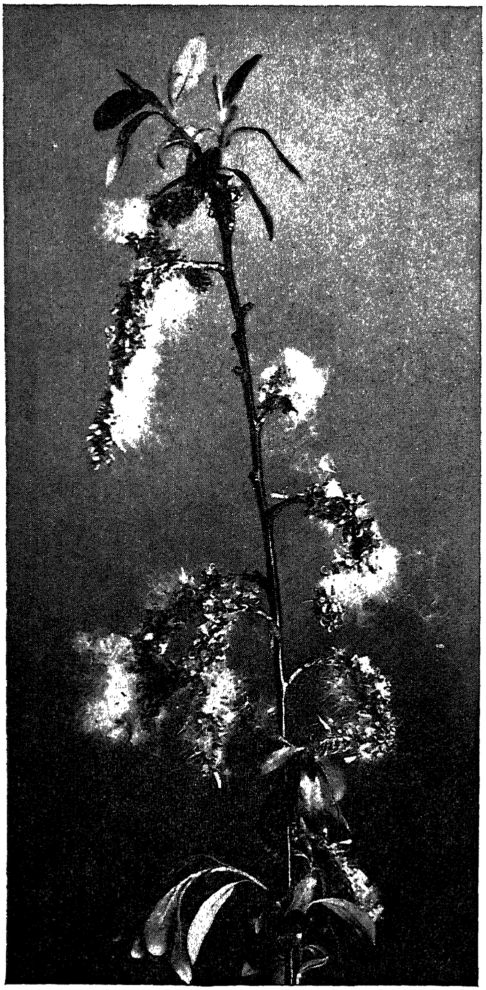
Although willow wood is soft and exceedingly light, it is very tough when seasoned and is used for many things. The wooden shoes of the European peasant, artificial limbs, willowware, and charcoal of the finest grain used in the manufacture of gunpowder are all made from the willow wood. The toughness and flexibility of the willow twigs have given rise to many industries; baskets, hampers, and furniture are made of them. To get these twigs the willow trees are pollarded, or cut back every year between the fall of the leaves and the flow of the sap in the spring. This pruning results in many twigs. The use of willow twigs in basketry is ancient. The Britons fought the Roman soldiers from behind shields of basket work; and the wattled huts in which they lived were woven of willow saplings smeared with clay. Salicylic acid, used widely in medicine, is made from willow bark, which produces also tannin and some unfading dyes.

There are many insect inhabitants of the willow, but perhaps the most interesting is the little chap who makes a conelike object on the twig of certain species of willow growing along our streams. This cone is naturally considered a fruit by the ignorant, but we know that the willow seeds are grown in catkins instead of cones. This willow cone is made by a small gnat which lays its egg in the tip of the twig; as soon as the little grub hatches, it begins to gnaw the twig, and this irritation for some reason stops the growth. The leaves instead of developing along the stem are dwarfed and overlap each other. Just in the center of the cone at the tip of the twig the little larva lives its whole life surrounded by food and protected from enemies; it remains in the cone all winter, in the spring changes to a pupa, and after a time comes forth — a very delicate little fly. The larva in this gall does not live alone. It has its own little apartment at the center, but other gall gnats live in outer chambers and breed there in great numbers. It is well to gather these cones in winter; examine one by cutting it open to find the larva, and place others in a fruit jar with a cover so as to see the



Verne Morton

Pistillate blossoms of the pussy willow



Verne Morton

Seeds of the willow

little flies when they shall issue in the spring. (See p. 337.)

There is another interesting winter tenant of willow leaves, but it is rather difficult to find. On the lower branches may be discovered, during winter and spring, leaves rolled lengthwise and fastened, making elongated cups. Each little cup is very full of a caterpillar which just fits it, the caterpillar's head forming the plug of the opening. This is the partially grown larva of the viceroy butterfly. A larva of the autumn brood of this butterfly eats off the tip of the leaf each side of the midrib for about half its length, fastens the petiole fast to the twig with silk, then rolls the base of the leaf into a cup, lines it with silk and backs into it, there to remain until fresh leaves on the willow in spring afford it new food.

Suggested Reading — Page 622.

LESSON 179
The Willows

Leading Thought — The willows have their pollen-bearing flowers and their seed-bearing flowers on separate trees; the pollen is distributed by bees and by the wind. The willow pussies are the pollen-bearing flowers.

Method — As early in March as is practicable, have the pupils gather twigs of as many different kinds of willows as can be found; these should be put in jars of water and placed in a warm, sunny window. The catkins will soon begin to push out from the bud scales, and the whole process of flowering may be watched.

Observations — 1. How can you tell the common willow tree from afar? In what localities do these trees grow? What is the general shape of the big willow? How high is the trunk, or bole? What sort of bark has it? Are the main branches large or small? Do they stand out at a wide angle or lift up sharply? What color are the terminal shoots, or spray?

2. Are the buds opposite or alternate on the twigs? Is there a bud at exactly the end of any twig? How many bracts are there covering the bud?

3. Which appear first, the leaves or the blossoms? Study the pussies on your twigs and see if they are all alike. Is one kind more soft and furry than the other? Are they of different colors?

4. Take one of the furry pussies. Describe the little bract, which is like a protecting hood at its base. What color is the fur? After a few days, what color is the pussy? Why does it change from silver color to yellow? Pick one of the catkins apart and see how the fur protects the stamens.

5. Take one of the pussies which is not so furry. Can you see the little pistils with the Y-shaped stigmas set in it? Is each

little pistil set at the base of a little scale with fringed edges?

6. Since the pollen-bearing catkins are on one tree and the seed-bearing catkins are on the other, and since the seeds cannot be developed without the pollen, how is the pollen carried to the pistils? For this answer, visit the willows when the pussies are all in bloom and listen. Tell what you hear. What insects do you see working on the willow blossoms? What are they after?

7. What sort of seed has the willow? How is it scattered? Do you think the wind or water has most to do with planting willow seed?

WORK FOR MAY OR SEPTEMBER — 8. Describe willow foliage and leaves. How can you tell willow foliage at a distance?

9. What sort of roots has the willow? Why are the willows planted along the banks of streams? If you wished to plant some willow trees how would you do it? Would you plant seeds or twigs?

10. For what purposes is willow wood used? How are the twigs used? Why are they specially fitted for this use? What is pollarding a tree? What chemicals do we get from willow bark?

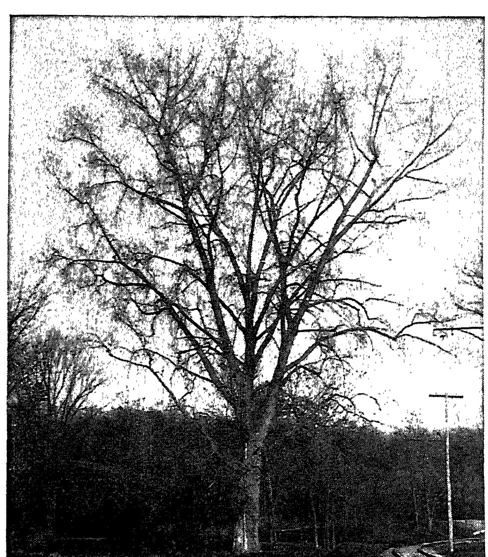
11. Do you find willow cones on your willows? Cut one of these cones through and see if you can find any seeds. What is in the middle of it? What do you think made the scales of the cone? Do you think this little gall insect remains in here all winter?

12. In winter, hunt the lower branches of willows for leaves rolled lengthwise, making a winter cradle for the young caterpillars of the viceroy butterfly.

THE COTTONWOOD OR CAROLINA POPLAR

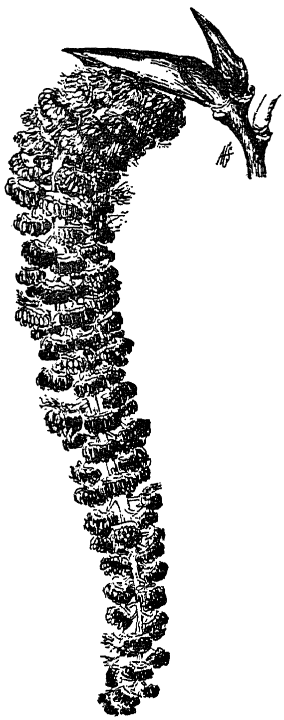
The sojourner on our western plains where streams are few and sluggish, disappearing entirely in summer, soon learns to love the cottonwoods, for they will grow and cast their shade for men and cattle where few other trees could endure. The cottonwood may be unkempt and ragged, but it is a tree, and we are grateful to it for its ability to grow in unfavorable situations. In the Middle West it attains its perfection, although in New York we have some superb specimens — trees which are more than one hundred feet in height and with majestic trunks, perhaps five or six feet through. The deep-furrowed, pale gray bark makes a handsome covering. The trunk divides into great outswinging, widely spaced branches, which bear a fine spray on their drooping ends. Sargent declares that at its best the cottonwood is one of the stateliest inhabitants of our eastern forests. The variety we plant in cities we call the Carolina poplar, but it is a cottonwood. It is a rapid grower, and therefore a great help to the "boom towns" of the West and to the boom suburbs in the East; although for a city tree its weak branches break too readily in wind storms in old age. However, it keeps its foliage clean, the varnished leaves shedding the dust and smoke; because of this latter quality it is of special use in towns that burn soft coal.

The cottonwood twigs which we gather for study in the spring are yellowish or



Cottonwood

reddish, those of last year's growth being smooth and round, while those showing previous growth are angular. The buds are



Anna C. Stryke

Staminate catkin of cottonwood

red-brown and shining, and covered with resin which the bees like to collect for their glue. The leaf buds are slender and sharp-pointed; the flower buds are wider and plumper.

The two sexes of the flowers are borne on separate trees. The trees bearing pollen catkins are so completely covered with them that they take on a very furry, purplish appearance when in blossom. These catkins are from three to five inches long and half an inch thick, looking fat and pendulous; each fringed scale of the catkin has at its base a disc looking like a white bracket, from which hang the reddish-purple anthers; these catkins fall after the pollen is shed and look like red caterpillars upon the ground.

The seed-bearing flowers are very different; they look like a string of little, greenish beads loosely strung. Each pistil is globular and set in a tiny cup, and it has three or four stigmas which are widened or lobed; as it matures, it becomes larger and darker green, and the string elongates to six or even ten inches. The little pointed pods open into two or more valves and set free the seeds, which are provided with a fluff of pappus to sail them off on the breeze; so many of the seeds develop that every object in the neighborhood is covered with their fuzz, and thus the tree has gained its name "cottonwood."

The foliage of the cottonwood is like that of other poplars, trembling with the breeze. The heavy, subcircular leaf is supported on the sidewise flattened petiole, so that the slightest breath of air sets it quaking; a gentle breeze sets the whole tree twinkling and gives the eye a fascinating impression as of leaves beckoning. The leaf is in itself pretty. It is from three to five inches long, broad, slightly angular at the base, and has a long, tapering, pointed tip. The edge is saw-toothed, and also slightly ruffled except near the stem where it is smooth; it is thick and shining green above and paler beneath. The long, slender petiole is red or yellowish, and the leaves are placed alternately on the twigs.

In the autumn the leaves are brilliant yellow. The wood is soft, weak, fine-grained, whitish or yellowish, and has a

Cyrus Crosby

The growing fruits of the cottonwood

satiny luster; it is not durable. It is used somewhat for building and for furniture, in some kinds of cooperage, and also for crates and woodenware; but its greatest use is for making the pulp for paper. Many newspapers and books are printed on cottonwood paper. It is common from the Middle States to the Rocky Mountains and from Manitoba to Texas.

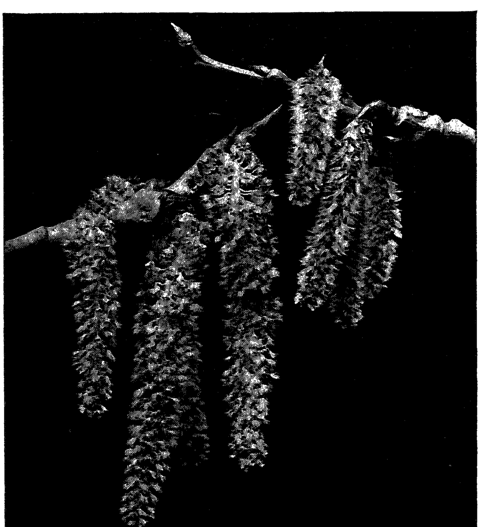
LESSON 180

The Cottonwood

Leading Thought — The cottonwood is a poplar. It grows rapidly and flourishes on the dry western plains where other trees fail to gain a foothold. It grows well in the dusty city, its shining leaves shedding the smoke and dirt.

Method — Begin this study in spring before the cottonwoods bloom. Bring in twigs in February, give them water and warmth, and watch the development of the catkins. Afterwards watch the unfolding of the leaves and study the tree. Twigs of the aspen, if brought indoors in early spring, provide a very interesting study.

Observations — 1. What is the color of the bark on the cottonwood? Is it ridged deeply? What is the color of the twigs?



Ralph W. Curtis

Flowers of trembling aspen, sometimes called "popple tree," a near relative of the cottonwood

Ralph W. Curtis

Lombardy poplar, another relative of the cottonwood

Are they round or angular, or both? Describe the winter buds and bud scales. Can you tell which bud will produce leaves and which flowers?

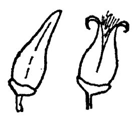
2. Describe the catkin as it comes out. Has this catkin anthers and pollen, or will it produce seed? Do you think the seeds are produced on the same trees as the pollen?

3. Find a pollen-bearing catkin. Describe the stamens. Can you see anything but the anthers? On what are they set?

What color are they? What color do they give to the tree when they are in blossom? What happens to the catkins after their pollen is shed?

4. Find a seed-bearing catkin. How long is it? Do you see why this tree is called the necklace poplar? Describe the pistils which make the beads on the necklace.

5. When do the seeds ripen? If you have lived near the tree, how do you know when they are ripe? How long is the catkin with the ripened seeds? How many balls on the necklace now? What is the color? How many seeds come out of each little pod? How are the seeds floated on the air? Why do we call this tree " cottonwood "?



Seed pod of poplar, shut and open

6. How large is the largest cottonwood that you know? Sketch it to show the shape of the tree. Are the main branches large? Do they droop at the tips?

7. How does the foliage of the cottonwood look? Does it twinkle with the wind? Examine the leaves upon a branch and tell why you think they twinkle. Are the petioles round or flat? Are they flattened sidewise or up and down? Are they stiff or slender? Describe the leaves, giving their shape, veins, edges, color, and texture above and below. Are the edges ruffled as well as toothed? Is the leaf heavy? If a breeze comes along how would it affect such a heavy, broad leaf on such a slender, thin petiole? Blow against the leaves and see how they move. Do you understand, now, why they tremble in the slightest breeze? Can you see why the leaves shed smoke and dust, when used for shading city streets?

8. Why is the cottonwood used as a shade tree? Do you think it makes a beautiful shade tree? How long does it take it to grow? What kind of wood does it produce? For what is the wood of the cottonwood used?

THE WHITE ASH

Myths and legends cluster about the ash tree. It was, in the Norse mythology, the tree " Igdrasil," the tree of the universe, which was the origin of all things. " As straight as a white ash tree " was the highest compliment that could be paid to the young pioneer; so straight is its fiber and so strong its quality that the American Indians made their canoe paddles from it.

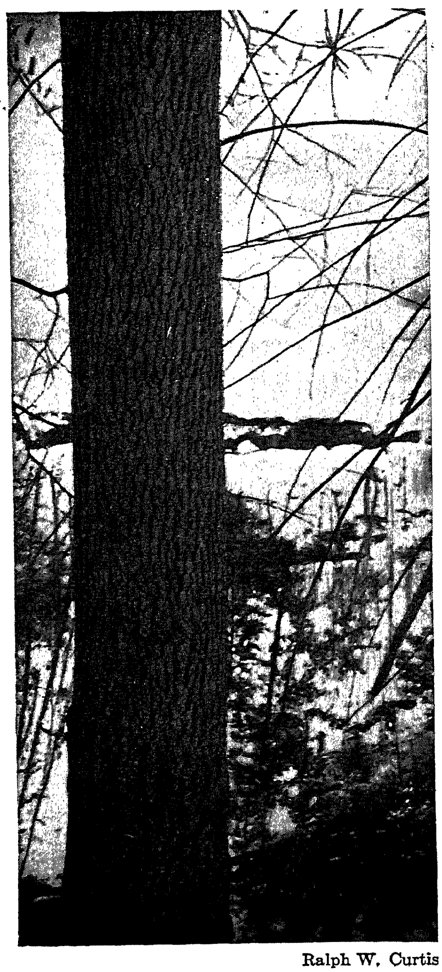
The bark of the ashes is very beautiful. It is divided into fine, vertical ridges, giving the trunks the look of being shaded with pencil lines; the bark smooths out on the lower branches. But even more characteristic than the bark are the ash branches and twigs; the latter are sparse, coarse, and clumsy, those of the white ash being pale orange or gray, and seemingly warped into curves at the ends; they are covered with whitish gray dots, which reveal themselves under the lens to be breathing-pores.

The white ash loves to grow in rich woods or in rich soil anywhere, even though it be shallow; at its best, it reaches the height of 130 feet, with a trunk six feet through. Its foliage is peculiarly graceful; the leaves are from eight to twelve inches long and are composed of from five to nine leaflets. The leaflets have little petiolules connecting them with the petiole; in shape they are ovate with edges obscurely toothed or entire; the two basal leaflets are smaller than the others and the end one largest; in texture, they are satiny, dark green above, whitish beneath, with feather-like veins, often hairy on the lower side. The petioles are swollen at the base. The leaves are set opposite upon the twig; except for the horse chestnut, the ashes are our only common trees with compound leaves which have the leaves opposite. This characteristic distinguishes the ashes from the hickories. The autumn foliage has a very peculiar color; the leaves are dull purple above and pale yellow below; this brings the sunshine color into the shadowy parts of the tree, and gives a curious effect of no perspective. Notwithstanding this, the autumn coloring is a joy to the artistic eye and is very characteristic.

The fruits of the ash are borne in crowded clusters; the delicate stalk, from three to five inches long, is branched into smaller stalks to which are joined two or three keys. Often several of these main stalks come from the same bud at the tip of last year's wood, so that they seem crowded. The fruit is winged, the wing being almost twice as long as the seed set at its base. Thoreau says: "The keys of the white ash cover the trees profusely, a

G. F. Morgan

Pistillate blossoms of white ash



Ralph W. Curtis

White ash

sort of mulberry brown, an inch and a half long, and handsome." The fruits cling persistently to the tree, and I have often observed them being blown over the surface of the snow as if they were skating to a planting place.

The flowers appear in April or May, before the leaves. The pistillate flowers make an untidy fringe, curling in every direction around the twigs. The chief flowerstalk is three to four inches long, quite stout, pale green, and from this arise short, fringed stalks, each carrying along its sides the knobs on little stalks — which are the pistillate flowers. Each tiny flower seems to be bristling with individuality, standing off at an angle to get a share of the pollen. The flower has the calyx four-lobed; the style is long and slender and is divided into a V-shaped purple stigma.

The staminate flowers appear early in the spring, and look like knobs on the tips of the coarse, sparse twigs; they consist of masses of thick, green anthers with very short, stout filaments; each calyx is four-lobed. These flowers are attached to a five-branching stem; but the stem and its branches cannot be seen unless the anthers are plucked off, because they hang


Verne Morton

Young ash

in such a crowded mass. Later the leaves come out beyond them.

The leaf buds in winter are very pretty; they are white, bluntly pointed, with a pale gray half-circle below, on which was set last year's leaf. Another one of Nature's miracles is the bouquet of leaves coming from one of the big four-parted terminal buds, which is made up of four scales, two of which are longer and narrower than the others. Within the bud each little leaflet is folded like a sheet of paper lengthwise, and folded with the other leaflets like the leaves of a book; and when they first appear they look like tiny, scrawny birds' claws. But it is not merely one pair of leaves that comes from this bud, but many, each pair being set on a twig opposite and at right angles to the next pair on either side. Even as many as five pairs of these splendid compound leaves may come from this one prolific bud. As they push out, the green stem of the new wood grows, thus spacing the pairs properly for the making of beautiful foliage.

LESSON 181

Ash Trees

Leading Thought — The ashes are among our most valuable timber trees; the white ash is one of the most beautiful and useful of them all. It does not make forests, but it grows in them, and its wood is of great value for many things.

Method — The pupils should all see the tree where it grows. The questions may be given to them for their field note-books. The lesson may begin in the fall and be continued in the spring.

Observations — 1. What is there about the bark of the ash tree which distinguishes it from other trees? Where does the white ash grow? What is the height and thickness of the ash tree you are studying?

2. The ash leaf is a compound leaf; of how many leaflets is it composed? What is the texture and shape of the leaflets? Describe the veins. Do the leaflets have petioles (petiolules)? Are the edges of the leaflets toothed? Which of the leaflets is largest? Which smallest? Is the petiole swollen at the base? How are the leaves arranged on the twigs? How does this distinguish the ashes from all our other trees which have compound leaves? How do the hickories have their leaves arranged? What color is the ash foliage in autumn?

3. Describe the seeds of the ash and the way they are arranged on their stems. Where are they placed on the tree? How long do they cling? How does the snow help to scatter them?

4. When does the white ash blossom? Are the pistillate and staminate flowers together or separate? Find and describe them.

5. What are our uses for ash timber?

For what are the saplings used? How did the Indians use the white ash? Write a theme on all the interesting things you can find about the ash trees.

6. How many species of the ash trees do you know?

I care not how men trace their ancestry,
To ape or Adam; let them please their whim;
But I in June am midway to believe
A tree among my far progenitors,
Such sympathy is mine with all the race,
Such mutual recognition vaguely sweet
There is between us. Surely there are times
When they consent to own me of their kin,
And condescend to me and call me cousin,
Murmuring faint lullabies of eldest time,
Forgotten, and yet dumbly felt with thrills
Moving the lips, though fruitless of the words.

— "UNDER THE WILLOWS," LOWELL

THE APPLE TREE

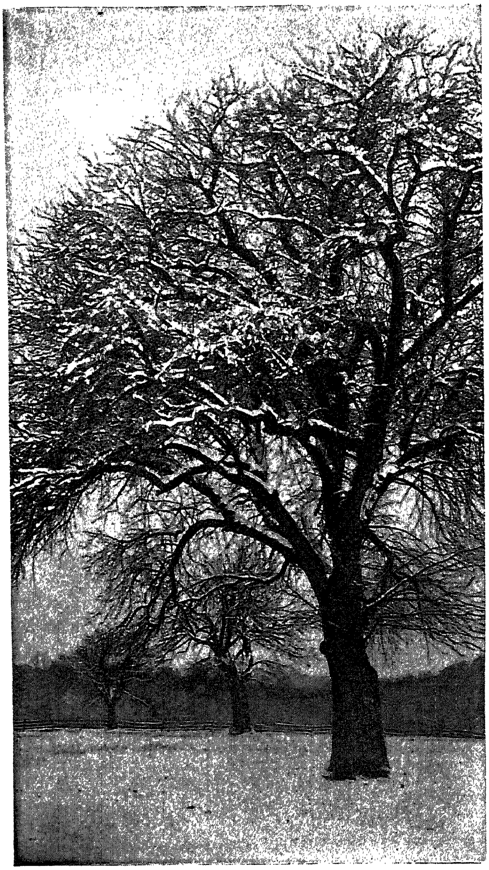
As the apple tree among the trees of the wood, so is my beloved among the sons. I sat down under his shadow with great delight, and his fruit was sweet to my taste.

— "THE SONG OF SOLOMON"

An old-fashioned orchard is always a delight to those of us who love the picturesque. The venerable apple tree with its great twisted and gnarled branches, rearing aloft its rounded head, and casting its shadow on the green turf below, is a picture well worthy of the artist's brush. And that is the kind of orchard I should always have, because it suits me, just as it does bluebirds, downies, and chickadees, as a place to live in. However, if I wished to make money by selling apples, I should need to have an orchard of comparatively young trees, which should be straight and well pruned, and the ground beneath them well cultivated; for there are few plants that respond more generously to cultivation than does the apple tree. In such an orchard, a few annual crops might be grown while the trees were young, and each year there should be planted in August or September the seed of crimson clover or of some other good cover crop. This would grow so as to protect the ground from washing during the heavy rains and thaws of fall and winter, and in the spring it would be plowed under to add more humus to the soil.

The apple originally came from southwestern Asia and the neighboring parts of Europe, but it has been cultivated so long that we have no accounts of how it began. The prehistoric lake dwellers of Switzerland ate this fruit. In this country the apple thrives best on clay loam, although it grows on a great variety of soils; where wheat and corn grow, there will the apple grow also. In general, the shape of the apple-tree head is rounded or broadly pyramidal; however, this differs somewhat with varieties. The trunk is short and rather stocky, the bark is a beautiful soft

A Baldwin apple tree

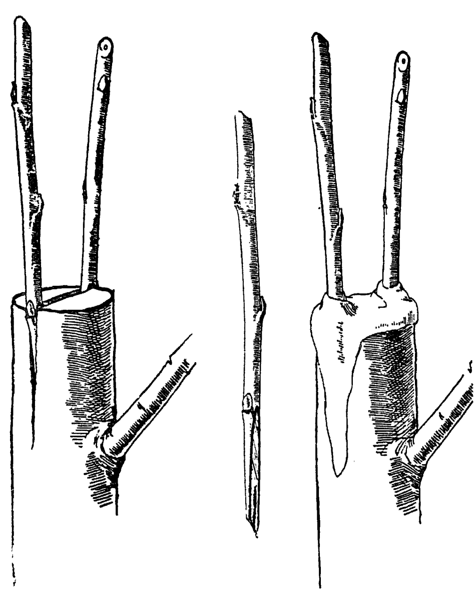


Verne Morton

Apple tree in winter

gray and is decidedly scaly, flaking off in pieces which are more or less quadrangular. The wood is very fine-grained and heavy. On this account for many years it was used for wood engraving and is also a favorite wood for wood carving; it makes an excellent fuel. The spray is fine, and while at the tips of the limbs it may be drooping or horizontal, it often grows erect along the upper sides of the limbs, each shoot looking as if it were determined to be a tree in itself. The leaves are oval, with toothed edges and long petioles. When the leaves first appear each has two stipules at its base. The shape of the apple leaves depends to some extent upon the variety of the apple.

It has long been the practice not to depend upon the seeds for reproducing a variety; for, since insects do such a large work in pollinating the apple flowers, it would be quite difficult to be sure that a seed would not be a result of a cross between two varieties. Therefore, the matter is made certain by the process of grafting or budding. There are several modes of grafting; one in common use is the cleft-graft. A scion, which is a twig bearing several buds, is cut from a tree of the desired variety, and its lower end is cut wedge-shaped. The branch of the tree to be grafted is cut off across and split down through the end to the depth of about two inches; the wedge-shaped end of the scion is pressed into this cleft, so that its bark will come in contact with the inner edge of the bark on one side of the cleft branch. The reason for this is that the growing part of the tree is the cambium layer, which is just inside of the bark, and if the cambium of the scion does not come in contact with the cambium of the branch they will not grow together. After the graft becomes well established, the other branches of the tree are cut off and the tree produces apples only from that part of it which grows from the graft. After the scion has been set in the stock, all of

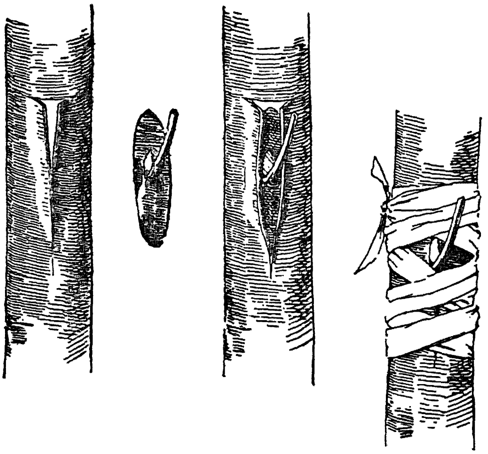


Cleft-grafting

1, Cleft-graft; 2, scion for cleft-grafting; 3, the graft waxed the wounded parts are covered with grafting wax, which keeps in the moisture and keeps out disease germs.

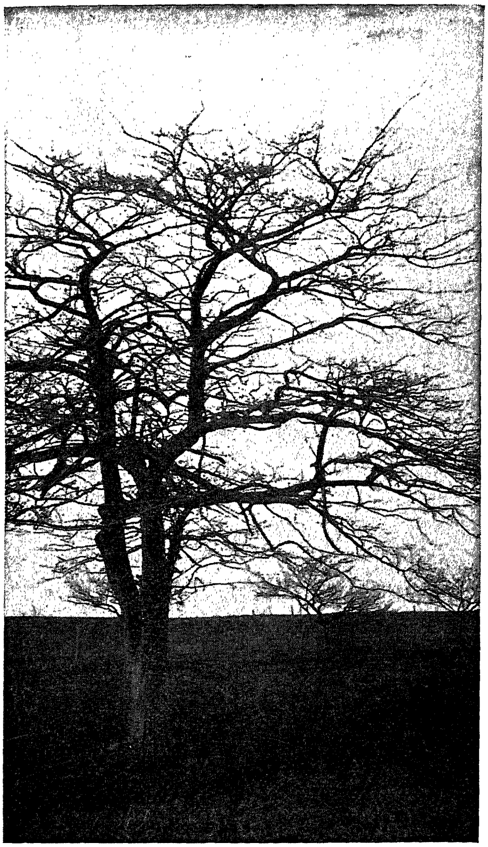
Budding is done on a similar principle, but in a different fashion. A seedling apple tree about a year and a half old has a T-shaped slit cut into its bark; into this suture a bud cut from a tree of the desired variety is inserted, and is bound in with yarn. The next spring this tree is cut back to just above the place where the bud was set in, and this bud shoot grows several feet; the next year the tree may be sold to the orchardist. Budding is done on a large scale in the nurseries, for it is by this method that the different varieties are placed on the market.

Most varieties of apple trees should be set forty feet apart each way. It is possible, if done judiciously, to raise some small crops on the land with the young orchard, but care should be taken that they do not rob the trees of their share of the water and minerals in the soil. Some varieties begin to bear much sooner than others, even at seven years; but an orchard does not come into full bearing until after it has been planted fifteen or twenty years. The present practice is to prune a tree so that the trunk shall be short. This makes the picking of the fruit much easier and also exposes the tree less to wind and sun-scald.



Shield-budding

1, The T-shaped slit and the bud; 2, the bud set in the slit; 3, the bud tied



Verne Morton

Thorn apple. In winter, the low broad form of this tree is quite evident

There are certain underlying principles of pruning that every child should know: The pruning of the root cuts down the amount of moisture which the tree is able to get from the soil. The pruning of the top throws the food into the branches which are left and makes them more vigorous. If the buds at the tips of the twigs are pruned off, the food is forced into the side buds and into the fruit, which make greater growth. Thinning the branches allows more light to reach down into the tree, and gives greater vigor to the branches which are left. A limb should be pruned off smoothly where it joins the larger limb, and no stump should be left projecting; the wound should be painted so as not to allow fungus spores to enter.

We should not forget that we have a native apple, which we know as the thorn apple. Its low, broad head in winter makes a picturesque point along the fences; its fine, thick spray, spread horizontally, makes a fit framework for the bridal bouquet which will grow upon it in June; and it is scarcely less beautiful in autumn, when covered with the little, red apples called "haws." Though we may refrain from eating these native apples, which consist of a bit of sweet pulp around large seeds, the codling moth finds them most acceptable.

Suggested Reading — *The Apple Tree*, by Liberty Hyde Bailey; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons; Our Plant Friends and Foes*, by William A. DuPuy; also, readings on page 622.

LESSON 182
The Apple Tree

Leading Thought — The tree of each variety of apple has its own characteristic shape, although all apple trees belong to one general type. If apple trees of a certain variety are desired, they can be produced by budding or grafting; trees grown from apple seeds do not produce apples of the same variety as those of the parent tree.

Method — A visit to a large, well-grown orchard in spring or autumn will aid in making this work interesting. Any apple tree near at hand may be used for the lesson.

Observations — 1. How tall is the largest apple tree you know? What variety is it? How old is it? How can you distinguish old apple trees from young ones at a glance?

2. Choose a tree for study: How thick is its trunk? What is the shape of its head? Does the trunk divide into large branches or does it extend up through the center of the head?

3. What sort of bark has it? What is the color of the bark?

4. Does the spray stand erect or is it gnarled and querly? Does the spray grow simply at the ends of the branches or along the sides of the branches?

5. Are the leaves borne at the tip of the spray? Are the leaves opposite or alternate? Describe or sketch an apple leaf. Does it have stipules at its base when it first appears?

6. What is the character of apple-tree wood? What is it used for?

7. Did this tree come from a seed borne in an apple of the same variety which it produces? What is the purpose of grafting a tree? What is a scion? How and why do we choose a scion? How do we prepare a branch to receive the scion? If you should place the scion at the center of the branch would it grow? Where must it be placed in order to grow? How do we protect the cut end of the branch after it is grafted? Why?

8. What is meant by the term "budding"? What is the difference between grafting and budding? Describe the process of budding.

9. Where is budding done on a large scale? How do nurserymen know what special varieties of apples their nursery stock will bear? How old is a tree when it is budded? How old when it is sold to the orchardist?

10. Why should the soil around apple trees be tilled? Is this the practice in the best-paying orchards?

11. What is often used as a cover crop in orchards? When is this planted? For what purpose?

12. How far apart should apple trees be set? How may the land be utilized while the trees are growing? At what age does an apple tree usually come into bearing?

13. Is the practice now to allow an apple tree to grow tall? Why is an apple tree with a short trunk better than one with a long trunk?

14. What does it do to a tree to prune its roots? What does it do to a tree to prune its branches?

15. How does it affect a tree to prune the buds at the tips of the twigs?

16. How does it affect a tree to thin the branches? Describe how a limb should be pruned and how the wound thus made should be treated. Why?

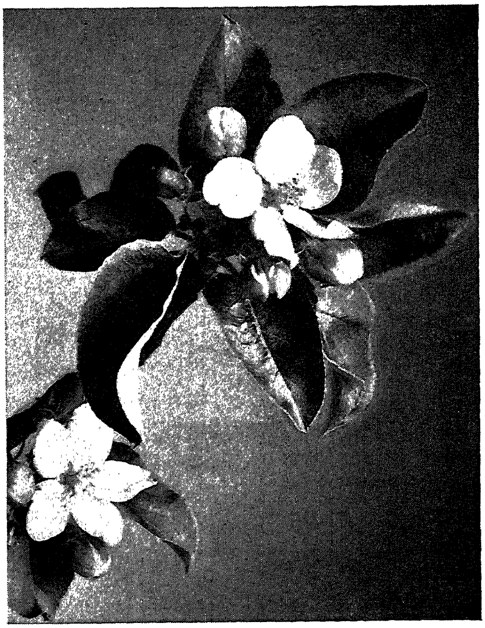
HOW AN APPLE GROWS

An apple tree in full blossom is a beautiful sight. If we try to analyze its beauty we find that on the tip of each twig there is a cluster of blossoms, and set around them, as in a conventional bouquet, are the pale, soft, downy leaves. These leaves and blossoms come from the terminal winter buds, which are protected during winter by little scales which are more or less downy. With the bursting of the bud, these scales fall off, each one leaving its mark crosswise on the twig, marking the end of the year's growth; these little ridges close together and in groups mark the winters which the twig has experienced, and thus reveal its age.

Varieties of apples differ in whether the blossoms or the leaves push out first; the season may cause a like difference. The white, downy leaves at first have two narrow stipules at the base of their petioles. They are soft, whitish, and fuzzy, as are also the flower stem and the calyx, which holds fast in its slender, pointed lobes the globular flower bud. We speak of the lobes of the calyx because they are joined at the base, and are not entirely separate as are sepals. The basal part of the calyx is cup-shaped, and upon its rim are set the large, oval petals, each narrowing to a slender stem at its base. The petals are set between the sepals or lobes of the calyx, the latter appearing as a beautiful, pale green, five-pointed star at the bottom of the flower. The petals are pink on the outside and white on the inside, and are veined from base to edge like a leaf; they are crumpled more than are the cherry petals.

The many pale, greenish white stamens of different lengths and heights stand up like a column at the center of the flower. They are tipped with pale yellow anthers, and are attached to the rim of the calyx-cup. They are really attached in ten different groups, but this is not easy to see.

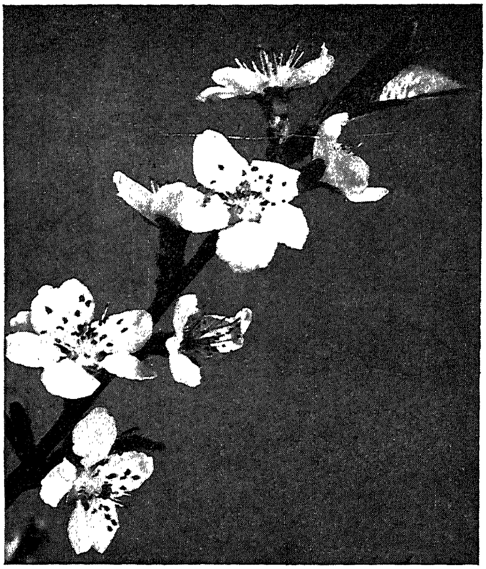
The five pale green styles are very silky and downy and are tipped with green stigmas. The pistils all unite at their bases making a five-lobed, compound ovary. The upper part of this ovary may be seen above the calyx-cup, but the lower portion is grown fast to it and is hidden within it. The calyx-cup is what develops into the pulp of the apple, and each of these pistils becomes one of the five cells in the apple core. If one of the stigmas does not receive pollen, its ovary will develop no seed; this often makes the apple lopsided. When the petals first fall, the calyx lobes are spread wide apart; later they close in toward the center, making a tube. To note exactly the time of this change is important, since the time of spraying for the codling moth is before the calyx lobes close. These lobes may be seen in any ripe apple as five little, wrinkled scales at the blossom end; within them may be seen the dried and wrinkled stamens, and within the circle of stamens, the sere and blackened styles.



Verne Morton

Apple blossoms

There may be five or six, or even more



Verne Morton

Peach blossoms

blossoms developed from one winter bud, and there may be as many leaves encircling them, forming a bouquet at the tip of the twig. However, rarely more than two of these blossoms develop into fruit, and the fruit is much better when only one blossom of the bouquet produces an apple; if a tree bears too many apples it cannot perfect them.

The blossoms and fruit are usually at the end of the twigs and spurs of the apple tree; and only rarely do they grow along the sides of the branches as do those of the cherry and the peach. However, there are many buds which produce only leaves; and just at the side and below the spur, where the apple is borne, a bud is developed, which pushes on and continues the growth of the twig, and will in turn be a spur and bear blossoms the following year.

LESSON 183

How an Apple Grows

Leading Thought — The purpose of the apple blossom is to produce apples which shall contain seeds to grow into more apple trees.

Method — This lesson should begin with the apple blossoms in the spring and should continue, with occasional observations, until the apples are well grown. If this is not possible, the blossom may be studied, and directly afterward the apple may be observed carefully, noting its relation to the blossom.

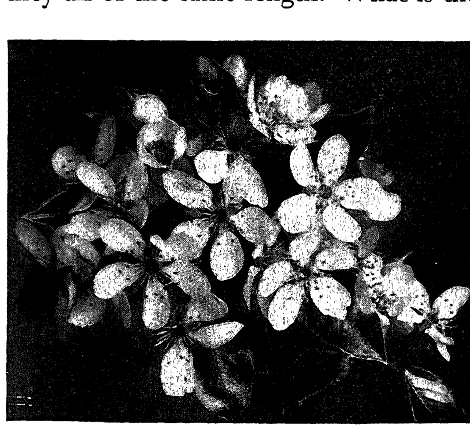
Observations — 1. How are the apple buds protected in the winter? As the buds open what becomes of the protecting scales? Can you see the scars left by the scales after they have fallen? How does this help us to tell the age of a twig or branch?

2. As the winter buds open, which appear first — the flowers or the leaves? Do they both come from the same bud? Do all the buds produce both flowers and leaves?

3. Study the bud of the apple blossom. Describe its stem; its stipules; its calyx. What is the shape and position of the lobes or sepals of the calyx? Why do we usually call them the " lobes of the calyx " instead of sepals?

4. Sketch or describe an open apple blossom. How many petals? What is their shape and arrangement? Can you see the calyx lobes between the petals as you look down into the blossom? What sort of figure do they make? Are the petals usually cup-shaped? What is their color outside and inside? Why do the buds seem so pink and the blossoms so white?

5. How many stamens are there? Are they all of the same length? What is the



Verne Morton

Pear blossoms

color of the filaments and anthers? On what are they set?

6. How many pistils do you see? How many stigmas are there? Are the ovaries united? Are they attached to the calyx?

7. Describe the young leaves as they appear around the blossoms. What is their color? Have they any stipules? Why do they make the flowers look like a bouquet?

8. After the petals fall, what parts of the blossom remain? What part develops into the apple? Does this part enclose the ovaries of the pistils? How can you tell in the ripe apple if any stigma failed to receive pollen?

9. What is the position of the calyx lobes directly after the petals fall? Do they change later? How does this affect spraying for the codling moth?

10. Watch an apple develop; look at it once a week and tell what parts of the blossom remain with the apple.

11. How many blossoms come from one winter bud? How many leaves? Do the blossoms ever appear along the sides of the branches, as in the cherries? How many blossoms from a single bud develop into apples?

M. V. Slingerland

Just ready to spray. A pear and two apples from which the petals have already fallen, with calyx lobes widely spread

12. Since the apple is developed on the tip of the twig, how does the twig keep on growing?

13. Compare the apple with the pear, the plum, the cherry, and the peach in the following particulars: position on the twigs; number of petals; number and color of stamens; number of pistils; whether the pistils are attached to the calyx-cup at the base.

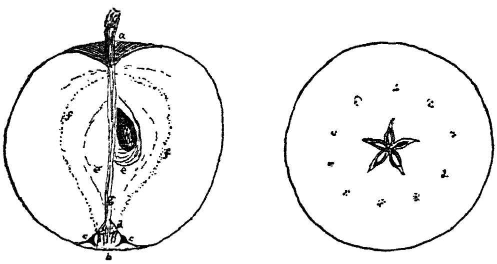
THE APPLE

Man fell with apples and with apples rose,
If this be true; for we must deem the mode
In which Sir Isaac Newton could disclose,
Through the then unpaved stars, the turnpike road,
A thing to counterbalance human woes.

— Byron

Apples seem to have played a very important part in human history, and from the first had much effect upon human destiny, judging from the trouble that ensued both to Adam and to Helen of Troy from meddling, even though indirectly, with this much esteemed fruit. It is surely no more than just to humanity — shut out from the Garden of Eden — that the apple should have led Sir Isaac Newton to discover the law which holds us in the universe; and that, in these later centuries, apples have been developed so beautiful and so luscious as almost to reconcile us to the closing of the gates of Paradise.

While it is true that no two apples were ever exactly alike, any more than any two leaves, yet their shapes are often very characteristic of the varieties. From the big, round Baldwin to the cone-shaped gillyflower, each has its own peculiar form, and also its own colors and markings and its own texture and flavor. Some have tough skins, others bruise readily even with careful handling; but to all kinds, the skin is an armor against those ever-present foes, the fungus spores, myriads of which are floating in the air ready to enter the smallest breach, and by their growth bring about decay. Even the tip of a branch or twig swayed by the wind may bruise an apple and cause it to rot;



1 2

1, *Apple cut along core; 2, Apple cut across core showing the five carpels and the ten outer core lines*

a, cavity; b, basin; c, calyx lobes; d, calyx-tube with withered stamens attached; e, carpels; f, outer core lines, terminating at a point where stamens are attached; g, fibers extending from stem to basin

windfalls are always bruised and will not keep. Greater care in packing, wrapping, picking, and storing, so as to avoid contact with other apples, is a paying investment of labor to the apple grower.

The cavities at the stem and basin ends of the fruit are also likely to have, in the same variety, a likeness in their depth or shallowness, and thus prove a help in identifying an apple. At the blossom or basin end of the fruit may be seen five scales, which are all that remain of the calyx lobes which enclosed the blossom; and within them are the withered and shrunken stamens and styles.

When the fruit is cut, we see that the inner parts differ as much in the different varieties as do the outer parts. Some have large cores, others small. The carpels, or seed cells, are five in number, and when the fruit is cut across through the center these carpels show as a pretty, five-pointed star; in them the seeds lie, all pointing toward the stem. Some apples have both seeds and carpels smooth and shining, while in others they are tufted with a soft, fuzzy outgrowth. The number of seeds in each cell varies; quite often the number is two. If a carpel is empty, the apple is often lopsided, and this signifies that the stigma of that ovary received no pollen. The apple seed is oval, plump, and pointed, with an outer shell, and a delicate inner skin covering the white meat; this separates readily into two parts, between which, at the point, may be seen the germ. The entire core, with the pulp immediately surrounding the seed cells, is marked off from the rest of the pulp by the core lines, faint in some varieties but distinct in others. In our native crab apples this separation is so complete that, when the fruit is ripe, the core may be plucked out leaving a globular cavity at the center of the apple.

Extending from the stem to the basin, through the center of the apple, is a bundle of fibers, five in number, each attached to the inner edge of a carpel, or seed box. Other bundles of fibers pass through the flesh about halfway between the core and the skin. Delicate as they are, so that no one observes them in eating the fruit, they show clearly as a second core line, and each terminates at a point in the calyx-tube where the stamens were attached — as can be easily seen by dissecting an apple. In transverse section, these show as ten faint dots placed opposite each outer point and inner angle of the star at the center formed by the carpels. Sometimes the seeds are very close to the stem, and the apple is said to have a sessile core; if at the center of the fruit, it has a medium core; if nearest to the blossom end, it has a distant core. This position of the core marks different varieties.

Apples, even of the same variety, differ much in yield and quality according to the soil and climate in which they grow. Varieties of apples are constantly changing; new varieties are introduced and older varieties are discarded. The Baldwin is still the leading variety in New York State but it has a distinct downward trend in the newer plantings. Northern Spy and Rhode Island Greening are still holding their own. In the plantings of recent years, McIntosh and Cortland have been most popular; it is only a question of time until the McIntosh will lead in New York State.

Too often in passing through the country, we see neglected and unprofitable orchards, with soil untilled, the trees unpruned and scale-infested, yielding scanty fruit, fit only for the cider mill and the vinegar barrel. This kind of orchard must pass away and give place to the new horticulture.

LESSON 184

The Apple

Leading Thought — The apple is a nutritious fruit, wholesome and easily digested. The varieties of apple differ in shape, size, color, texture, and flavor. A perfect apple has no bruise upon it and no wormholes in it.

Method — Typical blossoms of different varieties of apples should be brought into the schoolroom, where the pupils may closely observe and make notes about their appearance. Each pupil should have one or two apples that may be cut in vertical and transverse sections, so that the pulp, core lines, carpels, and seeds may be observed. After this lesson there should be an apple exhibit, and the pupils should be taught how to score the apples according to size, shape, color, flavor, and texture.

Observations — 1. Sketch the shape of your apple. Is it almost spherical, or flattened, or long and egg-shaped, or with unequal tapering sides? How does the shape of the apple help in determining its variety?

2. What is the color of the skin? Is it varied by streaks, freckles, or blotches? Has it one blushing cheek, the rest being of a different color?

3. Is the stem thick and fleshy, or short and knobby, or slender and woody and long? Does each variety have a characteristic stem?

4. Is the cavity or depression where the stem grew narrow and deep like a tunnel, or shallow like a saucer?

5. Examine the blossom end, or basin. What is its shape? Can you find within it the remnants of the calyx lobes, the stamens, and the pistils of the flower?

6. What is the texture of the skin of the apple? Is it thin, tough, waxy, or oily? Has it a bloom that may be rubbed off? From what sort of injury does the skin protect the apple?

Experiment 1. Take three apples of equal soundness and peel one of them; place them on a shelf. Place one of the unpeeled apples against the peeled one, and the other a little distance from it. Does the peeled apple begin to rot before the other two? Does the unpeeled apple touching the peeled one begin to decay first at the point of contact?

Experiment 2. Take an apple with a smooth, unblemished skin and vaccinate it with some juice from an apple that has begun to decay; perform the operation with a pin or needle, pricking first the unsound fruit and then the sound one; this may be done in patterns around the apple or with the initials of the operator's name. Where does this apple begin to decay? What should these two experiments teach us about the care and storage of fruit?

7. Cut an apple through its center from stem to blossom end. Describe the color, texture, and taste of the pulp. Is it coarse or fine-grained? Crisp or smooth? Juicy or dry and mealy? Sweet or sour? Does it exhale a fragrance or have a spicy flavor?

8. Is the flesh immediately surrounding the core separated from the rest of the pulp by a line more or less distinct? This is called the core line and differs in size and outline in different varieties. Can you find any connection between the stem and blossom ends and the core? Can you see the fibrous threads which connect them?

9. Cut an apple transversely across the middle. In what shape are the seed cells arranged in the center? Do the carpels or seed cells, vary in shape in different varieties? Are they closed, or do they all open into a common cavity? Can you see, between the core lines and the skin, faint

little dots? Count, and tell how they are arranged in relation to the star formed by the core.

10. The stiff, parchment-like walls of the seed cells are called carpels. How many of these does the apple contain? Do all apples have the same number of carpels? Are the carpels of all varieties smooth and glossy, or velvety? How many seeds do you find in a carpel? Do they lie with the points toward the stem end or the blossom end of the apple? Where are they attached to the apple? Describe the apple seed — its outer and inner coat and its "meat."

11. Is the core at the center of the apple, or is it nearer to the stem end or to the blossom end of the fruit? Are all apples alike in this particular?

12. Describe fully all the varieties of apples which you know, giving the average size, texture, and color of the skin, the shape of the cavities at the stem and blossom ends, the color, texture, and flavor of the pulp, and the position within the apple of the core.

THE PINE

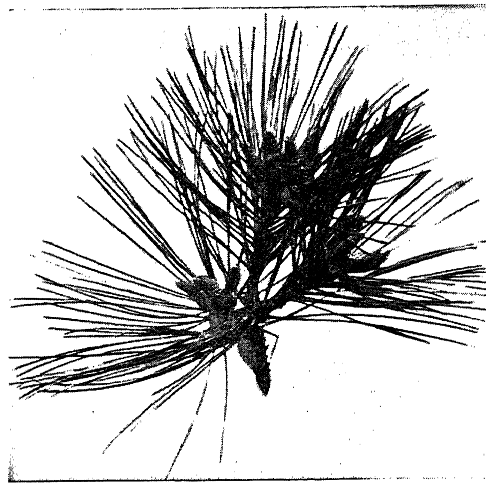
None other of our native trees is more beautiful than the pine. In the East, we have the white pine with its fine-tasselled foliage, growing often one hundred and fifty to two hundred feet in height and reaching an age of from two to three hundred years. On the Pacific coast, the splendid sugar pine lifts its straight trunk from two to three hundred feet in height; and although the trunk may be from six to ten feet in diameter yet it looks slender, so tall is the tree. A sugar pine cone on my desk measures twenty-two inches in length and weighs almost one pound, although it is dried and emptied of seed.

There is something majestic about the pines, which even the most unimpressionable feel. Their dark foliage outlined against wintry skies appeals to the imagination, and well it may, for it represents an ancient tree costume. The pines are among the most ancient of trees, and were the contemporaries of those plants which were put to sleep, during the Devonian age, in the coal beds. It is because the pines and the other evergreens belong essentially to earlier ages, when the climate was far different from that of today, that they do not shed their leaves like the more recent, deciduous trees. They stand among us, representatives of an ancient race, and wrap their green foliage about them as an Indian sachem does his blanket, in calm disregard of modern fashion of attire.

All cone-bearing trees have typically a central stem from which the branches come off in whorls, but so many things have happened to the old pine trees that the evidence of the whorls is not very plain; the young trees show this method of growth clearly, the white pine having five branches in each whorl. Sometimes pines are seen which have two or three stems near the top; but this is a story of injury to the tree and its later victory.

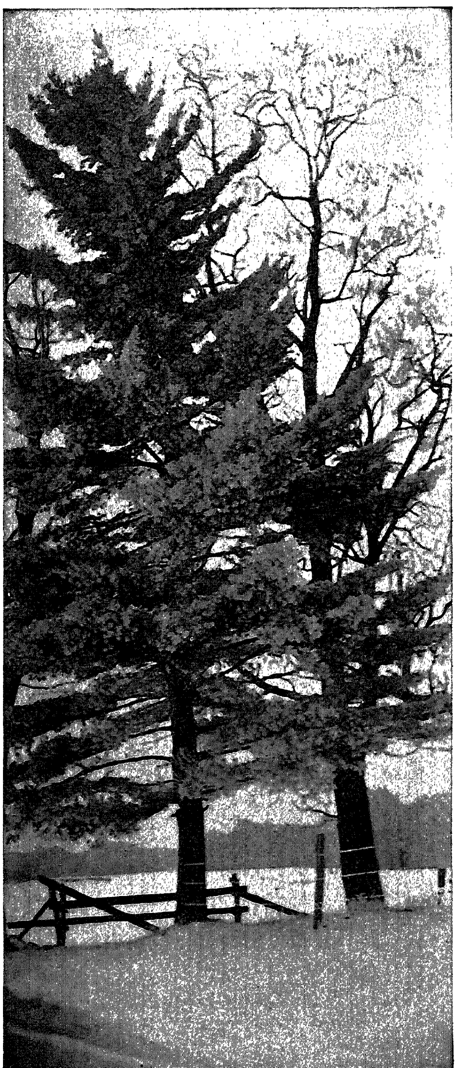
The very tip of the central stem in the evergreens is called "the leader," because it leads the growth of the tree upward; it stretches up from the center of the whorl of last year's young branches, and there at its tip are the buds which produce this year's branches. There is a little beetle which appears to be possessed of evil, for it seems to like best of all to lay its eggs in the very tip of this leader; the grub, after hatching, feeds upon the bud and bores down into the shoot, killing it. Then comes the question of which branch of the upper whorl shall rise up and take the place of the dead leader; but this is an election which we know less about than we do of those resulting from our blanket ballots. We do know that one branch of this upper whorl arises and continues the growth of the tree. Sometimes there are two candidates for this position, and they each make such a good struggle for the place that the tree grows on with two stems instead of one — and sometimes with even three. This evil insect injures the leaders of other conifers also, but these are less likely to allow two competitors to take the place of the dead leader.

The lower branches of many of the pines come off almost at right angles from the bole; the foliage is borne above the branches, which gives the pines a very different appearance from that of other trees. The foliage of most of the pines is dark green, looking almost black in winter; the pitch pine has the foliage yellowish green, and the white pine, bluish green; each species has its own peculiar shade. There is great variation in the color and form of the bark of different species. The white pine has nearly smooth bark on the young trees, but on the older ones it has ridges that are rather broad, flat, and scaly, separated by shallow sutures, while the pitch pine has its bark in scales like the covering of a giant alligator.



G. F. Morgan

Austrian pine in blossom showing staminate flowers



Verne Morton

White pine in Winter

The foliage of the pine consists of pine needles set in little bundles on raised points which look like little brackets along the twigs. When the pine needles are young, the bundle is enclosed in a sheath making the twig look as if it were covered with pinfeathers. In many of the species this sheath remains, encasing the base of the bundle of needles; but in the white pine it is shed early. The number of leaves in the bundle helps us to determine the species of the tree; the white pine has five needles in each bunch, the pitch pine has three, while the Austrian pine has two. There is a great difference in the length and the color of the needles of different species of pine. Those of the white pine are soft, delicate, and pliable, and from three to four inches in length; the needles of the pitch pine are stiff and coarse and about the same length; the

G. F. Morgan

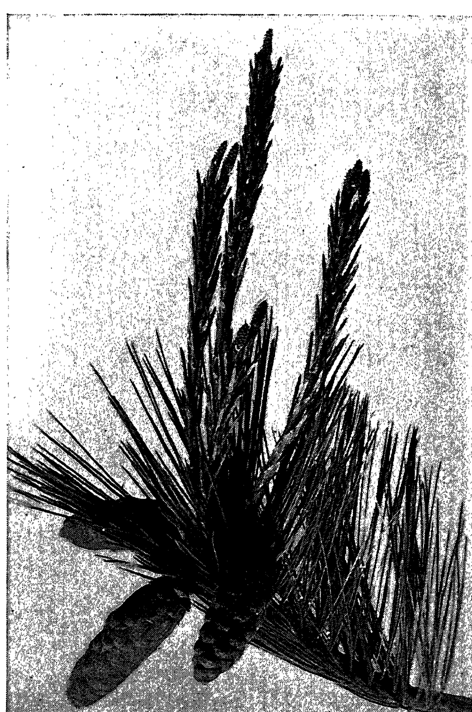
Austrian pine, staminate blossoms and empty cones

white pine needles are triangular in section, and are set so as to form distinct tassels, while those of the Austrian pine simply clothe the ends of the twigs. The needles of the pine act like the strings of an æolian harp; and the wind, in passing through the tree, sets them into vibration, making a sighing sound which seems to the listener like the voice of the tree. Therefore, the pine is the most companionable of all our trees and, to one who observes them closely, each tree has its own tones and whispers a different story.

The appearance of the unripe cone is another convincing evidence that mathematics is the basis of the beautiful. The pattern of the overlapping scales is intricate and yet regular — to appreciate it one needs to try to sketch it. Beneath each scale, when it opens wide, we find nestled at its base two little seeds; each provided with a little wing so that it can sail off with the wind to find a place to grow. The shape of the scales of the cone is another distinguishing characteristic of the pine, and sketching the outside of scales from several different species of pine cones will develop the pupils' powers of observation; the tip of the scale may be thickened or armed with a spine.

The pine cone requires two years for maturing; the pistillate flower from which it is developed is a tiny cone with each scale spread wide and standing upright to catch the pollen for the tiny ovule nestled within it. The pistillate flower of the white pine grows near the tip of the new twig, and is pinkish in color. In the Austrian pine it is the merest pink dot at first, but after a little shows itself to be a true cone with pink-purple scales, which stand up very erect and make a pretty object when viewed through a lens; each scale is pink at its three-pointed tip, with pink wings just below, the inner portions being pale green. The cone is set just beside the growing tip of the twig, is pointed upward, and its sheath scales are turned back like chaff around its base.

In June when the new shoots of the pine twigs stand up like pale green candles on a Christmas tree, at their bases may be found the staminate catkins set in radiating whorls, making galaxies of golden stars against the dark green background of foliage. In the Austrian pine,



Ralph W. Curtis

Young and mature cones of white pine

one of these pollen catkins may be an inch or two long and a half-inch in width; each little scale of this cone is an anther sac, filled to bursting with yellow pollen. From these starry pollen cones there descends a yellow shower when a breeze passes; for the pine trees depend upon the wind to sift their pollen dust into the lifted cups of the cone scales, which will close upon the treasure soon. The pollen grains of pine are very beautiful when seen through a microscope; and it seems almost incredible that the masses of yellow dust sifted in showers from the pines when in blossom should be composed of these beautiful structures. When the pine forests on the shores of the Great Lakes are in bloom, the pollen covers the waves for miles out from the shores.

If we examine the growing tips of the pine branches, we find the leaves look callow and pinfeathery. The entire leaf is wrapped in a smooth, shining, silken sheath, at the tip of which its green point protrudes. The sheath is tough like parchment and is cylindrical, because the pine needles within it are perfectly adjusted one to another in cylindrical form. The sheath is made up of several layers, one over the other, and may be pulled apart. The new leaves are borne on the new, pale green wood.

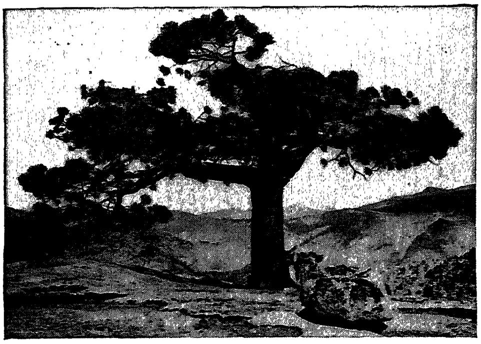
R. E. Horse

White pines

Ralph W. Curtis

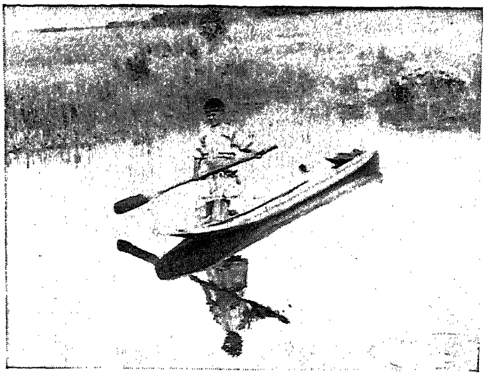
White pine *Norway spruce*
Pitch pine *Hemlock*

The uses of pines are many. The lumber of many of the species, especially that of the white pine, is free from knots and is used for almost everything from house-building to masts for ships. In the southern states, the long-leaved pines are tapped for resin, which is not the sap of the tree, as is generally supposed. Pine sap is like other sap; the resin is a product of certain glands of the tree, and is of great use to it in closing wounds and thus keeping out the spores of destructive fungi. It is this effort of the tree to heal its wounds that makes it pour resin into the cuts made



U. S. Geological Survey, G. K. Gilbert

Yellow pine on the brink of the Little Yosemite Valley



Leonard K. Beyer

Seminole boy in a cypress dugout, Everglades, Florida

by the turpentine gatherers. This resin is taken to a distillery, where the turpentine is given off as a vapor and condensed in a coiled tube which is kept cold. What is left is known as "rosin."

Suggested Reading — *First Studies of Plant Life*, by George F. Atkinson; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 2, *Outdoor Visits; Our Plant Friends and Foes*, by William A. DuPuy; *The Story of a Thousand-Year Pine*, by Enos A. Mills; also, readings on page 622.

LESSON 185

The Pine

Leading Thought — The pines are among our most ancient trees. Their foliage is evergreen but is shed gradually. The pollen-bearing and the seed-producing flowers are separate on the tree. The seeds are winged and are developed in cones.

Method — At least one pine tree should be studied in the field. Any species will do, but the white pine is the most interesting. The Austrian pine which is commonly planted in parks is a good subject. The leaves and cones may be studied in the schoolroom, each pupil having a specimen.

Observations — 1. What is the general shape of the pine tree? Is there one central stem running straight up through the center of the tree to the top? Do you find any trees where this stem is divided into two or three near the top? Describe how the pine tree grows. What is the "leader"? What happens if the leader is injured? How do the topmost branches of the young pine look? Do they all come off from the same part of the stem? How many are there in a whorl?

2. What color is the bark? Is it ridged or in scales?

3. Do the branches come off the main stem at right angles or do they lift up or droop down? Where is the foliage borne on the branches? What is the color of the foliage? Is the pine foliage ever shed, or does the pine leaf, when it comes, stay on as long as the tree lives?

4. Study the pine leaves. Why are they called needles? Note that they grow several together in what we call a bundle. How many in one bundle? Is the bundle enclosed in a little sheath at the base? Are the bundles grouped to make distinct tassels? Study one of the needles. How long is it? Is it straight or curved? Flexible or coarse and stiff? Cut it across and examine it with a lens. What is the outline in cross section? Why does the wind make a moaning sound in the pines?

White-pine cone

5. Study a pine cone. Does it grow near the tip of the branch or along the sides? Does it hang down or stand out stiffly? What is its length? Sketch or describe its general shape. Note that it is made up of short, overlapping scales. What pattern do the scales make as they are set together? Describe or sketch one scale; has it a thickened tip? Is there a spine at the tip of the scale?

6. Where in the cone are the seeds? Describe or sketch a pine seed. How long is its wing? How is it carried and planted? When the cone opens, how are the seeds scattered? What creatures feed upon the pine seed?

7. Study the pine when in blossom, which is likely to be in June. This time is easily determined because the air around the tree is then filled with the yellow pollen dust. Study the pollen-bearing flower. Is it conelike in form? Does it produce a great deal of pollen? If you have a microscope, look at the pollen through a high objective and describe it. How many of the pollen catkins are clustered together? On what part of the twigs are they borne? Where are the pistillate flowers which are to form the young cones? How large are they and how do they look at the time the pollen is flying? Do they point upward or droop downward? Look beneath the scales of a little cone with a lens and see if you can find the flowers. What is it that carries the pine pollen to the flowers in the cone?

8. Name all the uses for pine lumber that you know. Write an English theme on how turpentine is produced from pines and the effect of this industry upon pine forests. Where does resin appear on the pine? Of what use is it to the tree? Do you think it is pine sap? What is the difference between resin and rosin?

9. How long do the pine trees live? Write a story of some of the changes that have taken place in your neighborhood since the pine tree which you have been studying was planted.

10. Make the following drawings: a bundle of pine needles showing the sheath and its attachment to the twig; the cone; the cone scale; the seed. Sketch a pine tree.

THE NORWAY SPRUCE

The Norway spruce is a native of Europe, and we find it in America one of the most satisfactory of all spruces for ornamental planting; it lifts its slender cone from almost every park and private estate in our country, and is easily distinguished from all other evergreens by the drooping, pendant habit of its twigs, which seem to hang down from the straight, uplifted branches. We have spruces of our own — the black, the white, and the red spruces; and it will add much to the interest of this lesson for the pupils to read in the tree and forestry books concerning these American species. Chewing gum and spruce beer are the products of the black and red spruce of our eastern forests. The Douglas spruce, which is a fir and not a spruce, is also commonly planted as an ornamental tree, but it is only at its best on the Pacific Coast, where it is one of the most magnificent of trees.

The Norway spruce tree is in form a beautiful cone, slanting from its slender tip to the ground, on which its lower drooping branches rest; the upper branches come off at a narrower angle from the sturdy central stem than do the widespreading lower branches. On the older trees, the twigs hang like pendulous fringes from the branches, enabling them to shed the snow more readily — a peculiarity which is of much use to the tree, because it is a native of the snowy northern countries of Europe and also grows successfully in the high altitudes of the Alps and other mountains. If we stroke a spruce branch toward the tip, the hand slides smoothly over it; but brush backward from the tip, and the hand is pricked

Norway spruce

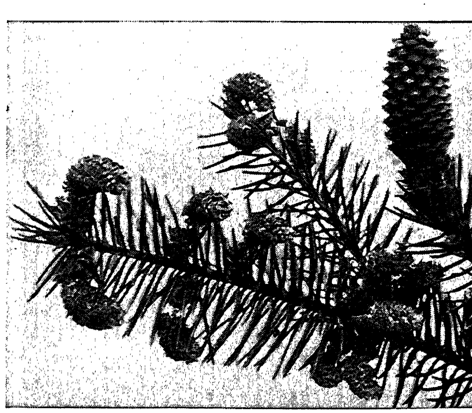
by hundreds of the sharp, bayonet-pointed leaves; this arrangement permits the snow to slide off.

If we examine a twig of the present year's growth, we can see on every side of its brown stem the pointed leaves, each growing from a short ridge; but the leaves on the lower side stretch out sidewise, and those above lift up angularly. Perhaps the twig of last year's growth has shed its leaves which grew on the underside and thus failed to reach the sun. The leaf of the spruce is curved, stiff, and four-sided, and ends in a sharp point. It is dark yellowish above and lighter beneath and is set stiffly on the twig. The winter buds for next year's growth may be seen at the tips of the twigs, covered with little, recurved, brown scales quite flower-like in form. In the balsam fir, which is often planted with the Norway spruce, these buds are varnished.

The cones are borne on the tips of the branches and hang down. In color they are pale wood-brown; they are from four to six inches long, and are very conspicuous. They are made up of broad scales that are thin toward the notched tips; they are set around the central stem in spirals of five rows. If we follow one spiral around marking it with a winding string, it will prove to be the fifth row above the place where we started. These manifold spirals can be seen sometimes by looking into the tip end of a cone. The cone has much resin on it, and is a very safe place for seeds; but when it begins to open, squirrels impatiently tear it to pieces, harvesting the seeds and leaving a pile of cone scales beneath the tree to tell of their piracy.

A Norway spruce in blossom is a beautiful sight; the little, wine-red pistillate cones are lifted upwards from the tips of the twigs, while short terminal branches are laden with the pollen-bearing catkins, which are soft and caterpillarish, growing on soft, white stems from the base of scales which enclosed and protected them during the winter; these catkins are filled with the yellow dust. The young cones continue to stand upright after the scales have closed on the pollen which has been sifted by the wind to the ovules at the base of the scales; and for some time they remain most ornamentally purplish red. Before the cone is heavy enough to bend from its own weight, it turns around and downward, and then changes its color to green, ripening into brown in the fall.

The Norway spruce grows on the Alps



G. F. Morgan

Staminate blossoms and young cone of a Norway spruce abundantly, and like the youth with the banner, "excelsior" is its motto; this appears even in its scientific name (*Picea excelsa*). Here it grows to the height of one hundred to one hundred and fifty feet. Its wood is valuable and its pitch is marketed. In this country, it is used chiefly for ornamental planting and for windbreaks.

SUGGESTED READING — *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 5, *Science at Home*; also, readings on page 622.

LESSON 186

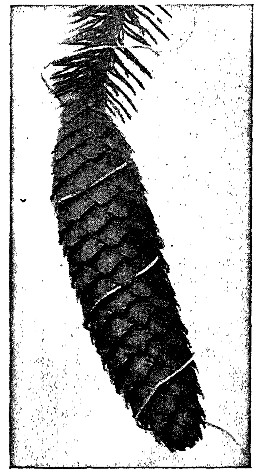
THE NORWAY SPRUCE

LEADING THOUGHT — The Norway spruce is one of the most valuable of the trees which have come to America from Europe. It grows naturally in high places and in northern countries where there is much snow; its drooping twigs cannot hold a great burden of snow, and thus it escapes being crushed.

METHOD — This lesson should begin in the autumn when the cones are ripe. The tree should be observed by all of the pupils, and they should bring in twigs and cones for study in the schoolroom. The lesson should be taken up again in May when the trees are in blossom.

L. H. Bailey

Cones of Norway spruce



Cyrus Crosby

A cone of Norway spruce, showing that the spiral of the scales is in rows of five

OBSERVATIONS — 1. What is the general shape of the tree? Do the lower branches come off at the same angle as the upper? If untrimmed, what can you see of the trunk? Do the lower branches rest upon the ground? What advantage would this be to the tree in winter? Do the twigs stand out, or droop from the branches? Of what advantage is this in case of heavy snow? What is the color of the foliage? Where did the Norway spruce come from?

2. What is the color of the twig? How are the leaves set upon it? Are there more leaves on the upper than on the under side of the twigs of this year's growth? Of last year's growth? Brush your hand along a branch toward the tip. Do the leaves prick? Brush from the tip backward. Is the result the same? Why is this angle of the leaves to the twig a benefit during snowstorms?

3. Take a single leaf. What is its shape? How many sides has it? Is it soft or stiff? Is it sharp at the tip? Describe the buds which are forming for next year's growth. Look along the twigs and see if you can

discover the scales of the bud which produced last year's growth.

4. Where are the cones borne? How long does it take a cone to grow? Is it heavy? Is there resin on it? Note that the scales are set in a spiral around the center of the cone. Wind a string around a cone following the same row of scales. How many rows between those marked with a string? Look into the tip of a cone and see the spiral arrangement. Sketch and describe a cone scale, paying special attention to the shape of the tip. Try to tear a cone apart. Is this easily done? Hang a closed cone in a dry place and note what happens.

5. Describe the seed, its wings, and where it is placed at the base of the scale. How many seeds under each scale? When do the cones open of themselves to scatter the seed? Do you observe squirrels tearing these apart to get the seed?

6. The Norway spruce blossoms in May. Find the little flower which will produce the cone, and describe it. What color is it? Is it upright or hanging down? Do the scales turn toward the tip or backward? Why is this? Where are the pollen catkins borne? How many of them arise from the same place on the twig? Can you see the little scales at the base of each pistillate catkin? What are they? Are they very full of pollen? Do the insects carry the pollen for the Norway spruce, or does the wind sift it over the pistillate blossoms? After the pollen is shed, note if the scales of the young cones close up. How long before the cones begin to droop?

7. What use do we make of the Norway spruce? What is it used for in Europe?

All outward wisdom yields to that within,
Whereof nor creed nor canon holds the key;
We only feel that we have ever been
And evermore shall be.

And thus I know, by memories unfurled
In rarer moods, and many a nameless sign,
That once in Time, and somewhere in the world,
I was a towering pine.

Rooted upon a cape that overhung
The entrance to a mountain gorge; whereon
The wintry shade of a peak was flung,
Long after rise of sun.

There did I clutch the granite with firm feet,
There shake my boughs above the roaring gulf,
When mountain whirlwinds through the passes beat,
And howled the mountain wolf.

There did I louder sing than all the floods
Whirled in white foam adown the precipice,
And the sharp sleet that stung the naked woods,
Answer with sullen hiss.

I held the eagle till the mountain mist
Rolled from the azure paths he came to soar,
And like a hunter, on my gnarled wrist
The dappled falcon bore.

— From "THE SPIRIT OF THE PINE,"
BAYARD TAYLOR

THE HEMLOCK

O'er lonely lakes that wild and nameless lie,
Black, shaggy, vast and still as Barca's sands
A hemlock forest stands. Oh forest like a pall!
Oh hemlock of the wild, Oh brother of my soul,
I love thy mantle black, thy shaggy bole,
Thy form grotesque, thy spreading arms of steel.

— Pattee

In its prime, the hemlock is a magnificent tree. It reaches the height of from sixty to one hundred feet and is cone-shaped. Its fine, dense foliage and drooping branches give it an appearance of exquisite delicacy; and I have yet to see elsewhere such graceful tree-spires as are the hemlocks of the Sierras, albeit they have bending tips. However, an old hemlock becomes very ragged and rugged in appearance; and dying, it rears its wind-broken branches against the sky, a gaunt figure of stark loneliness.

The hemlock branches are seldom broken by snow; they droop to let the burden slide off. The bark is reddish, or sometimes gray, and is furrowed into wide, scaly ridges. The foliage is a rich dark green, but whitish when seen from below. The leaves of the hemlock are really arranged in a spiral, but this is hard to demonstrate. They look as though they were arranged in double rows along each side of the little twig; but they are not in the same plane and there is usually a row of short leaves on the upper side of the twig. The leaf is blunt at the tip and has a little petiole of its own which distinguishes it from the leaves of any other species of conifer; it is dark, glossy green above, pale green beneath, marked with two white, lengthwise lines. In June, the tip of every twig grows and puts forth new leaves which are greenish yellow in color, making the tree very beautiful and giving it the appearance of blossoming. The leaves are shed during the third year. The hemlock cones are small and are borne on the tips of the twigs. The seeds are borne two beneath each scale, and they have wings nearly as large as the scale itself. Squirrels are so fond of them that probably but few have an opportunity to try their wings. The cones mature in one year, and usually fall in the spring. The hemlock blossoms in May; the pistillate flowers are very difficult to observe, as they are tiny and greenish and are placed at the tip of the twig. The pollen-bearing flowers are little, yellowish balls on delicate, short stems, borne along the sides of the twig.

Ralph W. Curtis

Hemlock branch showing young and mature cones

Hemlock bark is rich in tannin and is used in great quantities for the tanning of leather. The timber, which is coarse-grained, is stiff and is used in framing buildings and for railroad ties; nails and spikes driven into it cling with great tenacity and the wood does not split in nailing. Oil distilled from the leaves of hemlock is used as an antiseptic.

The dense foliage of the hemlock offers a shelter to birds of all kinds in winter; even the partridges roost in the young trees. These young trees often have branches drooping to the ground, making an evergreen tent which forms a winter harbor for mice and other beasties. The seed-eating birds which remain with us during the winter feed upon the seeds; and as the cones grow on the tips of the delicate twigs, the red squirrels display their utmost powers as acrobats when gathering this, their favorite food.

SUGGESTED READING — Page 622.

LESSON 187
THE HEMLOCK

LEADING THOUGHT — This is one of the most common and useful and beautiful of our evergreen trees. Its fine foliage makes it an efficient winter shelter for birds.

METHOD — Ask the children the questions and have them make notes on the hemlock trees of the neighborhood. The study of the leaves and the cones may be made in the schoolroom.

OBSERVATIONS — 1. Where does the hemlock tree grow in your neighborhood? What is the general shape of the tree? What sort of bark has it? How tall does it grow? How are its branches arranged to shed the snow?

2. What is the color of the foliage? How are the leaves arranged on the twigs? Are all the leaves of about the same size? What is the position of the smaller leaves?

3. Break off a leaf and describe its shape; its petiole. Does the leaf of any other evergreen have a petiole? What is the color and marking of the hemlock leaf above? Below? At what time of year are the new leaves developed? How does the hemlock tree look at this time? Does the hemlock ever shed its leaves?

4. Are the hemlock cones borne on the tip of the twigs or along the side? How long does it take a cone to mature? When does it fall? How many scales has it? Where are the seeds borne? How many seeds beneath each scale? Describe and sketch a hemlock seed. How are the seeds scattered? Study the tree in May, and see if you can find the blossom.

5. Make drawings of the following: the hemlock twig, showing the arrangement of the leaves; single leaf, enlarged; cone; cone scale; seed.

6. What creatures feed upon the hemlock seed? What birds find protection in the hemlock foliage in winter?

7. For what purposes is hemlock bark used? What is the timber good for? Is a nail easily pulled out from a hemlock board?

THE DOGWOOD

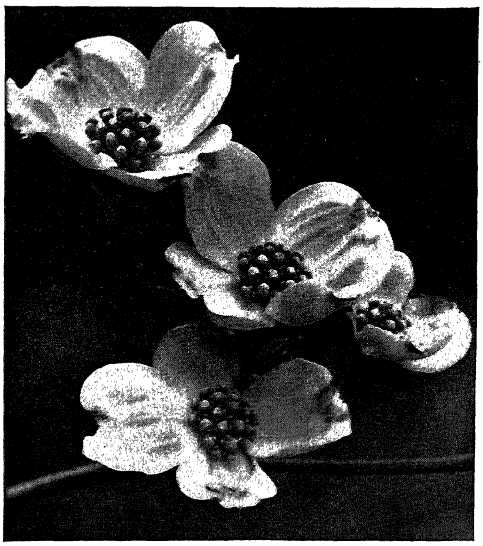
Through cloud rifts the sunlight is streaming in floods to far depths of the wood,
Retouching the velvet-leafed dogwood to crimson as vital as blood.

There is no prettier story among the flowers than that of the bracts of the dogwood, and it is a subject for investigation which any child can work out for himself. I shall never forget the thrill of triumph I experienced when I discovered for myself the cause of the mysterious dark notch at the tip of each great white bract, which I had for years idly noticed. One day my curiosity mastered my inertia, and I hunted a tree over for a flower bud, for it was rather late in the season; finally I was rewarded by finding the bracts in all stages of development.

The flowering dogwood forms its buds during the summer, and of course they must have winter protection. They are wrapped in four close-clasping, purplish brown scales, one pair inside and one pair outside, both thick and well fitted to protect the bunch of tiny flower buds at their center. But when spring comes, these bud scales change their duties, and by rapid growth become four beautiful white or pinkish bracts which we call the dogwood flower. For months these bracts cover the true flowers which are at their center and then display them to an admiring world.

The artistic eye loves the little notch at the tip of the bracts, even before it has read in it the story of winter protection, of which it is an evidence.

The study of the flowers at the center is more interesting if aided by a lens. Within each blossom can be seen its tube, set in the four-lobed calyx. It has four slender petals curled back, its four chubby, greenish yellow anthers set on filaments which lift them up between the petals; and at the center of all is the tiny green pistil.



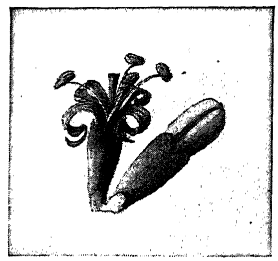
Hugh Spencer

Dogwood

There may be twenty, more or less, of these perfect flowers in this tiny, greenish yellow bunch at the center of the four great, flaring bracts. These flowers do not open simultaneously, and the yellow buds and open flowers are mingled together in the rosette. The calyx shows better on the bud than on the open flower. It might be well to explain to the pupils that a bract is simply a leaf in some other business than that ordinarily performed by leaves.

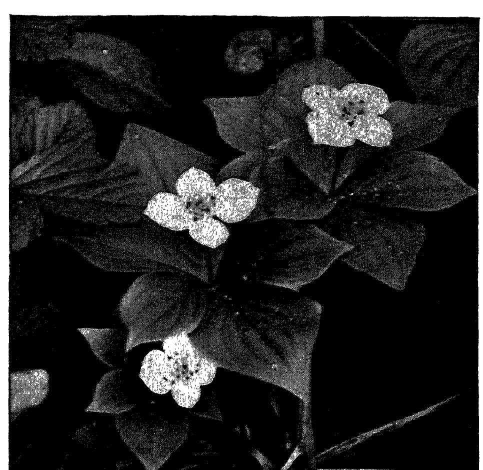
The twigs have a beautiful, smooth bark, purplish brown above and greenish below. The flowers grow at the tips of the twigs; and the young leaves are just below the flowers and also at the tips of the twigs. These twigs are spread and bent in a peculiar way, so that each white flower-head may be seen by the admiring world and not be hidden behind any of its neighbors. This habit makes this tree a favorite for planting, since it forms a mass of white bloom.

The dogwood banners unfurl before the flowers at their hearts open, and they re-



Blossom and bud of dogwood enlarged

main after the last flower has received within itself the vital pollen which will enable it to mature into a beautiful berry. This long period of bloom is another quality which adds to the value of the dogwood as an ornamental tree. At the time the bracts fall, the curly petals also fall out leaving the little calyx-tubes standing with style and stigma projecting from their centers, making them look like a bunch of lilliputian churns with dashers. In autumn, the foliage turns to a rich, purplish crimson — a most satisfying color.



Charles E. Mohr

Dwarf cornel or bunchberry — a dwarf dogwood

During the winter, the flowering dogwood, which renders our forests so beautiful in early spring, may be readily recognized by its bark, which is broken up into small scales and mottled like the skin of

The flower buds of the dogwood are formed during the previous season

a serpent; and on the tips of its branches are the beautiful clusters of red berries, or speaking more exactly, drupes. This fruit is oval, with a brilliant, shining, red, pulpy covering which must be attractive to birds. At its tip it has a little purple crown, in the center of which may be seen the remnant of the style, but this attractive outside covers a seed with a very thick, hard shell, which is quite indigestible and fully able to protect, even from the attack of the digestive juices of the bird's stomach, the tender white kernel within it, which includes the stored food and the embryo. There are in the North other common species of dogwood which have dark blue fruit.

Suggested Reading — Page 622.

LESSON 188

The Dogwood

Leading Thought — The real petals of the dogwood are not the chief means of attracting insects to its flowers. The showy portions are really bracts and not the true flower.

Method — Observe a branch of the dogwood when it is in flower. The branch should have upon it some flowers that are unopened. Study the flower first, and ask the pupils to discover for themselves why the great white bracts have a notch in the tip. A lens is a great help to the interest in studying these tiny flowers.

Observations — 1. What is there at the center of the group of bracts? How do the parts at the center look? Are they of the same shape? Are some opened and others not? Can you see how many petals this tiny flower has? Describe its calyx. How many stamens has it? Can you see the pistil? If a flower has a calyx and stamens and a pistil, has it not all that a flower needs?

2. How many of these flowers are there at the center of what is often called the dogwood "blossom"? What color are they? Would they show off much if it were not for the great white banners around them? Do we not think of these great white bracts as the dogwood flower?

3. Study one of these banners. What is its shape? Are the four white bracts the same shape and size? Make a sketch of these four bracts with the bunch of flowers at the center. What is there peculiar about each one of these white bracts? Find one of the flower-heads which is not yet opened and watch it develop into a small flower.

4. Sketch the bracts from below. Is one pair wider than the other? Is the wider pair inside or outside?

5. Where are the flowers of the dogwood borne? How are the twigs arranged so as to unfurl all the banners and not hide one behind another, so that the whole tree is a mass of white?

6. While studying the flowers, study where the young leaves come from. Can you still see the scales which protected the leaf buds?

7. What kind of fruit develops from the dogwood blossoms? What colors are its leaves in autumn?

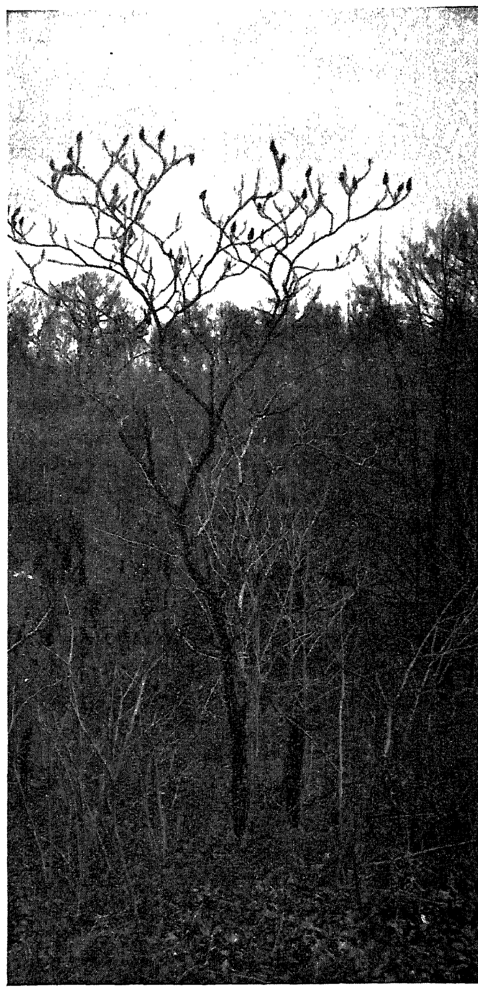
THE VELVET OR STAGHORN SUMAC

The sumacs with flame leaves at half-mast, like wildfire spread over the glade;
Above them, the crows on frayed pinions move northward in ragged parade.

The sumacs, in early autumn, form a " firing line " along the borders of woodlands and fences, before any other plant but the Virginia creeper has taken on brighter colors. No other leaves can emulate the burning scarlet of their hues. The sumacs are a glory to our hills; and sometime, when Americans have time to cultivate a true artistic sense, these shrubs will play an important part in landscape gardening. They are beautiful in summer, when each crimson " bob " (a homely New England name for the fruit panicle) is set at the center of the bouquet of spreading, fernlike leaves. In winter nakedness they are most picturesque, with their broadly branching twigs bearing aloft the wine-colored pompons against the background of snow; at this time and in early spring when more desirable food is lacking, the birds eat the pleasantly acid drupes. In spring, they put out their soft leaves in exquisite shades of pale pinkish green, and when in blossom their staminate panicles of greenish white cover them with loose pyramids of delicate bloom.

Well may it be called velvet sumac, for this year's growth of wood and the leaf stems are covered with fine hairs, pinkish at first, but soon white; if we slip our fingers down a branch, we can tell, even without looking, where last year's growth began and ended, because of the velvety feel. The name staghorn sumac is just as fitting, for its upper branches spread widely like a stag's horns and, like them, the new growth is covered with velvet.

The leaves are borne on the new wood, and therefore at the ends of branches; they are alternate; the petiole broadens where it clasps the branch, making a nursery for the next year's bud, which is nestled below it. The leaves are compound and the number of leaflets varies



Verne Morton

Sumac

from eleven to thirty-one. Each leaflet is set close to the midrib, with a base that is not symmetrical; the leaflets have their edges toothed, and are long and narrow; they do not spread out on either side of the midrib like a fern, but naturally droop somewhat, and thus conceal their undersides, which are much lighter in color. The leaflets are not always set exactly

Verne Morton

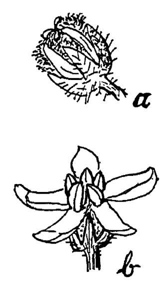
The staghorn sumac

opposite; the basal ones are bent back toward the main stem, making a fold in the base of each. The end leaflets are not always three, symmetrically set, but sometimes are two and sometimes one, with two basal lobes.

The wine-colored "bob" is cone-shaped, but with a bunchy surface. Remove all the drupes from it and note its framework of tiny branches, and again pay admiring tribute to nature's way of doing up compact packages. Each fruit is a drupe, as is also the cherry. A drupe is merely a seed within a fleshy layer, all being enclosed in a firmer outside covering; here, the outside case is covered with dark red fuzz, a clothing of furs for winter, the fur standing out in all directions. The fleshy part around the seed has a pleasantly acid taste, and one of my childhood diversions was to share these fruits in winter with the birds. I probably inadvertently ate also many a little six-footed brother hidden away for winter safe-keeping, for every sumac panicle is a crowded insect tenement.

It is only in its winter aspect that we can see the peculiar way of the sumac's branching, which is in picturesque zigzags, ending with coarse, widespreading twigs. Each terminal twig was a stem for the bouquet of blossom and fruit set about with graceful leaves, but in the winter, after the leaves have fallen, the coarse branching is very noticeable. The wood of the sumac has a pith, and is coarse in texture.

During late May the new growth starts near the end of last year's twig; the buds are yellowish and show off against the dark gray twigs. From the center of these buds comes the fuzzy new growth, which is usually reddish purple; the tiny leaves are folded, each leaflet creased at its midrib and folded tightly against itself; as the leaves unfold, they are olive-green tinted with red, and look like tassels coming out around the old dark red "bob." When the sumacs are in blossom, we see in every group of them two kinds; one with pyramids of white flowers, and the other with pinkish callow bobs. The structure of these two different flower-clusters is really the same, except that the white ones are looser and more widely spread. Each flower of the white panicle is staminate, and has five greenish, somewhat hairy sepals and five yellowish white petals, at the center of which are five large anthers.



a, Pistillate flower from a "bob." b, Staminate flower from the greenish panicle

A flower from the bob is quite different; it has the five hairy sepals alternating with five narrow, yellowish white petals, both clasping the globular base or ovary, which is now quite covered with pinkish plush, and bears at its tip the three styles flaring into stigmas.

The velvet sumac is larger than the smooth species (*Rhus glabra*), and is easily distinguished from it, since the new wood of the latter is smooth and covered with bloom but is not at all velvety. The poison sumac (page 514), dangerous to many people when handled, is a swamp species and its fruit is a loose, drooping panicle of whitish berries, very much like that of poison ivy; therefore, any sumac that has the red bob is not dangerous. The poison species has the edges of its leaflets entire and each leaflet has a distinct petiole of its own where it joins the midrib.

There is much tannin in sumac and it is used extensively to tan leather. The bobs are used for coloring a certain shade of brown. The famous Japanese lacquer is made from the juice of a species of sumac.

LESSON 189

The Velvet or Staghorn Sumac

Leading Thought — The sumac is a beautiful shrub in summer because of its fernlike leaves; it is picturesque in winter, and its colors in autumn are most brilliant. Its dark red fruit clusters remain upon it during the entire winter. In June it shows two kinds of blossoms on different shrubs; one is whitish and bears the pollen, the other is reddish and is a pistillate flower, later developing into the seed on the " bob," or fruit cluster.

Method — Begin this study in October when the beautiful autumn color of the leaves attracts the eye. Observations to be made in the field should be outlined and should be answered in the field notebooks. The study of the fruit and leaf may be made in the schoolroom, and an interest should be developed which will lead to the study of the interesting flowers the following spring. The sumacs in autumn make a beautiful subject for water-color sketches, and their peculiar method of branching with their dark red seed clusters or bobs makes them excellent subjects for winter sketching.

Observations — 1. Why is this called the velvet sumac? Why is it called the staghorn sumac? Look at the stems with a lens and describe the velvet. Can you tell this year's wood by the velvet? Is there any velvet on last year's wood? Is there any on the wood below? What is there peculiar in the appearance of last year's wood? What are the colors of the hairs that make the velvet on this year's growth? On last year's growth? What is the color of this year's growth under the velvet? Where are the leaves borne?

2. Look at the leaves. How many come off the stem between two, one of which is above the other? Is the midrib velvety? What is its color at base and at tip? What is the shape of the petiole where it joins the stem? Remove the leaf. What do you find hidden and protected by its broad base?

3. How many leaflets are there on the longest leaf which you can find? How many on the shortest? Do the leaflets have little petioles, or are they set close to the midrib? How does the basal pair differ from the others? Are the leaflets the same color above as below? Are the pairs set exactly opposite each other? Look at the three leaflets at the tips of several leaves and see if they are all regular in form. Draw a leaflet, showing its base, its veins, and its margin. Draw an entire leaf, and color it as accurately as possible.

4. Study the fruit. Pick one of the bobs and note its general shape. Is it smooth or bunchy? Sketch it. Remove one of the little bunches and find out why it is of that shape. Remove all of the seeds from one of last year's bobs and see how the fruit is borne. Sketch a part of such a bare stem.

5. Take a single fruit; look at it through a lens and describe it. What are the colors? Cut or pare away the flesh, and describe the seed. What birds live on the sumac seeds in winter? How many kinds of insects can you find wintering in the bob? Find a fruit free from insects and taste it.

Winter Work — 6. Study the sumac after the leaves have fallen and sketch it. What is there peculiar in its branching? Of what use to the plant is its method of branching? Break a branch and look at the end. Is there a pith? What color are the wood and pith?

May or June Work — 7. Where on the branch does the new growth start? How are the tiny leaves folded? Look over a group of sumacs and see if their blossoms all look alike. Are the different kinds of blossoms found on the same tree or on different trees? Take one of the white pyramidal blossom clusters; look at one of these flowers with a lens and describe its sepals and petals. How many anthers has it and where are they? This is a pollen-bearing flower and has no pistil. How are its tiny staminate flowers arranged on the stem to give the beautiful pyramid shape? This kind of flower cluster is called a panicle.

8. Take one of the green bobs and see if it is made up of little round flowers. Through a lens study one of these. How many sepals? How many petals? Describe the middle of the flower around which the petals and sepals clasp. Is this the ovary, or seed box? Can you see the stigmas protruding beyond it? What insects visit these flowers?

9. How can you tell the velvet or staghorn sumac from the smooth sumac? How can you tell both of these from the poison sumac?

10. To what uses are the sumacs put?

I see the partridges feed quite extensively upon the sumach berries, at my old house. They come to them after every snow, making fresh tracks, and have now stripped many bushes quite bare.

— Thoreau's Journal, Feb. 4, 1856

THE WITCH HAZEL

In the dusky, somber woodland, thwarting vistas dull and cold,
Thrown in vivid constellations, gleam the hazel stars of gold,
Gracious gift of wealth untold.

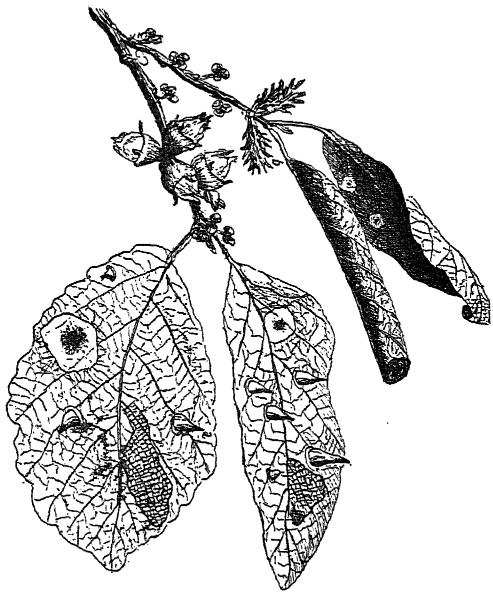
Hazel blossoms brightly glowing through the forests dark and drear,
Work sweet miracles, bestowing gladness on the dying year,
Joy of life in woods grown sere.

Witch hazel is not only a most interesting shrub in itself, but it has connected with it many legends. From its forked twigs were made the divining rods by which hidden springs of water or mines of precious metals were found, as it was firmly believed that the twig would turn in the hand when the one who held it passed over the spring or mine. At the present day, its fresh leaves and twigs are used in large quantities for the distilling of the healing extract so much in demand as a remedy for cuts and bruises and for chapped or sunburned skins. It is said that the Oneida Indians first taught the white people concerning its medicinal qualities.

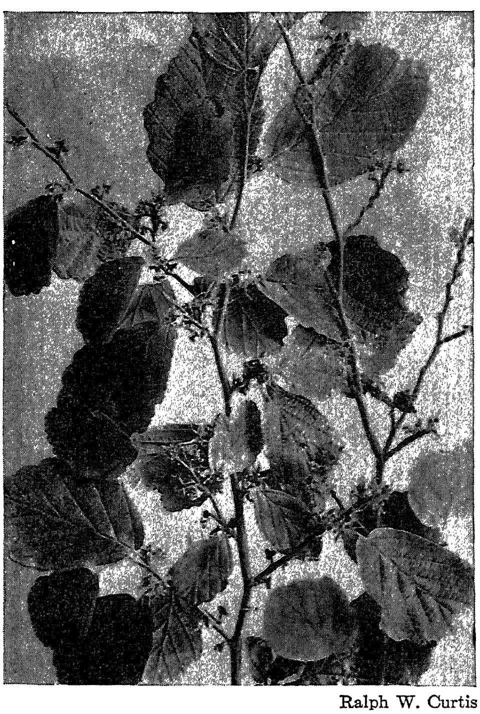
The witch hazel is a large shrub, usually from six to twelve feet high, although under very advantageous circumstances it has been known to take a treelike form and attain a height of more than twenty feet. Its bark is very dark grayish brown, smooth, specked with little dots, which are the lenticels, or breathing-pores. If the season's growth has been rapid, the new twigs are lighter in color, but when stunted by drouth or poor soil, the new growth has a tint similar to the old. The wood is white, very tough and fibrous, with a pith or heartwood of softer substance and yellow in color. The leaves are alternate, and the leaf buds appear at the tips of the season's twigs, while the blossoms grow at the axils of the leaves.

The witch-hazel leaf is nearly as broad as it is long, bluntly pointed at its tip, with a stem generally less than one-half inch in length. The sides are unequal in size and shape, and the edges are roughly scalloped. The veins are almost straight, and are depressed on the upper side but very prominent beneath, and they are lighter in color than the rest of the leaf. Witch-hazel leaves are likely to be apartment houses for insects, especially the insects that make galls. Of these there are many species, each making a differently shaped gall. One of the most common is a gall shaped like a little horn or spur on the upper side of the leaf and having a tiny door opening on the underside of the leaf. If one of these snug little homes is torn open, it will be found occupied by a community of little aphids, or plant lice.

The witch-hazel blossoms appear at the axil of a leaf or immediately above the scar from which a leaf has fallen, the season of bloom being so late that often the bush is bare of leaves and is clothed only with the yellow, fringelike flowers. Usually the flowers are in clusters of three, but occasionally four or five can be found on the same very short stem. The calyx is four-lobed, the petals are four in number, shaped like tiny, yellow ribbons, about one-half inch long and not much wider than a coarse thread. In the bud, these petals are rolled inward in a close spiral, like a watch spring, and are coiled so tightly that each bud is a solid little ball no larger than a bird shot. There are four stamens lying between the petals, and between each two of these stamens is a little scale just opposite the petal. The anthers are most interesting. Each has two little doors which fly open, as if by magic springs, and throw out the pollen which clings to them. The pistil has two stigmas, which are joined above the two-celled ovary within which the seeds develop. The blossoms sometimes open in late September, but the greater number appear in October and November. They are more beautiful in November after the leaves have fallen, since these yellow, starry flowers seem to bring light and warmth into the landscape. After the petals fall, the calyx forms a beautiful little urn, holding the growing fruit.



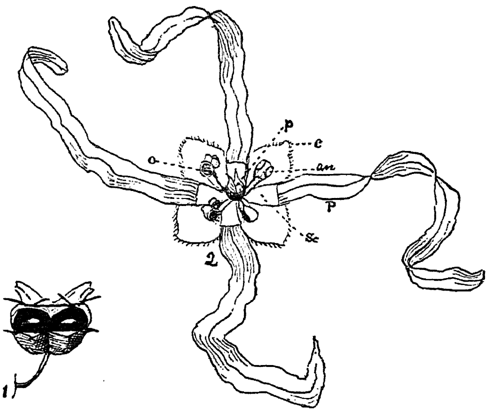
Leaves, fruits, and blossoms of witch hazel. Various types of galls, and the work of miners can be seen on the leaves



Ralph W. Curtis

Blossoms, leaves, and fruits of witch hazel

The nuts seem to require a sharp frost to separate the closely joined parts; it requires a complete year to mature them. One of these nuts is about half an inch long and is covered with a velvety green outer husk, until it turns brown; cutting through it discloses a yellowish white inner shell, which is as hard as bone; within this are the two brown seeds each ornamented with a white dot; note particularly that these seeds lie in close-fitting cells. The fruit, if looked at when the husk is opening, bears an odd resemblance to a grotesque monkey-like face with staring eyes. Frosty nights will open the husks, and the dry warmth of sunny days or of the heated schoolroom will cause the edges of the cups which hold the seeds to



1, *A queer little face — witch-hazel nut ready to shoot its seeds.* 2, *Enlarged flower of witch hazel showing the long petals*

p, with dotted line, the pistil; an, anther; o, anther with doors open; c, lobes of calyx; sc, scale opposite the base of petal

curve inward with such force as to send the seeds many feet away; ordinarily they are thrown from ten to twenty feet, but Hamilton Gibson records one actual measurement of forty-five feet. The children should note that the surface of the seeds is very polished and smooth, and the way they are discharged may be likened to that by which an orange seed is shot from between the fingers.

LESSON 190

The Witch Hazel

Leading Thought — The witch hazel blossoms during the autumn, and thus adds beauty to the landscape. It has an interesting mechanism by which its seeds are shot for a distance of many feet.

Method — This lesson divides naturally into two parts; a study of the way the seeds are distributed is fitted for the primary grades, and a study of the flower for more advanced grades. For the primary grades the lesson should begin by the gathering of the twigs which bear the fruit. These should be brought to the schoolroom — there to await results. Soon the seeds will be popping all over the schoolroom, and then the question as to how this is done, and why, may be made the topic of the lesson. For the study of the flower and the shrub itself, the work should begin in October when the blossoms are still in bud. As they expand they may be studied, a lens being necessary for observing the interesting little doors to the anthers.

Observations — 1. Is the witch hazel a shrub or a tree?

2. What is the color of the bark? Is it thick or thin, rough or smooth, dark or light, or marked with dots or lines? Is there any difference in color between the older wood and the young twigs? Is the wood tough or brittle? Dark or light in color?

3. Do the leaves grow opposite each other or alternate? On what part of the plant do the leaf buds grow?

4. What is the general shape of the

G. F. Morgan

Flowers and fruit of witch hazel

leaf? Is it more pointed at the base or at the tip? Are the leaves regular in form, or larger on one side than the other? Are the edges entire, toothed, or wavy? Are the petioles short or long? Are the veins straight or branching? Are they prominent? Are the leaves of the same color on both sides?

5. Are there many queerly shaped little swellings on the leaf above and below? See how many of these you can find. Tell what you think they are.

6. Do the flowers grow singly or in clusters? What is the shape and color of the petals, and how many of them are there in each blossom? Describe the calyx. If there are any flower buds just opening, observe and describe the way the petals are folded within them.

7. How many stamens? With a lens observe the way the two little doors to the anther fly open; how is the pollen thrown out? What is the shape of the pistil? How many stigmas?

8. Does each individual flower have a stem or is there a common stem for a cluster of blossoms? Do the flowers grow at the tips or along the sides of the twigs? When do the witch-hazel flowers appear and how long do they last?

9. Make a drawing of a witch-hazel nut before it opens. What is the color of the outer husk when ripe? Cut into a closed nut and observe the extreme hardness and strength of the inner shell.

10. Where are the seeds situated? Can you see that the shell, when partially open, ready to throw out the seeds, resembles a queer little face? Describe the color and marking of the seeds; are they rough or smooth? How far have you known the witch hazel to throw its seeds? Study the nut and try to discover how it throws the seeds so far.

THE MOUNTAIN LAUREL

As a child I never doubted that the laurel wreaths of Grecian heroes were made from mountain laurel, and I supposed, of course, that the flowers were used also. My vision was of a hero crowned with huge wreaths of laurel bouquets, which I thought so beautiful. It was a shock to exchange this sumptuous headgear of my dreams for a plain wreath of leaves from the green bay tree.

However, the mountain laurel leaf is evergreen and beautiful enough to crown a victor; in color it is a rich, lustrous green above, with a yellow midrib, the lower side being of a much lighter color. In shape, the leaf is long, narrow, pointed at each end and smooth-edged, with a rather short petiole. The leaves each year grow on the new wood, which is greenish and rough, in contrast with the old wood, which is rich brownish red. The leaves are arranged below the flower-cluster, so that they make a shining green base for this natural bouquet.

The flowers grow on the tips of the

W. C. Muenscher

Mountain laurel

branching twigs, which are huddled together in a manner that brings into a mass many flowers. I have counted seventy-five of them in a single bunch; the youngest

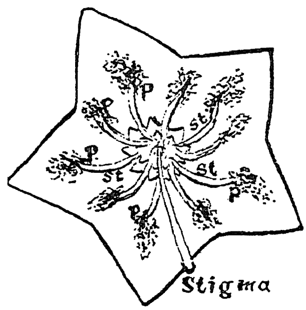


Diagram of flower of laurel
p, pocket; st, stamen

flowers grow nearest the tip of the twig. The blossom stems are pink, and afford a rich background for the starry open flowers and knobby closed buds. The bud of the laurel blossom is very pretty and resembles a bit of rose-colored pottery; it has a five-sided, pyramidal top, and at the base of the pyramid are ten little buttresses which flare out from the calyx. The calyx is five-lobed, each lobe being green at the base and pink at the point. Each one of the ten little buttresses or ridges is a groove in which a stamen is growing, as we may see by looking into an opening flower; each anther is "headed" toward the pocket which ends the groove. The filament lengthens and shoves the anther into the pocket, and then keeps on growing until it forms a bow-shaped spring, like a sapling with the top bent to the ground. The opening flower is saucer-like, pinkish white, and in form is a five-pointed star. At the bottom of the saucer a ten-pointed star is outlined in crimson; and bowed above this crimson ring are the ten white filaments with their red-brown anthers stuffed cozily into the pockets, one pocket at the center of each lobe, and one halfway between; each pocket is marked with a splash of crimson with spotty edges. From the center of the flower projects the stigma, far from and above the pollen pockets.

Each laurel flower is thus set with ten spring-traps; a moth or bee, seeking the nectar at the center of the flower, is sure to touch one or all of these bent filaments. As soon as one is touched, up it springs and slings its pollen hard at the intruder. The pollen is not simply a shower of powder, but is in the form of a sticky string, as if the grains were strung on cobweb silk. When liberating these springs with a pencil point, I have seen the pollen thrown a distance of thirteen inches; thus, if the pollen ammunition does not strike the bee, it may fall upon some open flower in the neighborhood. The anthers spring back after this performance and the filaments curl over each other at the center of the flower below the pink stigma; but after a few hours they straighten out and each empty anther is suspended above its own pocket. The anthers open while in the pocket; each one is slit open at its tip so that it is like the leather pocket of a sling.

After the corollas fall, the long stigma still projects from the tip of the ripening ovary, and there it stays, until the capsule is ripe and open. The five-pointed calyx remains as an ornamental cup for the fruit. The capsule opens along five valves, and each section is stuffed with little, almost globular seeds.

The mountain laurel grows in woods and shows a preference for rocky mountain sides or sandy soil.

Another of the common species is the sheep laurel, which grows in swampy places, especially on hillsides. The flowers of this are smaller and pinker than the mountain laurel, and are set below the leaves on the twig. Another species, called the pale or swamp laurel, has very small flowers, not more than half an inch in breadth and its leaves have rolled-back edges and are whitish green beneath. This species is found only in cold peat bogs and swamps.

LESSON 191

The Mountain Laurel

Leading Thought — The laurel blossom is set with ten springs, and each spring acts as a sling in throwing pollen upon visiting insects, thus sprinkling the visitor with pollen which it carries to other flowers.

METHOD — Have the pupils bring to the schoolroom a branch of laurel which shows blossoms in all stages from the bud. Although this lesson is on the mountain laurel, any of the other species will do as well.

OBSERVATIONS — 1. How are the laurel leaves set about the blossom clusters? What is the shape of the laurel leaf? What are its colors above and below? How do the leaves grow with reference to the flowers? Do they grow on last year's or this year's wood? How can you tell the new wood from the old?

2. Take a blossom bud. What is its shape? How many sides to the pyramid-like tip? How many little flaring ridges at the base of the pyramid? Describe the calyx.

3. What is the shape of the flower when open? How many lobes has it? What is its color? Where is it marked with red?

4. In the open blossom, what do you see of the ten ridges, or keels, which you noticed in the bud? How does each one of these grooves end? What does the laurel blossom keep in these ten pockets? Touch one of the ten filaments with a pencil and note what happens.

5. Take a bud scarcely open. Where are the stamens? Can you see the anthers? Take a blossom somewhat more open. Where are the anthers now? From these observations explain how the stamens place their anthers in the pockets. How do the filaments grow into bent springs?

6. Are the anthers open when they are still in the pocket? Look at an anther with a lens and tell how many slits it has. How do they open? Are the pollen grains loose when they are thrown from the anther? How are they fastened together? Does this pollen mass stick to whatever it touches?

7. What is the use to the flower of this arrangement for throwing pollen? What insects set free the stamen springs? Where is the nectar which the bee or moth is after? Can it get this nectar without setting free the springs? Touch the filaments with a pencil and see how far they will sling the pollen.

8. Describe the pistil in the open flower. Is the stigma near the anthers? Would they be likely to throw their pollen on the stigma of their own flower? Could they throw it on the stigmas of neighboring flowers?

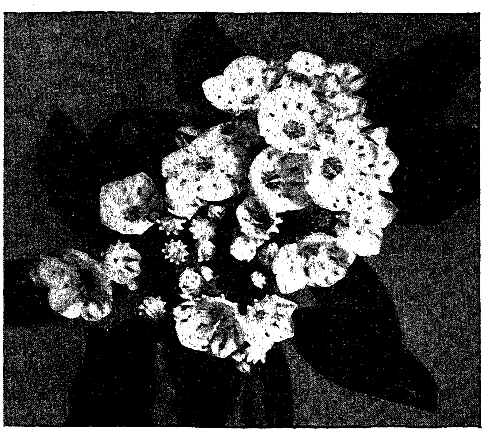
9. How does the fruit of the laurel look? Does the style still cling after the corolla falls? Describe the fruit capsule. How does it open? How do the seeds look? Are there many of them?

10. Where does the mountain laurel grow? What kind of soil does it like? Do you know any other species of laurel? If so, are they found in the same situations as the mountain laurel?

A childish gladness stays my feet,
As through the winter woods I go,
Behind some frozen ledge to meet
A kalmia shining through the snow.

I see it, beauteous as it stood
Ere autumn's glories paled and fled,
And sigh no more in pensive mood,
"My leafy oreads are all dead."

I hear its foliage move, like bells
On rosaries strung, and listening there,



Verne Morton

Spray of mountain laurel

Forget the icy wind that tells
Of turfless fields, and forests bare.

All gently with th' inclement scene
I feel its glossy verdure blend; —
I bless that lovely evergreen
As heart in exile hails a friend.

Its boughs, by tempest scarcely stirred,
Are tents beneath whose emerald fold
The rabbit and the snowbound bird
Forget the world is white and cold.

And still, 'mid ruin undestroyed,
Queen arbor with the fadeless crown,
Its brightness warms the frosty void,
And softens winter's surliest frown.

— From " THE MOUNTAIN LAUREL,"
THERON BROWN

FLOWERLESS PLANTS

FERNS

Many interesting things about ferns may be taught to the young child, but the more careful study of these plants is better adapted to the pupils in the higher grades, and is one of the wide-open doors that lead directly from nature-study to systematic science. While the pupils are studying the different forms in which ferns bear their fruit, they can make collections of all the ferns of the locality. Since ferns are easily pressed and are beautiful objects when mounted on white paper, the making of a fern herbarium is a delightful pastime; or leaf prints may be made which give beautiful results (see p. 626); but better, perhaps, than either collections or prints, are pencil or water-color drawings with details of the fruiting organs enlarged. Not only is such a portfolio a thing of beauty, but the close observation needed for drawing brings much knowledge to the artist.

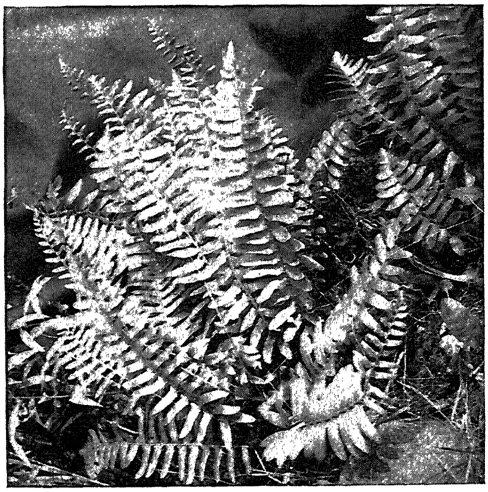
Suggested Reading — *Field Book of Common Ferns*, by Herbert Durand; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *First Studies of Plant Life*, by George F. Atkinson; *Guide to Eastern Ferns*, by Edgar T. Wherry; *How to Know the Ferns*, by Frances Theodora Parsons; *Our Ferns; Their Haunts, Habits and Folklore*, by Willard N. Clute; *Wild Flowers and Ferns in Their Homes and in Our Gardens*, by Herbert Durand; additional references are to be found in the bibliography in the back of this Handbook.

THE CHRISTMAS FERN

No shivering frond that shuns the blast sways on its slender chaffy stem;
Full veined and lusty green it stands, of all the wintry woods the gem.

— W. N. Clute

The rootstock of the fern is a humble example of " rising on stepping stones of our dead selves," this being almost literally true of the tree ferns. The rootstock, which is a stem and not a root, has, like other stems, a growing tip from which, each year, grow beautiful green fronds and numerous rootlets. These graceful fronds rejoice the world and our eyes for the summer, and make glad the one who, in winter, loves to wander often in the woods to inquire after the welfare of his many friends during their period of sleeping and waking. These fronds, after giving their message of winter cheer, and after the following summer has made the whole woodland green and the young fronds are growing thriftily from the tip of the rootstock, die down; and in midsummer we can find the old fronds lying sere and brown, with broken stipes, just back of the new fern clump; if we examine the rootstock we can detect, behind those fronds, remains of the stems of the fronds of year before last; and still farther behind we may trace all the stems of fronds which gladdened the world three years ago. Thus we learn that this rootstock may have been creeping on an inch or so each season for many years. One of the chief differences between our ferns and the tree ferns of the tropics, which we often see in greenhouses, is that in the tree fern the rootstock rises in the air instead of creeping on, or below, the



Verne Morton

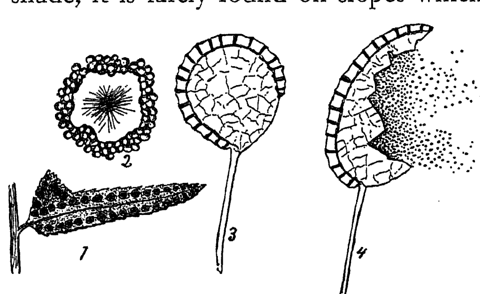
The Christmas fern. The contracted tips of some of the fronds consist of fruiting pinnæ

surface of the ground. This upright rootstock of the tree fern also bears fronds at its tip, and its old fronds gradually die down, leaving it rough below its crown of green plumes.

The Christmas fern has its green stipe, or petiole, and its rachis, or midrib, more or less covered with ragged, brownish scales, which give it an unkempt appearance. Its pinnæ, or leaflets, are individually very pretty; in color they are dark, shining green, lance-shaped, with a pointed lobe or ear at the base projecting upward. The edges of the pinnæ are delicately toothed; each point is armed with a little spine, and the veins are fine, straight, and free to the margin; the lower pinnæ often have the earlike lobe completely severed.

In studying a fertile fern from above, we notice that about a dozen pairs of the pinnæ near the tip are narrowed and roughened and are more distinctly toothed on the margins. Examining them underneath, we find on each a double row of circular raised dots, which are the fruit dots, or sori; there is a row between the midrib and margin on each side, and also a double row extending up into the point at the base. Early in the season these spots look like pale blisters; later they turn pale brown, each blister having a depression at its center; by the middle of June, masses of tiny globules, not larger than pinpoints, push out from beneath the margin of these dots. The blister-like membrane is simply a cover for the growing spores, and is called the indusium; by July it shrivels into an irregular scroll, still clinging to the pinnule by its depressed center; and by this time the profusion of tiny globules covers the entire underside of the pinna like a brown fuzz. If we scrape off some of this fuzz and examine it with a lens, we can see that it consists of numberless little globules, each with a stem to attach it to the leaf; these are the spore cases, or sporangia, each globule being packed full of spores which, even through the lens, look like yellowish powder. But each particle of this dust has its own structure and contains in its heart the living fern-substance.

Not all the fronds of the fern clump bear these fruit dots. The ones we select for decoration are usually the sterile fronds, for the fertile ones are not so graceful, and many uninformed people think the brown spore cases are a fungus. The Christmas fern, being evergreen and very firm in texture, is much used in holiday decoration, whence its common name, which is more easily remembered than *Polystichum acrostichoides*, its real name. It grows best in well-shaded woodlands, liking better the trees which shed their leaves than the evergreens. It is indeed well adapted to thrive in damp, cold shade; it is rarely found on slopes which



1, *Fertile leaflet of Christmas fern showing indusia and spore cases.* 2, *An indusium and spore cases, enlarged.* 3, *A spore case, enlarged.* 4, *A spore case discharging spores, enlarged* face the south, and full sunshine may kill it.

Suggested Reading — Readings on page 693.

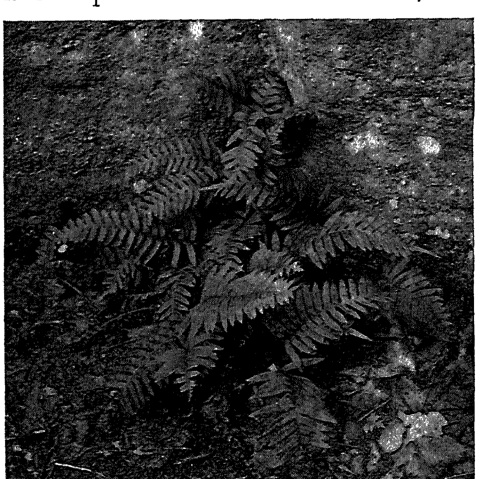
LESSON 192

The Christmas Fern

Leading Thought — The fern has a creeping underground stem called the rootstock, which pushes forward and sends up fresh fronds each year. Some of the fronds of the Christmas fern bear spores on the lower surface of the terminal pinnæ.

Method — This lesson should be given during the latter part of May, when the fruit dots are still green. Take up a fern and transplant it in a dish of moss in the schoolroom, and later plant it in some convenient shady place. The pupils should sketch the fertile frond from the upper side so as to fix in their minds the contracted pinnæ of the tip; one of the lower pinnæ should be drawn in detail, showing the serrate edge, the ear, and the venation. The teacher should use the following terms constantly and insistently, so as to make the fern nomenclature a part of the school vocabulary, and thus fit the pupils for using fern manuals.

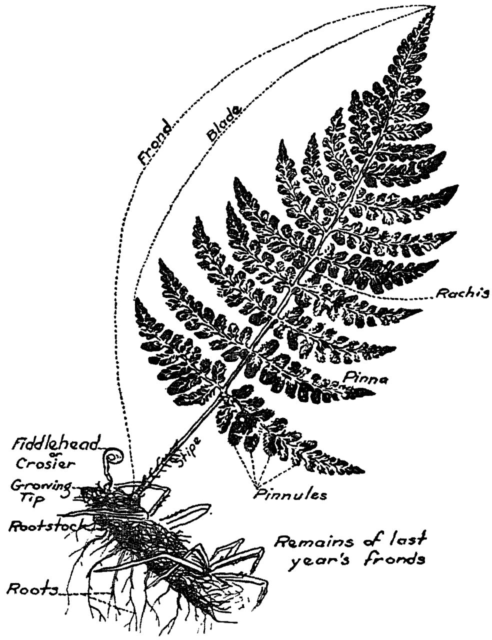
A *frond* is all of the fern which grows on one stem from the rootstock; the *blade* is that portion which bears leaflets; the



Buffalo Museum of Science

Common polypody, often mistaken for the Christmas fern

stipe is the stem or petiole; the *rachis* is the midrib and is a continuation of the



Leaf print of a fern with the parts named. This fern is twice pinnate

stipe; the *pinna* is a chief division of the midrib or rachis, when the fern is compound; the *pinnule* is a leaflet of the last division; the *sori* are the fruit dots; the *indusium* is the membrane covering the fruiting organs; the *sporangia* are the tiny brown globules, and are the spore cases; the *spores* make up the fine dust which comes from the spore cases. It would be well to make on the blackboard a diagram of the fern with its parts named, so that the pupils may consult it while studying ferns.

Observations — 1. Study a stump of the Christmas ferns. Are there any withered fronds? Where do they join the rootstock? Do the green fronds come from the same place on the rootstock as the withered ones?

2. Take a frond of the Christmas fern. Are the stem, or stipe, and the midrib, or rachis, smooth or rough? What color are the scales of the stalk? Do you think that these scales once wrapped the fern bud?

3. Does each frond of a clump have the

same number of pinnæ on each side? Can you find fronds where the pinnæ near the tip are narrower than those below? Take a lower pinna and draw it carefully, showing its shape, its edges, and its veins. Is there a point, or ear, at the base of every pinna? Is it a separate lobe or a mere point of the pinna?

4. Take one of the narrow pinnæ near the tip of the frond, and examine it beneath. Can you see some circular, roundish, blister-like dots? Are they dented at the center? How many of these dots on a pinna? Make a little sketch showing how they are arranged on the pinna and on the little earlike point. Look at the fruiting pinnæ of a fern during July, and describe how they look then.

5. Do all the fronds of a fern clump have these narrowed spore-bearing pinnæ? Do you know what those fronds are called that bear the fruit dots?

6. Where do you find the Christmas fern growing? Do you ever find it in a sunny place? Why is it called the Christmas fern?

FERN SONG

Dance to the beat of the rain, little Fern,
And spread out your palms again,
And say, " Tho' the sun
Hath my vesture spun,
He had labored, alas, in vain,
But for the shade
That the Cloud hath made,
And the gift of the Dew and the Rain."
Then laugh and upturn
All your fronds, little Fern,
And rejoice in the beat of the rain!

— John B. Tabb

THE BRACKEN

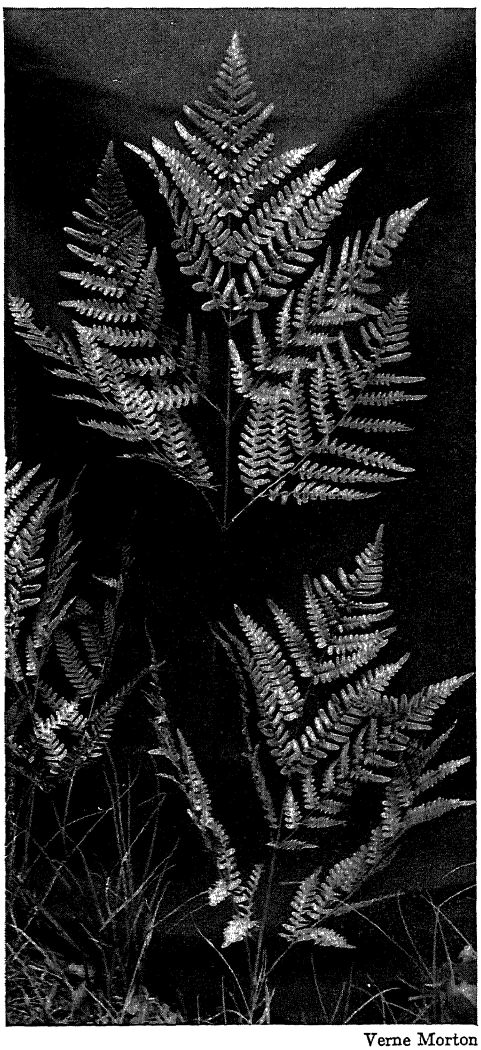
It is well for the children to study the animals and plants which have a world-wide distribution. There is something comforting in finding a familiar plant in strange countries; and when I have found the bracken on the coast ranges of California, on the rugged sides of the Alps, and in many other far places, I have always experienced a thrill of delightful memories of the fence-corners of the homestead farm. Since the bracken is so widespread, it is natural that it should find a place in literature and popular legend. As it clothes the mountains of Scotland, it is much sung of in Scottish poetry. Many superstitions cluster around it — its spores, if caught at midnight on a white napkin, are supposed to render the possessor invisible. Professor Clute, in *Our Ferns in Their Haunts*, gives a delightful chapter about the relation of the bracken to people.

For nature-study purposes, the bracken is valuable as a lesson on the intricate patterns of the fern leaf; it is in fact a lesson in pinnateness. The two lower branches are large and spreading, and are in themselves often three times pinnate; the branches higher up are twice pinnate; while the main branch near the tip is once pinnate, and at the tip is merely lobed. The lesson, as illustrated in the diagram of the fern, should be well learned for future study, because this nomenclature is used in all the fern manuals. The fact that a pinnule is merely the last division of a frond, whether it be twice or thrice pinnate, should also be understood.

The bracken does not grow best in complete shade, but it becomes established in waste places which are not too shaded; it thrives especially in woodsides, and in fence-corners on high and cold land. As Professor Clute says, " It is found both in woodland and in the open field; its favorite haunt is neither, but is that halfway ground where man leaves off and nature begins, the copse or the thicket." With us it usually grows about three feet high, but varies much in this respect. The great triangular fronds often measure two or three feet across, and are supposed to bear a likeness to an eagle with spread wings. Its rootstock is usually too deeply embedded in earth for the study of any except the most energetic; it is about the size of a lead pencil and is black and smooth; in its way it is a great traveler, sending up fronds fifteen or twenty feet from its starting place. It also sends off branching rootstocks.

The fruiting pinnules look as if they were hemmed and the edges of the hems embroidered with brown wool; but the embroidery is simply the spore cases pushing out from under the folded margin which protected them while developing.

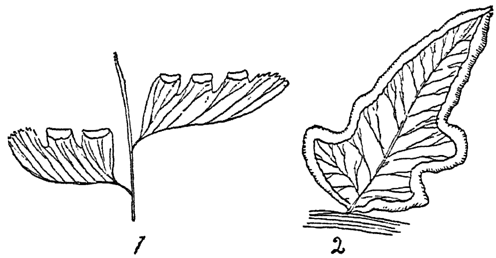
Much on which to base necromancy has been found in the figure shown in the cross section of the stem or stipe. The letter C thus made, supposed to stand for Christ, is a potent protection from witches. But this figure has also been compared to the devil's hoof, an oak tree, or



Verne Morton

Bracken

the initial of one's sweetheart, and all these imaginings have played their part in the lives of the people of past ages. It was



1, *Fruiting pinnules of the maidenhair fern, enlarged.* 2, *Fruiting pinnule of the bracken, enlarged. In both these species the spores are borne under the recurved edges of the pinnules*

believed in England that burning the bracken from the fields brought rain; the roots in time of scarcity have been ground and mixed with flour to make bread. The young ferns, or crosiers, are sometimes cooked and eaten like asparagus. The fronds have been used extensively for tanning leather and for packing fish and fruit, and when burned their ashes are used instead of soap.

In Europe, bracken grows so rankly that it is used for roof-thatching and for the bedding of cattle. The name "brake," which is loosely used for all ferns, comes from the word "bracken"; some people think that brakes are different from ferns, whereas this is simply a name which has strayed from the bracken to other species.

SUGGESTED READING — *Useful Wild Plants of the United States and Canada*, by Charles F. Saunders; also, readings on page 693.

LESSON 193

THE BRACKEN

LEADING THOUGHT — The bracken is a fern which is found in many parts of the world. It is much branched and divided, and it covers the ground in masses where it grows. The edges of its pinnules are folded under to protect the spores.

METHOD — Bring to the schoolroom large and small specimens of the bracken, and after a study is made tell about the superstitions connected with this fern and as far as possible interest the pupils in its literature.

OBSERVATIONS — 1. Do you find the bracken growing in the woods or open places? Do you find it in the cultivated fields? How high does it stand? Could you find the rootstock?

2. Take a bracken frond. What is its general shape? Does it remind you of an eagle with spread wings? Look at its very tip. Is it pinnate or merely lobed? Can you find a place farther down where the leaflets, or pinnules, are not joined at their bases? This is once pinnate. Look farther down and find a pinna that is lobed at the tip; at the base it has distinct pinnules. This is twice pinnate. Look at the lowest divisions of all. Can you find any part of this which is three times pinnate? Four times pinnate? Pinna means feather, pinnate therefore means feathered. If a thing is once pinnate, it means that it has along each side divisions similar to a feather; twice pinnate means that each feather has little feathers along each side; thrice pinnate means that the little feathers have similar feathers along each side, and so on.

3. Can you see whether the edges of the pinnules are folded under? Lift up one of these edges and see if you can find what is growing beneath it. How do these folded margins look during August and September?

4. Cut the stem, or stipe, of a bracken across and see the figure in it. Does it look like the initial C? Or a hoof, or an oak tree, or another initial?

5. Discover, if you can, the different uses which people of other countries find for this fern.

HOW A FERN BUD UNFOLDS

Verne Morton

Fiddle heads or crosiers. Young ferns unfolding

All of the parts of the frond of a fern are tightly folded spirally within the bud and every fold of every leaflet is also folded in a spiral. But the first glance at one of these little woolly spirals gives us but small conception of its marvelous enfolding. Every part of the frond is present in that bud, even to the fruiting organs; all the pinnæ and the pinnules are packed in the smallest compass — each division, even to the smallest pinnule, coiled in a spiral toward its base. These coiled fern buds are called crosiers; they are woolly, with scales instead of hairs. When the fern commences to grow, it stretches up and seems to lean over backward in its effort to be bigger. First the main stem, or rachis, loosens its coil; but before this is completed, the pinnæ, which are coiled at right angles to the main stem, begin to unfold; a little later the pinnules, which are folded at right angles to the pinnæ, loosen and seem to stretch and yawn before taking a look at the world which they have just entered; it may be several days before all signs of the complex coiling disappear. The crosiers of the bracken are queer-looking creatures, soon developing three claws which some people say look like the talons of an eagle; and so intricate is the action of their multitudinous spirals, that to watch them unfolding impresses one as would a miracle.

SUGGESTED READING — Readings on page 693.

LESSON 194

HOW A FERN BUD UNFOLDS

LEADING THOUGHT — All of the parts of the frond of a fern are tightly folded spirally within the bud, and every lobe of every leaflet is also folded in a spiral.

METHOD — The bracken crosier is a most illuminating object for this lesson, because it has so many divisions and is so large; it is also convenient, because it may be found in September. However, any fern bud will do. The lesson may be best given in May when the woodland ferns are starting. A root of a common fern with its buds may be brought to the schoolroom, where the process of unfolding may be watched at leisure. Later, the plant may be set out in a suitable place.

OBSERVATIONS — 1. Take a very young bud. How does it look? Do you see any reason why uninformed people call these buds caterpillars? Can you see why they are popularly called "fiddle heads"? What is their true name? How many turns of the coil can you count? What is the covering of the crosier? How is the stem grooved to make the spiral compact?

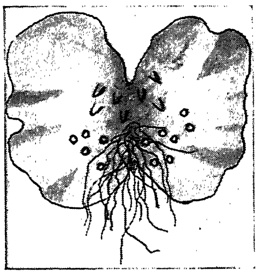
2. Take a crosier a little further advanced. How are its pinnæ folded? How is each pinnule of each pinna folded? How is each lobe of a pinnule folded? Is each smaller part coiled toward each larger part?

3. Write in your notebook the story of the unfolding fern, and sketch its stages each day from the time it is cuddled down in a spiral until it is a fully expanded frond.

THE FRUITING OF THE FERN

If we were required to know the position of the fruit dots or the character of the indusium, nothing could be easier than to ascertain it; but if it is required that you be affected by ferns, that they amount to anything, signify anything to you, that they be another sacred scripture and revelation to you, help to redeem your life, this end is not so easily accomplished. — THOREAU.

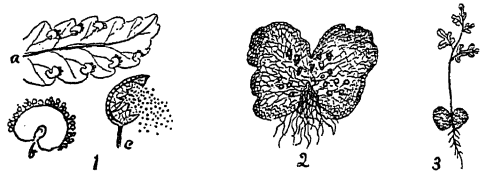
The fern, like the butterfly, seems to have several this-world incarnations; and perhaps the most wonderful of these is the spore. Shake the dust out of the ripened fern and each particle, although too small for the naked eye to see, has within it the possibilities of developing a mass of graceful ferns. Each spore has an outside hard layer, and within this an atom of fern-substance; but it cannot be developed unless it falls into some warm, damp place favorable for its growth; it may have to wait many years before chance gives it this favorable condition, but it is strong and retains its vital power for years. There are cases known where spores grew after twenty years of waiting. But what does this microscopic atom grow into? It develops into a tiny heart-shaped, leaflike structure which botanists call the prothallium; this has on its lower side little roots which reach down into the soil for nourishment; and on its lower surface are two kinds of pockets, one round and the other long. In the round pockets are developed bodies which may be compared to the pollen; and in the long pockets, bodies which may be compared to the ovules of flowering plants. In the case of ferns, water is necessary to float the pollen from the round pockets to the ovules in the long pockets. From a germ thus fertilized in one of the long pockets, a little green fern starts to grow, although it may be several years before it becomes a plant strong enough to send up fronds with spore dots on them. To study the structure of the spore requires the highest powers of the microscope; and even the prothallium in most species is very small, varying from the size of a pinhead to that of a small pea, and it is therefore quite



Prothallium, greatly enlarged, showing the two kinds of pockets and the rootlets

difficult to find. I found some once on a mossy log that bridged a stream, and I was never so triumphant over any other outdoor achievement. They may be found in damp places or in greenhouses, but the teacher who is able to show her pupils this stage of the fern will be very fortunate. The prothallium is a stage of the fern to be compared to the flower and seed combined in the higher plants; but this is difficult for young minds to comprehend. I like to tell the children that the fern, like a butterfly, has several stages: Beginning with the spore-bearing fern, we next have the spores, next the prothallium stage, and then the young fern. In the other case we have first the egg, then the caterpillar, then the chrysalis, and then the butterfly. Looking at the ripe fruit dots on the lower side of the fern leaf, we can easily see with a lens a mass of tiny globules; each one of these is a spore case, or sporangium (plural *sporangia*), and is fastened to the leaf by a stalk and has, almost encircling it, a jointed ring. (See figure on p. 694.)

When the spores are ripe, this ring straightens out and ruptures the globule, and out fly the spores. By scraping a little of the brown fuzz from a fruiting pinna of the Christmas fern upon a glass slide and placing a cover glass upon it, we find it very easy to examine through the microscope, and we are able thus to find the spore cases in all stages, and to see the spores distinctly. The spore cases may also be seen

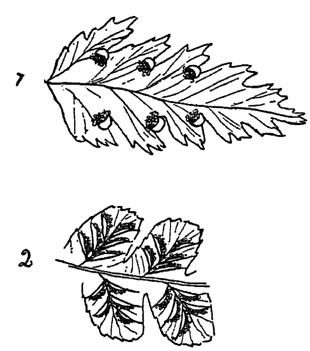


The life of a fern

1, a, pinna bearing fruit; b, a fruit dot, enlarged, showing spore cases pushing out around the edges of the indusium; c, spore case, enlarged, showing how it discharges the spores. 2, Prothallium, enlarged. 3, Young fern growing from the prothallium

with a hand lens, the spores seeming then to be mere dust.

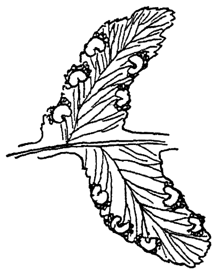
The different ways the ferns blanket their spore cases is a delightful study, and one which the pupils enjoy very much. All of our common ferns except the little polypody thus protect their spores. Whether this blanket be circular, or horseshoe-shaped, or oblong, or in the form of pocket or cup, depends upon the genus to which the fern belongs. The little protecting blanket membrane is called the indusium, and while its shape distinguishes the genus, the position in which it grows determines the species. I shall never forget my surprise and delight when, as a young girl, I visited the Philadelphia Centennial Exposition, and there in the



1, *Fruiting pinnule of the boulder fern, enlarged.* 2, *Fruiting pinnules of spleenwort, enlarged*

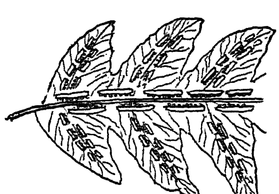
great conservatories saw for the first time the tree ferns of the tropics. One of these was labeled *Dicksonia*, and, mystified, I asked the privilege of examining the fronds for fruiting organs; when lo! the indusium proved to be a little cup, borne at the base of the tooth of the pinnule, exactly like that of our boulder fern, which is also a *Dicksonia*. I had a sudden feeling that I must have fern friends all over the world.

The children are always interested in the way the maidenhair folds over the tips



Fruiting pinnules of evergreen wood fern

of her scallops to protect her spore nursery. While many of our ferns have their fertile fronds very similar in form to the sterile ones, yet there are many common ferns with fertile fronds that look so different from the others that one would not think they were originally of the same pattern; but although their pinnules are changed into cups, or spore pockets, of various shapes, if they be examined carefully they will be seen to have the same general structure and the same divisions, however much contracted, as have the large sterile fronds. The *Osmundas*, which include the interrupted, the cinnamon, and the flowering ferns, are especially good for this part of the lesson. The sensitive fern, so common in damp places in



Fruiting pinnules of the chain fern

open fields, is also an excellent illustration of this method of fruiting. While studying the ferns, the teacher should lay stress upon the fact that they represent an early and simple form of plant, that they reached the zenith of their growth in the Carboniferous age, and that, to a large extent, our coal is composed of them. It is interesting to think that the exquisite and intricate leaf patterns of the ferns should belong to a primitive type.

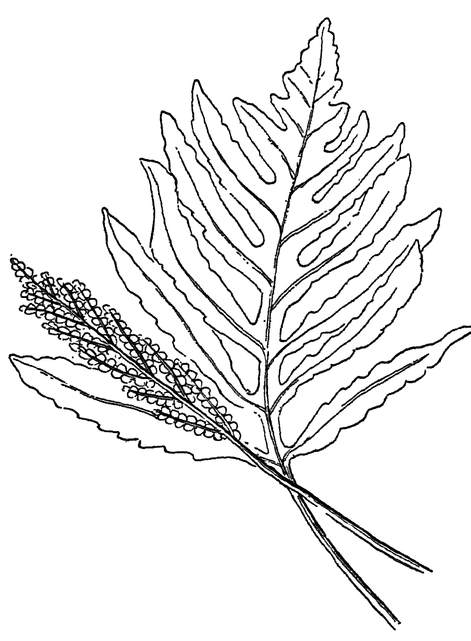
Suggested Reading — Readings on page 693.

LESSON 195

The Fruiting of the Fern

Leading Thought — Ferns do not have flowers, but they produce spores. Spores are not seeds; but fern spores grow into a tiny prothallium, and this in turn produces a young fern. Each genus of ferns has its own peculiar way of protecting its spores; and if we learn these different ways, we can recognize most ferns without effort.

Method — July is the best time for this lesson, which is well adapted for summer schools or camping trips. However, if it is desired to use it as a school lesson, it should be begun in June, when the fruiting organs are green, and it may be finished in September after the spores are discharged. Begin with the Christmas



A sensitive fern, showing sterile and fertile fronds fern, which ripens in June, and make the fruiting of this species a basis for comparison. Follow this with other wood ferns which bear fruit dots on the back of

Diagram of the interrupted fern, showing the three pairs of fruiting pinnæ, and a part of one of these enlarged. This fern often has fronds four or five feet high

the fronds. Then study the ferns which live in more open places, and which have fronds changed in form to bear the spores — like the sensitive, the ostrich, the royal, and the flowering ferns. A study of the interrupted fern is a desirable preparation for the further study of those which have special fruiting fronds; the interrupted fern has, at about the middle of its frond, one to five pinnæ on each side, fitted for spore-bearing, the pinnules being changed into globular cups filled with spore cases.

While not absolutely necessary, it is highly desirable that each member of the class should look at a fruit dot of some fern through a three-quarters objective of a compound microscope, and then examine the spore cases and the spores through a one-sixth objective. It must be remembered that this lesson is for advanced grades, and is a preparation for systematic scientific work. If a microscope is not available, the work may be done with a hand lens aided by pictures.

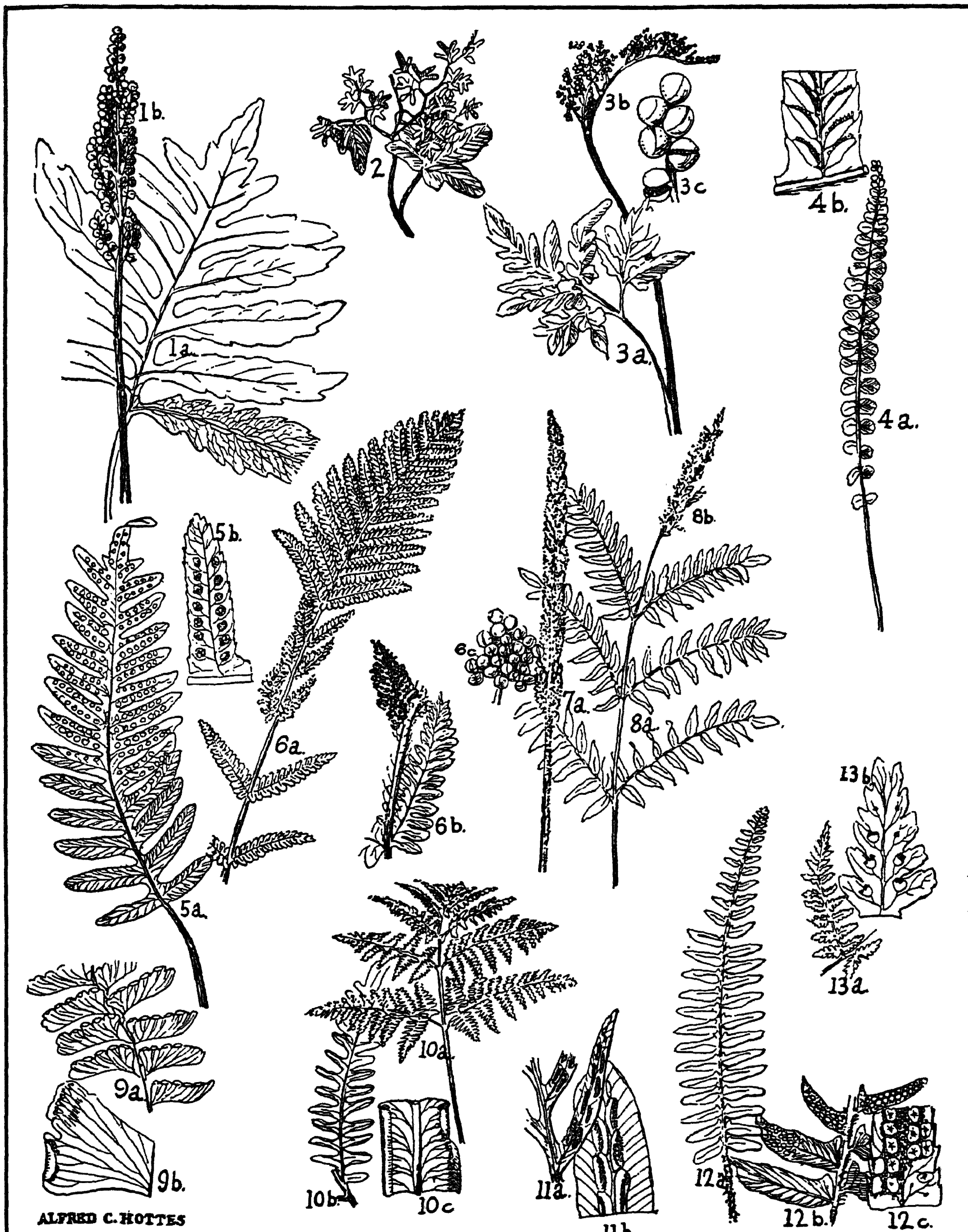
Observations — 1. Take a fern that is in fruit; lay it on a sheet of white paper and leave it thus for a day or two, where it will not be disturbed and where there is no draught; then take it up carefully; the form of the fern will be outlined in dust. What is this dust?

2. What conditions must the spores have in order to grow? What do they grow into?

3. Look at a ripe fruit dot on the back of a fern leaf and see where the spores come from. Can you see with a lens many little, brown globules? Can you see that some of them are torn open? These are the spore cases, called *sporangia*, each globule being packed with spores. Can you see how the sporangia are fastened to the leaf by little stems?

4. Almost all our common wood ferns have the spore cases protected by a thin membrane when very young; this little membrane is called the indusium, and it is of different shape in those ferns which do not have the same surname, or generic name. Study as many kinds of wood ferns as you can find. If the blanket, or indusium, is circular with a dent at the center where it is fastened to the leaf, and the spore cases push out around the margin, it is a *Christmas fern;* if horseshoe-shaped, it is one of the *wood ferns;* if oblong, in rows on each side of the midrib, it is a *chain fern;* but if oblong and at an angle to the midrib, it is a *spleenwort;* if it is pocket-shaped and opening at one side, it is a *bladder fern;* if it is cup-shaped, it is a *boulder fern;* if it breaks open and lies back in star shape, it is a *Woodsia;* if the edge of the fern leaf is folded over all along its margin to protect the spore cases, it is a *bracken;* if the tips of the scallops of the leaf are delicately folded over to make a spore blanket, it is the *maidenhair.*

5. If you know of swampy land where there are many tall brakes, look for a kind that has some of its pinnæ withered and brown. Examine these withered pinnæ, and you will see that they are not withered at all but are changed into little cups to hold spore cases. This is the *interrupted fern.* The *flowering fern* has the pinnæ at its tip changed into cups for spore cases. The *cinnamon fern,* which grows in swampy places, has whole fronds which are cinnamon-colored and look withered, but which bear the spores. The *ostrich fern,*



Bulletin 119, Agricultural Extension Service, Ohio State U.

Important characteristics which distinguish fern groups

1, Sensitive fern: a, frond; b, spore-bearing frond
2, Hartford or climbing fern
3, Grape fern: a, frond; b, modified frond producing spore cases; c, detail of spore cases
4, Spleenwort: a, frond; b, spore cases like pockets above veins
5, Common polypody: a, frond; b, large fruiting dots
6, Interrupted fern: a, spore-bearing pinnæ (leaflets) confined to a few in middle of frond; b and c, details showing arrangement of spore cases
7, Cinnamon fern: a, fertile frond
8, Royal fern: a, frond; b, the modified pinnæ at the tip producing spores
9, Maidenhair fern; a, pinnæ; b, detail showing spores beneath the folded margins of pinnæ
10, Bracken: a, entire frond; b, detail of pinnæ; c, spore-bearing folded margins of a pinnule
11, Chain fern: a, pinnæ; b, spore areas showing chain formation
12, Christmas fern: a, frond; b, spore cluster; c, detail of spore clusters
13, Bladder fern: a, frond; b, fruit dots

1. Purple Cliff Brake, Pellaea atropurpurea. *Sometimes called "winter brake" because in its southern range the fronds remain green all winter, this fern usually grows in situations which can be reached only with difficulty. It can be grown in cultivation if it is always kept in the same position. Should the plant be moved, the change in relation to the light will retard its growth.*

Range: *New England and British Columbia south and west to California and northern Mexico.* Habitat: *Crevices in dry rocks.* (*Photo by Dr. and Mrs. John Small*)

2. Climbing Fern, Lygodium palmatum. *Seventy-five years ago this fern was common, but in many places reckless picking has almost exterminated it. The fronds,* 1 *to* 3 *feet long, twine or climb about other plants or trail on the ground. The specimen shown in the picture is a typical young plant, which differs somewhat in general appearance from a mature plant.*

Range: *Massachusetts south to Florida.* Habitat: *Banks of streams.* (*Photo by Charles E. Mohr*)

3. Grape Fern. *This is one of the many variations of* Botrychium dissectum.

Range: *Nova Scotia and New Brunswick west to Wisconsin and Iowa, south to South Carolina, Georgia, and Florida.* Habitat: *A great variety of habitats: sterile hilltops, dry pastures, meadows, thickets, rich swampy woods and sandy banks in pine barrens.* (*Photo by Dr. and Mrs. John Small*)

4. Hart's-Tongue, Phyllitis Scolopendrium. *Although very rare in this country, this fern is common in parts of Eurasia, especially Great Britain.*

Range: *Locally in New Brunswick, Ontario, central New York, Tennessee, and North Carolina.* Habitat: *Shaded ravines in regions where there are limestone cliffs.* (*Photo by Dr. and Mrs. John Small*)

5. Hay-scented Fern, Dennstædtia punctilobula. *The fronds of this slender, tapering, pale green fern are* 1½ *to* 2 *feet long. They are very fragrant when dried.*

Range: *Nova Scotia to Minnesota south to Georgia.* Habitat: *Rocky pastures, meadows, thickets, and near swamps.* (*Photo by Leonard K. Beyer*)

6. Maidenhair Fern, Adiantum pedatum. *Except on the Atlantic coastal plains, this fern is rather widely distributed throughout North America. It is found in sheltered, shady places rather than in open areas of the woods.*

Range: *Nova Scotia to British Columbia south to Georgia and Arkansas.* Habitat: *Rich, moist woodlands.* (*Photo by Dr. and Mrs. John Small*)

7. Interrupted Fern, Osmunda Claytoniana. *This fern, the cinnamon fern* (*No.* 9), *and the royal fern* (*No.* 10), *are similar in many ways; they are tall, showy, and beautiful. They can be transplanted if shade, plenty of water, and good soil are provided.*

Range: *Minnesota to Newfoundland south to Missouri, Kentucky, and North Carolina.* Habitat: *Swampy areas.* (*Photo by Brooklyn Botanic Garden*)

8. Walking Leaf Fern, Camptosorus rhizophyllus. *The end frond of this fern seems capable of taking root at its tip; thus new plants are started. Sometimes the third generation maintains a connection with the original plant.*

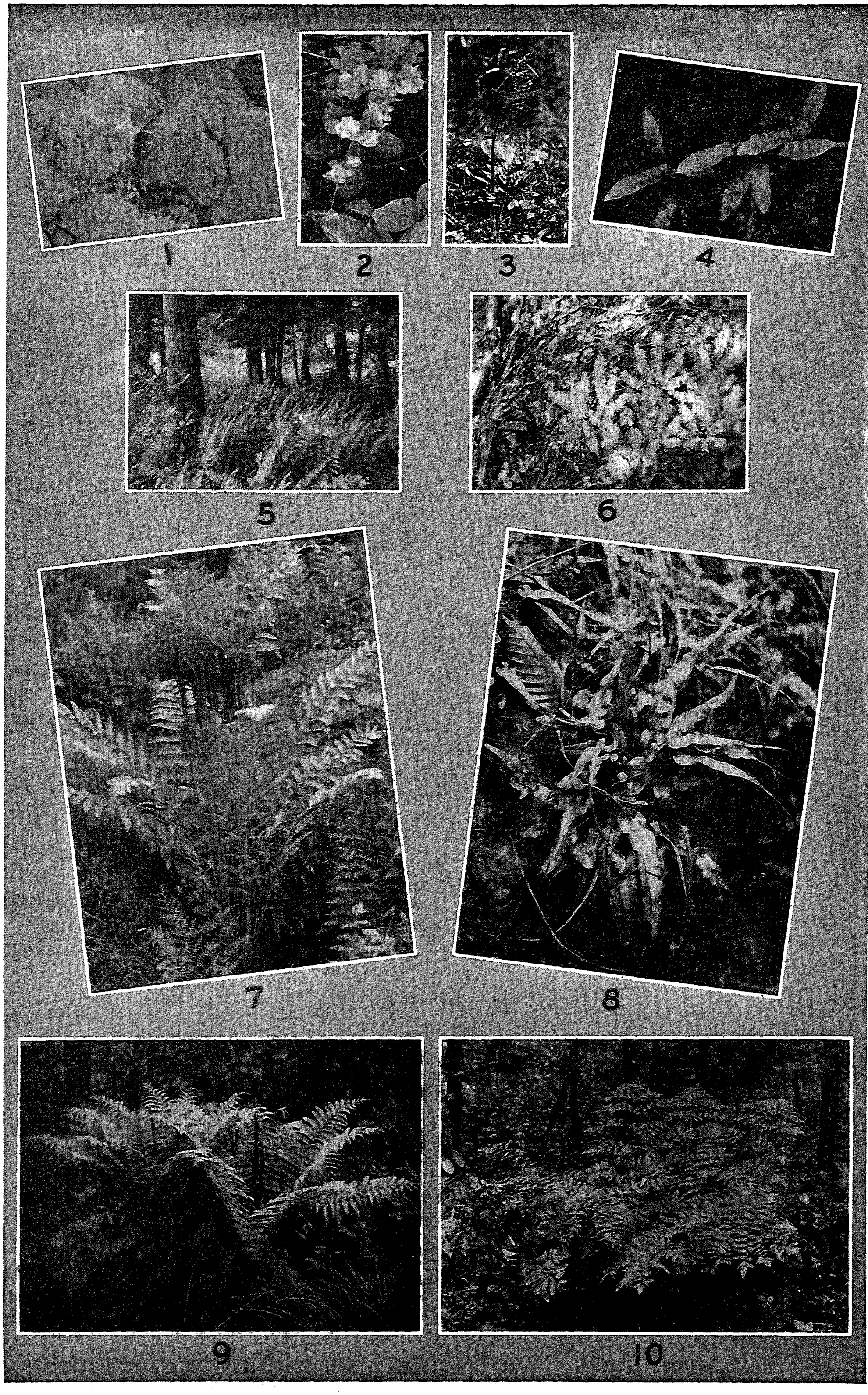
Range: *From Maine and southern Canada to Georgia and westward.* Habitat: *Locally in shady ravines on cliffs or decaying stumps.* (*Photo by Verne Morton*)

9. Cinnamon Fern, Osmunda cinnamomea. *The sterile fronds of this fern are quite similar in appearance to those of the interrupted fern; they can be distinguished by a tuft of wool at the base of the pinnæ.*

Range: *Canada to Florida west to New Mexico and into South America.* Habitat: *Swampy areas.* (*Photo by Brooklyn Botanic Garden*)

10. Royal or Flowering Fern, Osmunda regalis. *In North America the usual height of this fern is* 2 *to* 5 *feet, but in Europe it is said to reach a height of* 10 *feet.*

Range: *Southern and eastern Canada to Nebraska, Mississippi, and Florida into tropical America.* Habitat: *Swampy areas.* (*Photo by Buffalo Museum of Science*)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which has fronds that look like magnificent ostrich feathers, has stiff little stalks of fruiting fronds very unlike the magnificent sterile fronds. The *sensitive fern*, which grows in damp meadows and along roadsides, also has contracted fruiting fronds. If you find any of these, compare carefully the fruiting with the sterile fronds, and note in each case the resemblance in branching and in pinnules and also the shape of the openings through which the spores are sifted out.

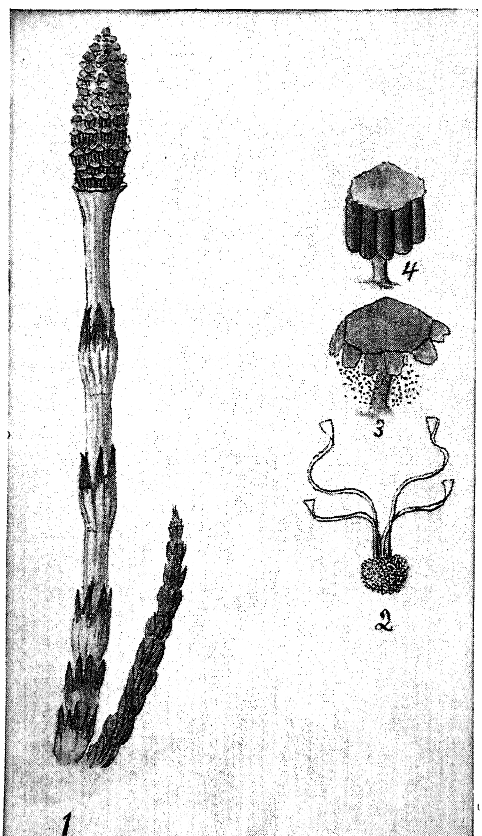
6. Gather and press specimens of as many ferns in the fruiting stage as you can find, taking both sterile and fruiting fronds in those species which have this specialization.

7. Read in the geologies about the ferns which helped in the making of our coal beds.

Nature made ferns for pure leaves to see what she could do in that line.

— Thoreau

THE FIELD HORSETAIL



1, *Fertile plant of the field horsetail;* 2, *spores;* 3, *disc discharging spores;* 4, *disc with spore sacs*

These queer, pale plants grow in sandy or gravelly soil, and since they appear so early in the spring they are objects of curiosity to children. The stalk is pale and uncanny looking; the pinkish stem, all the same size from bottom to top, is ornamented at intervals with upward-pointing, slender, black, sharp-pointed scales, which unite at the bottom and encircle the stalk in a slightly bulging ring, a ring which shows a ridge for every scale, extending down the stem. These black scales are really leaves springing from a joint in the stem, but they forgot long ago how to do a leaf's work of getting food from the air. The " blossom," which is not a real blossom in the eye of the botanist, is made up of rows of tiny discs which are set like miniature toadstools around the central stalk. Before it is ripe, there extends back from the edge of each disc a row of little sacs stuffed so full of green spores that they look united like a row of tiny green ridges. The discs at the top of the fertile spike discharge their spores first, as can be seen by shaking the plant over white paper, the falling spores looking like pale green powder. The burst and empty sacs are whitish, and hang around the discs in torn scallops, after the spores are shed. The spores, when seen under the microscope, are wonderful objects, each a little green ball with four spiral bands wound about it. These spirals uncoil and throw the spore, giving it a movement as of something alive. The motor power in these living springs is the absorbing of moisture.

The beginning of the sterile shoot can be seen like a green bit of the blossom

W. C. Muenscher

Field horsetail, Equisetum arvense, *though not a flowering plant "blooms" with spores*

spike of the plantain; but later, after the fertile stalks have died down, these cover the ground with their strange fringes. Not all kinds of horsetails have separate fruiting and vegetative shoots; in some the same stalk bears both fruiting and vegetative parts.

The person who first called these sterile plants "horsetails" had an overworked imagination, or none at all; for the only quality the two have in common is brushiness. A horse which had the hair of its tail set in whorls with the same precision as this plant has its branches would be one of the world's wonders. The *Equisetum* is one of the plants which give evidence of nature's resourcefulness; its remote ancestors probably had a whorl of leaves at each joint or node of the main stem and branches; but the plant now has so many green branches that it does not really need the leaves, and thus they have been reduced to mere points, and look like nothing but "trimming," they are so purely ornamental. Each little cup or socket, of the joint or node, in branch or stem, has a row of points around its margin, and these points are terminals of the angles in the branch. If a branch is triangular in cross section, it will have three points at its socket, if quadrangular it will have four points, and the main stem may have six or a dozen, or even more points. The main stem and branches are made up entirely of these segments, each set at its lower end in the socket of the segment behind or below it. These green branches, rich in chlorophyl, manufacture for the plant all the food that it needs. Late in the season this food is stored in the rootstocks, so that early next spring the fertile plants, nourished by this stored material, are able to push forth before most other plants, and thus develop their spores early in the season. There is a prothallium stage as in the ferns.

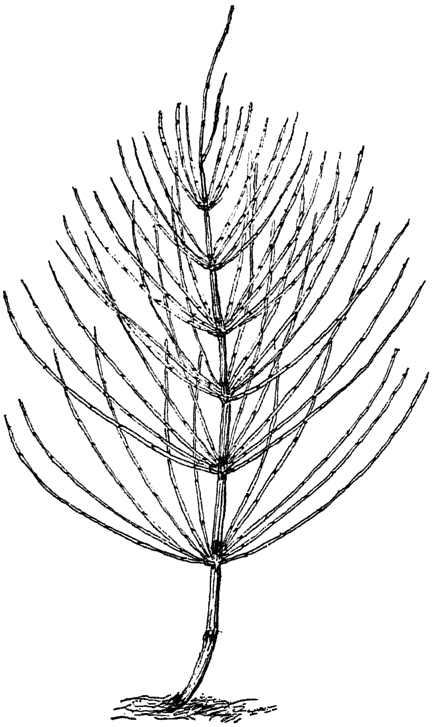
Above where the whorl of stems comes from the main branch, may be seen a row of upward-standing points which are the remnants of leaves; each branch as it leaves the stem is set in a little dark cup with a toothed rim. There is a nice gradation from the stout lower part of the stem to the tip, which is as delicate as one of the side branches.

The rootstock dies out behind the plant and pushes on ahead like the rootstock of ferns. The true roots may be seen attached on the underside. The food made in the summer is stored in little tubers, which may be seen in the rootstocks.

Dr. and Mrs. John Small

Club moss or ground pine, Lycopodium alopecuroides. *This plant is common in the bogs of pine-barrens*

Suggested Reading — *Fern Allies of North America*, by Willard N. Clute; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *Guide to Eastern Ferns*, by Edgar T. Wherry.



Sterile plant of the field horsetail

LESSON 196

The Field Horsetail

The Fertile Plant

Leading Thought — The horsetail is a plant that develops spores instead of seeds, and has green stems instead of leaves.

Method — In April and May, when the children are looking for flowers, they will find some of these weird-looking plants. These may be brought to the schoolroom and the observation lesson given there.

Observations — 1. Where are these plants found? On what kind of soil?

2. In what respect does this plant differ from other plants in appearance? Can you find any green part to it?

3. What color is the stem? Is it the same size its whole length? Is it smooth or rough?

4. Do you see any leaves on the stems? Do you see the black-pointed scales? In which direction do these scales point? Are they united at the bottom? What sort of ring do they make around the stem? Split a stem lengthwise and see if there are joints, or nodes, where the ring joins the stalk.

5. How does the "blossom" look? What color are the little discs that make up the blossom? How are the discs set?

6. Take one of the plants which has the discs surrounded by green ridges. Shake it over a white paper. What comes from it? Where does it come from? Which discs on the stalk shed the green spores first?

The Sterile Plant

Leading Thought — The horsetail or *Equisetum* is nourished by very different-looking stems from those which bore the spores. It lacks leaves, but its branches are green and do the work of making food for the plant.

Method — The sterile plants of the horsetail do not appear for several weeks after the fertile ones; they are much more

Dorothy M. Compton

Ground pine, Lycopodium complanatum, *is widely distributed in dry coniferous woods throughout North America, Europe, and Asia* numerous, and do not resemble the fertile plants in form or color. These sterile plants may be used for a lesson in September or October. Some of these plants with their roots may be brought into the schoolroom for study.

OBSERVATIONS — 1. Has this plant any leaves? How does it make and digest its food without leaves? What part of it is green? Wherever there is green in a plant, there is the chlorophyl-factory for making food. In the horsetail, then, what part of the plant does the work of leaves?

2. Take off one little branch and study it with the lens. How does it look? Pull it apart. Where does it break easily? How many joints, or nodes, are there in the branch?

3. Study the socket from which one of the segments was pulled off. What do you see around its edge? How many of these points? Look at the branch in cross section. How many angles has it? What relation do the points bear to the angles? Do you think these points are all there are left of true leaves?

4. How do the little green branches come off the main stem? How many in a place? How many whorls of branches on the main stem?

5. Study the bases of the branches. What do you see? Look directly above where the whorl of branches comes off the main stem. What do you see? Cut the main stem in cross section just below this place, and see if there are as many little points as there are angles or ridges in the stem. Do you suppose these little points are the remnants of leaves on the main stem?

6. What kind of root has the horsetail? Do you think this long running root is the true root or an underground stem? Where are the true roots? Do you think the rootstock dies off at the oldest end each year, like the fern? Can you find the little tubers in the rootstock which contain nourishment for next year's spore-bearing stalks?

THE HAIR-CAP MOSS OR PIGEON WHEAT

The mosses are a special delight to children because they are green and beautiful before other plants have gained their greenness in the spring and after they have lost it in the fall; to the discerning eye, a mossy bank or a mossy log is a thing of beauty always. When we were children we regarded moss as a forest for fairy folk, each moss stem being a tree, and we naturally concluded that fairy forests were evergreen. We also had other diversions with pigeon wheat, for we took the fruiting stem, pulled the cap off the spore capsule, and tucked the other end of the red stem into the middle of the capsule, making a beautiful coral ring with an emerald "set." To be sure, these rings were rather too delicate to last long, but there were plenty more to be had for nothing; so we made these rings into long chains which we wore as necklaces for brief and happy moments, their evanescence being one of their charms.

Pigeon wheat is a rather large moss which grows on dry knolls, usually near the margins of damp woodlands in just those places where wintergreens love to grow. In fall or winter it forms a greenish brown mass of bristling stems; in the early summer the stems are tipped with the vivid green of the new growth. The bristling appearance comes from the long sharp leaves set thickly upon the ruddy brown stems; each leaf is pretty to look at with a lens, which reveals it as thick though narrow, grooved along the middle, the edges usually armed with sharp teeth, and the base clasping the stem. These leaves, although so small, are wonderfully made; during the hot, dry weather they shut up lengthwise and twist into the merest threads; thus their soft, green surfaces do not lose as much moisture by exposure to the air. More than this, they huddle close to the stem and in this position they are less likely to suffer from the effect of drought. But as soon as the rains come, they straighten back at right angles

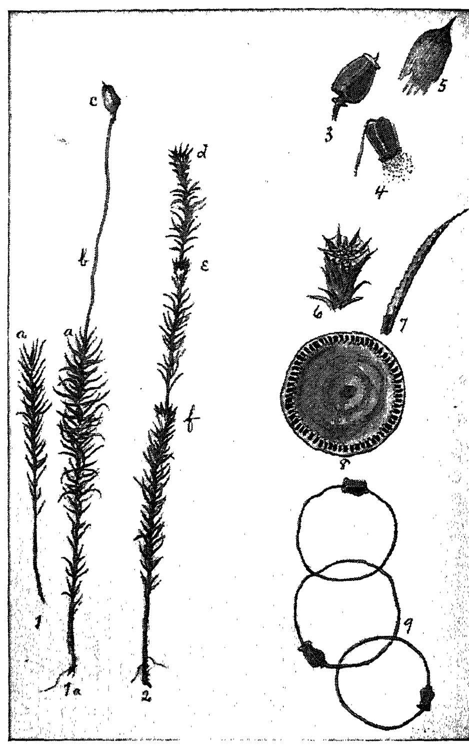
George E. Nichols

Hair-cap moss or pigeon wheat

to the stem, and curve their tips downward. Bring in some of this moss and let it dry, and then drop it into a glass of water and watch this miracle of leaf movement! And yet it is no miracle but a mechanism quite automatic, and therefore like other miracles, when once they are understood.

In early June the mossy knoll shows us the origin of the name pigeon grass or pigeon wheat, for it is then covered with a forest of shining, ruddy, stiff, little stalks, each stalk bearing on its tip a woolly object about the size of a grain of wheat. But it is safe to say that the pigeons and other birds enjoy our own kind of wheat better than this, which is attributed to them.

A study of one of these wheat grains reveals it as covered with a yellowish mohair cap, ending in a golden-brown peak at its tip, as if it were the original pattern of the toboggan cap; it closes loosely around the stem below. This "grain" is the spore capsule of the moss; the hairy cap pulls off easily when seized by its tip. This cap is present at the very beginning, even before the stalk lengthens; it protects the delicate tissues of the growing spore case. It is only through a lens that we can see it in all its silky softness. The capsule revealed by the removal of the cap is a beautiful green object, usually four-sided, set upon an elegant little pedestal where it joins the coral stalk, and with a lid on its top like a sugar-bowl cover, with a point instead of a knob at its center.



Hair-cap moss

1, Moss stem carrying the egg before fertilization. 1a, The same stem carrying the spore capsule and its stalk; b, stalk; c, spore capsule, with cap covering it. 2, Stalk showing the starlike cups; d, the cup in which was developed the sperms which fertilized the egg at a, this year; e, last year's cup; f, the cup of year before last; only the upper leaves of the stem are alive. 3, Spore capsule with the cap removed, showing the lid. 4, Spore capsule with lid off and shaking out the spores. 5, The cap. 6, Starlike cup in which the sperm is developed. 7, Leaf of moss. 8, The top of the spore capsule showing the teeth around the edge between which the spores sift out. 9, A part of a necklace chain made of the spore capsules and their stems

When the spores are ripe, this lid falls off, and then if we have a lens we may see another instance of moss mechanism. Looking at the uncovered end of the capsule, we see a row of tiny teeth around the margin, which seem to hold down an inner cover with a little raised rim. The botanists have counted these teeth and find there are 64. The teeth themselves are not important, but the openings between them are, since only through these openings can the spores escape. In fact, the capsule is a pepper box with a grating around its upper edge instead of holes in its cover; and when it is fully ripe, instead of standing right side up, it tips over; thus its spores are shaken out more easily. These teeth are like the moss leaves; they swell with moisture, and thus in rainy weather they, with the inner cover, swell so that not a single spore can be shaken out. If spores should come out during the rain, they would fall among the parent plants where there is no room for growth. But when they emerge in dry weather, the wind scatters them far and wide where there is room for development.

When seen with the naked eye, the spores seem to be simply fine dust, but each dust grain is able to produce moss plants. However, the spore does not grow up into a plant like a seed; it grows into fine, green, branching threads which push along the surface of damp soil; and on these threads little buds appear, each of which grows up into a moss stem.

If we examine some other plants of pigeon wheat moss, we find that some stems end in yellowish cups which look almost like blossoms; on closer examination, we find that there are several of these cups, one below the other, with the stem extending up through the middle. The upper cup matured this year, the one below it last year, and so on. These cups are star-pointed, and inside, at the bottom, is a starlike cluster of leaves. Among the leaves of this star-rosette are borne the *antheridia*, too small for us to see without a high-power microscope. The sperm cells from these *antheridia* are carried to other plants, some of which produce egg cells at their very tips, although the egg cell has no leaf rosette to show where it is. This egg cell, after receiving the sperm cells, grows into the spore capsule supported on its coral stem. These — stalk, capsule, and all — grow up out of the mother plant; the red stalk is enlarged at its base, and fits into the moss stem like a flagstaff in the socket. After the star-shaped cup has shed its sperm cells, the stem grows up from its center for an inch or so in height and bears new leaves, and next year will bear another starry cup. This condition is true of pigeon wheat and some others; but many other mosses have sperm and egg cells on the same plant.

The brown leaves on the lower part of the moss stem are dead, and only the green leaves on the upper part are living.

And this is the story of the moss cycle:

1. A plant with an egg cell at its tip; another plant with a star-cup holding the moss sperm cell which is splashed by a raindrop over to the waiting egg.

2. The egg cell as soon as fertilized develops into a spore capsule, which is lifted up into the world on a beautiful shining stem and is protected by a silky cap.

3. The cap comes off; the lid of the spore case falls off, the spores are shaken out and scattered by the wind.

4. Those spores that find fitting places grow into a net of green threads.

5. These green threads send up moss stems which repeat the story.

Suggested Reading — *First Studies of Plant Life*, by George F. Atkinson; *How to Know the Mosses*, by Elizabeth M. Dunham; *Mosses with a Hand-Lens*, by A. J. Grout.

LESSON 197

The Hair-Cap Moss

Leading Thought — The mosses, like the butterfly and the fern, have several stages in their development. The butterfly stages are the egg, the caterpillar, the chrysalis, the butterfly. The moss stages are the egg (or ovule), the spores, the branching green threads, and moss plants with their green foliage. In June we can

These plants make up that portion of the plant kingdom known as Bryophytes *or* Bryophyta. *Although they number more than* 16,000 *species, most of which are mosses, comparatively few are of any economic importance. The group is, however, of great interest to scientists because its members seem to represent a step in development between the algae and higher plants.*

Bryophytes do not have true roots as do the higher plants; instead of roots they have numerous hairlike growths called rhizoids. The rhizoids of the hepatics are only one-celled; those of the mosses are much more highly developed.

Hepatics grow in such a way as to make a flat covering over the ground. Mosses, because of their vegetative multiplication, usually grow in compact clusters. Their compactness enables mosses to store up for a long time any moisture that they collect. When dry they are dormant.

Mosses and liverworts are best distinguished by the way in which their spores are released. In mosses, with a few exceptions, the end of the capsule forms a lid which falls off, thus releasing the spores. In liverworts, the end of the capsule splits lengthwise and the segments bend apart, allowing the spores to fall out. Although not all liverworts have flat thalli, like those shown in Figures 6 *and* 8, *and many are surprisingly mosslike in appearance, these can be distinguished from mosses because the leaves of liverworts are only a single cell in thickness throughout all their area.*

1. BROOM MOSS, Dicranum scoparium. *This moss has its name from the resemblance it bears to a hair broom or long brush. It is so abundant throughout most parts of the Northern Hemisphere that it is often used by florists to produce the effect of green banks in exhibits. (Photo by E. B. Mains)*

2. COMMON HAIR-CAP, BIRD WHEAT, *or* PIGEON WHEAT MOSS, Polytrichium commune. *This very common moss, found not only in all parts of North America but in Europe and Asia as well, is the plant most people have in mind when they speak of moss. It grows, not only in woods but also in old fields and meadows, where it must withstand great variations in temperature and moisture. When dry, the leaves fold up against the stem and dry plants present a very different aspect from damp ones. In Europe the hair-cap mosses are used for small brooms and bed fillings. This is our largest moss; its stems may reach a foot in length but they are usually much smaller. (Photo by E. B. Mains)*

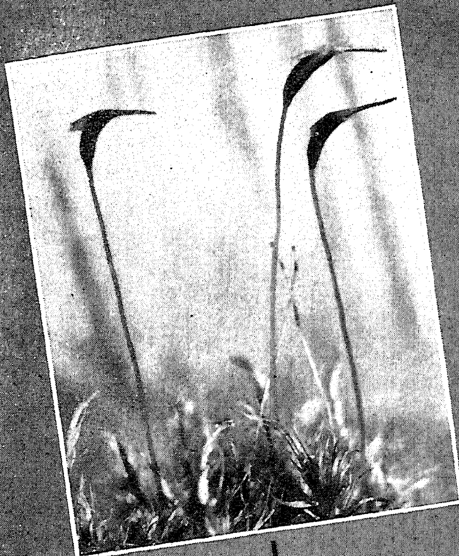
3. COMMON FERN MOSS, Thuidium delicatulum. *In distribution this moss is general; it grows on soil, stones, and logs in damp places. In appearance, it resembles a delicate fern; its general form reminds one of some of the types of frost pictures seen on windows in winter. (Photo by W. C. Steere)*

4. AWNED HAIR-CAP MOSS, Polytrichium piliferum. *This moss is much smaller than the pigeon wheat; it may be found growing in very dry situations, at high altitudes, and even on bare rock ledges. (Photo by Buffalo Museum of Science)*

5. PLUME MOSS, Hypnum Crista-castrensis. *In moist cool forests, one may expect to see this yellow-green moss at its best; there it may be found even completely covering old logs and stumps. (Photo by Buffalo Museum of Science)*

6. PURPLE-FRINGED RICCIA, Ricciocarpus natans. *This near relative of the mosses belongs to a group of plants known as hepatics. It is shown in the picture as it grows in stagnant pools; it may also grow on land, in which case it has a very different appearance. (Photo by W. C. Steere)*

7 *and* 8. TRUE LIVERWORT, Marchantia polymorpha. *These plants, known as liverworts or hepatics, are close allies of the mosses. The plant body is in the form of a thallus (as shown in the pictures) rather than a main stem and leaves. The thallus creeps on the ground to which it is attached by large hairs called rhizoids; these rhizoids perform the functions of roots. In No.* 7, *the portions of the plants which resemble the ribs of an umbrella bear the female reproductive bodies. The little cups on the surface of the thallus in No.* 8 *produce vegetative reproductive bodies called gemmæ or brood bodies. A slightly different umbrella-shaped growth on another plant (not figured) produces the male reproductive bodies. (Photos by E. B. Mains)*



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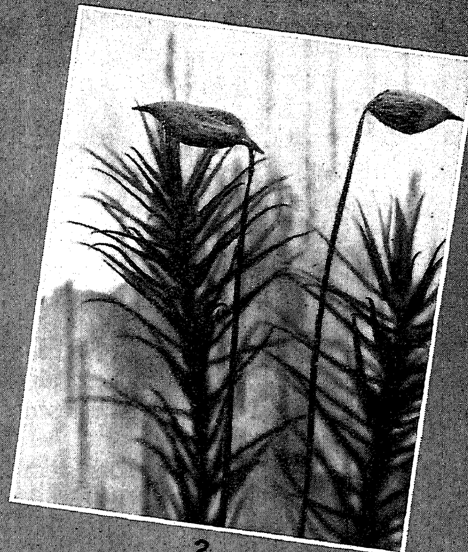

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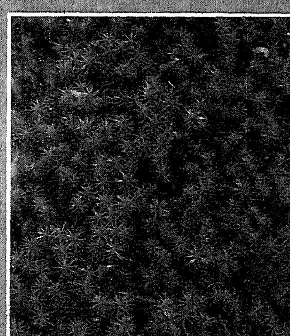

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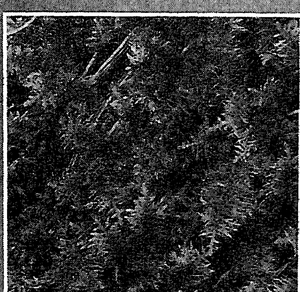

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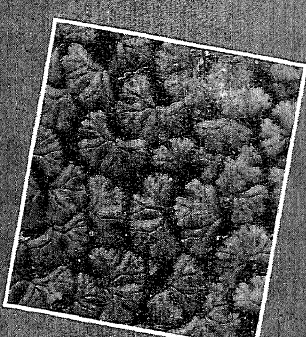

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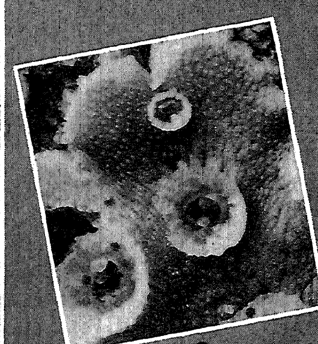

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find all these stages, except perhaps the branching-thread stage.

METHOD — The children should bring to the schoolroom a basin of moss in its fruiting stage; or still better, go with them to a knoll covered with moss. Incidentally tell them that this moss, when dried, is used by the Laplanders for stuffing their pillows, and that the bears use it for their beds. Once, a long time ago, people believed that a plant, by the shape of its leaf or flower, indicated its nature as a medicine, and as this moss looked like hair, the water in which it was steeped was used as a hair tonic.

OBSERVATIONS — 1. Take a moss stem with a grain of pigeon wheat at the end. Examine the lower part of the stalk. How are the leaves arranged on it? Examine one of the little leaves through a lens and describe its shape, its edges, and the way it joins the stem. Are the lower leaves the same color as the upper ones? Why?

2. Describe the pretty shining stem of the fruit, which is called the pedicel. Is it the same color for its entire length? Can you pull it easily from the main plant? Describe how its base is embedded in the tip of the plant.

3. Note the silken cap on a grain of the pigeon wheat. This is called the veil. Is it all the same color? Is it grown fast to the plant at its lower margin? Take it by the tip, and pull it off. Is this done easily? Describe what it covers. This elegant little green vase is called a spore capsule. How many sides has it? Describe its base which stands upon the stem. Describe the little lid. Pull off the lid; is there another lid below it? Can you see around the edge the tiny teeth which hold this lid in place?

4. Do all the spore vases stand straight up, or do some bend over?

5. Do you think the silken cap falls off of itself after a while? Can you find any capsules where the cap or veil and the lid have fallen off? See if you can shake any dust out of such a spore vase. What do you think this dust is? Ask your teacher, or read in the books, about moss spores and what happens if they find a damp place in which to grow.

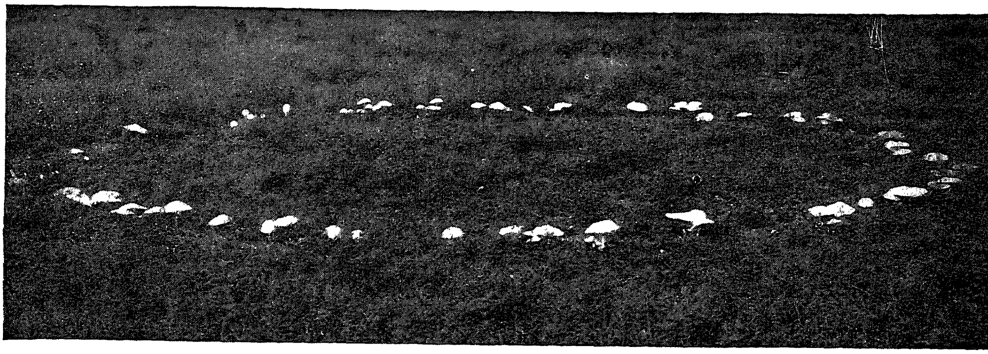
6. Hunt among the moss for some stems that have pretty, yellowish, starlike cups at their tips. How does the inside of one of these cups look? Ask the teacher to tell you what grows in this cup. Look down the stem and see if you can find last year's cup; the cup of two years ago. Measured by these cups how old do you think this moss stem is?

7. Select some stems of moss, both those that bear the fruit and those that bear the cups. After they are dried, describe how the leaves look. Examine the plant with a lens and note how these leaves are folded and twisted. Do the leaves stand out from the stem or lie close to it? Is this position of the leaves of any use to the plant in keeping the water from evaporating? How do the star-cups look when dry?

8. Place these dried stems in a glass of water and describe what happens to the cup. Examine some of the dried moss and the wet moss with a lens, and describe the difference. Of what use to the moss is this power of changing form when damp?

MUSHROOMS AND OTHER FUNGI

There is something uncanny about plants which have no green parts; indeed, many people find it difficult to think of them as plants. It is, therefore, no wonder that many superstitions cluster about toadstools. In times of old, not only was it believed that toads sat on them, but that fairies danced upon them and used them for umbrellas. The poisonous qualities of some species made them also a natural ingredient of the witch's cauldron. But science, in these days, brings revelations concerning these mysterious plants which are far more wonderful than the web which superstition wove about them in days of yore.

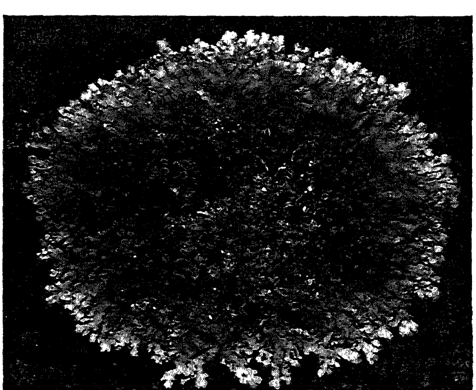


U. S. Dept. of Agriculture

A fairy ring

When we find plants with no green parts which grow and thrive, though unable to manufacture their own organic food through the alchemy of chlorophyll, sunlight, and air, we may safely infer that in one way or another they gain the products of this alchemy at second hand. Such plants are either parasites or saprophytes; if parasites, they steal the food from the cells of living plants; if saprophytes, they live on such of this food material as remains in dead wood, withered leaves, or soils enriched by their remains.

Thus, we find mushrooms and other fungus fruiting bodies, pallid, brown-olive, yellow, or red in color, but with no signs of the living green of other plants; and this fact reveals their history. Some of them are parasites, as certain species of bracket fungi which are the deadly enemies of living trees; but most of the fungus species that we ordinarily see are saprophytes, and live on dead vegetation. Fungi, as a whole, are a great boon to the world. Without them our forests would be choked out with dead wood. Decay is simply the process by which fungi and other organisms break down dead material, so that the major part of it returns to the air in gaseous form, and the remainder, now mostly humus, mingles with the soil.



Brooklyn Botanic Garden

A lichen

As a table delicacy, mushrooms are highly prized. A very large number of

George F. Atkinson

Meadow mushroom. A common edible mushroom

species are edible. But every year the newspapers report deaths resulting from eating the poisonous kinds — the price of an ignorance which comes from a lack of the powers of observation developed in nature-study. It would be very unwise for any teacher to give rules to guide her pupils in separating edible from poisonous mushrooms, since the most careful directions may be disregarded or misunderstood. She should emphasize the danger incurred by mistaking a poisonous for an edible species. One small button of the deadly kind, if eaten, may cause death. A few warning rules may be given, which, if firmly impressed on the pupils, may result in saving human life.

First and most important, avoid all mushrooms that are covered with scales, or that have the base of the stem included in a sac, for two of the poisonous species, often mistaken for the common edible mushroom, have these distinguishing characteristics. Care should be taken that every specimen be collected in a way to show the base of the stem, since in some poisonous species this sac is hidden beneath the soil.

Second, avoid the young, or button, stages, since they are similar in appearance in species that are edible and in those that are poisonous.

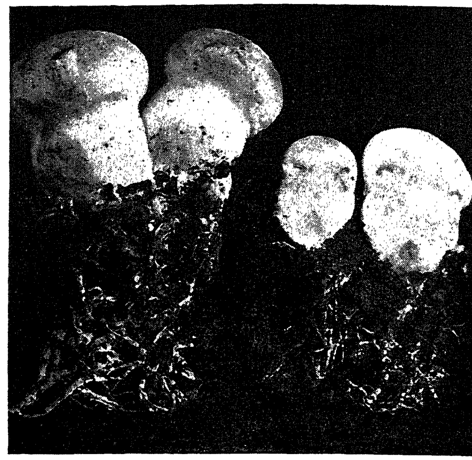
Third, avoid those that have milky juices; unless the juices are reddish in color, the mushrooms should not be eaten.

Fourth, avoid those with shiny, thin, or brightly colored caps, and those with whitish or clay-colored spores.

Fifth, no mushroom or puffball should be eaten after its meat has begun to turn brown or has become infested with fly larvæ.

George F. Atkinson

The deadly amanita, Amanita phalloides. *Note the form of the ring, and the cup at the base of the stem*



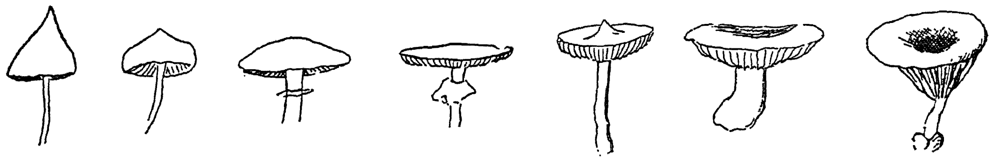
George F. Atkinson

Young stages of cultivated edible mushrooms, showing spawn

How Mushrooms Look and How They Live

There are many kinds of mushrooms varying greatly in form, color, and size, but wherever they appear it means that sometime previous the mushroom spores have been planted there. There they threw out threads which have penetrated the food substance and gained a successful growth, which finally resulted in sending up into the world the fruiting organs. In general shape these consist of a stem with a cap upon it, making it usually somewhat umbrella-shaped. Attached to the cap, and usually under it, are platelike growths called gills, or a fleshy surface which is full of pores. In the gills, each side of each plate develops spores. These, as fine as dust, are capable of producing other mushrooms.

In the common edible species of mushroom (*Agaricus campestris*), the stem is white and almost cylindrical, tapering slightly toward the base; it is solid, although the core is not so firm as the outside. When it first pushes above the ground, it is in what is called the " button stage " and consists of a little, rounded cap covered with a membrane which is attached to the stem. Later the cap spreads wide, for it is naturally umbrella-shaped, and it tears loose this membrane, leaving a piece of it attached to the stem; this remnant is called the ring or collar. The collar is very noticeable in many species, but in the common mushroom it soon shrivels and disappears. The cap is at first rounded and then convex; its surface is at first smooth, looking soft and silky; but as the plant becomes old, it is often broken up into triangular scales which are often dark brown, although the color of the cap is usually white or pale brown. The gills beneath the cap are at first white, but later, as the spores mature, they become brownish black because of the ripened spores.



Cone-shaped *Bell-shaped* *Convex* *Plane* *Raised at center* *Depressed* *Funnel form*

SUGGESTED READING — *Field Book of Common Mushrooms,* by William S. Thomas; *Fields and Fencerows,* by Walter P. Porter and Einar A. Hansen; *First Studies of Plant Life,* by George F. Atkinson; *The Mushroom Book,* by Nina L. Marshall; *The Mushroom Handbook,* by Louis C. C. Krieger; *Mushrooms,* by W. B. McDougall; *Mushrooms of Field and Wood,* by Margaret McKenny; *Nature and Science Readers,* by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons; Our Plant Friends and Foes,* by William A. DuPuy.

LESSON 198
MUSHROOMS

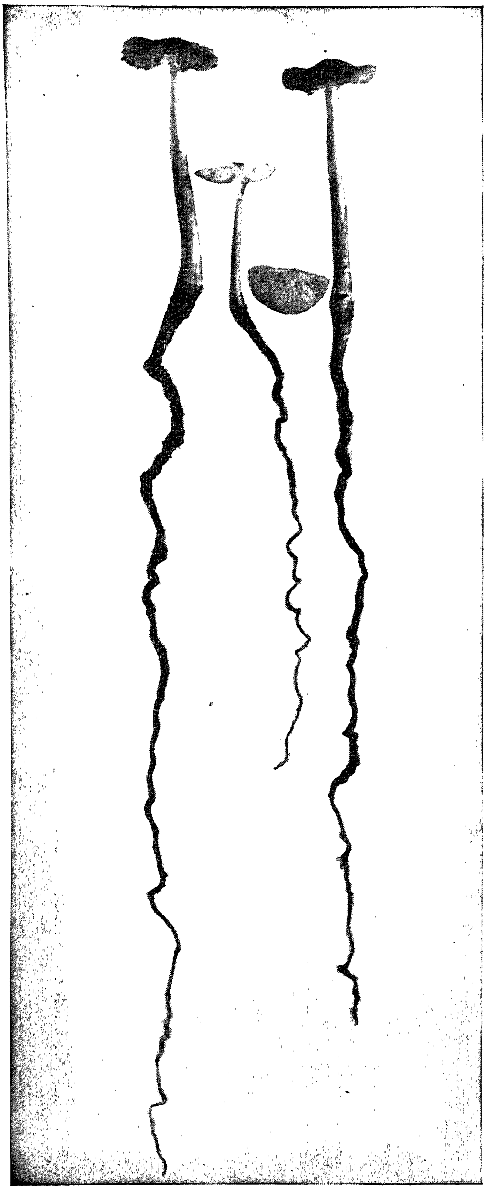
LEADING THOUGHT — Mushrooms are the fruiting organs of the fungi which grow in the form of threads, spreading in every direction through the food material. The dust which falls from ripe mushrooms is made up of spores, which are not true seeds, but which will start a new growth of the fungus.

METHOD — The ideal method would be to study the mushrooms in the field and forest, making an excursion for the purpose of collecting as many species as possible. But the lesson may be given from specimens brought into the schoolroom by pupils, care being taken to bring with them the soil, dead wood, or leaves on which they were found growing. After studying one species thus, encourage the pupils to bring in as many others as possible. There are a few terms which the pupils should learn to use, and one method of teaching them is to place the diagrams shown above and on page 719, on the blackboard, and leave them there for a time.

Since mushrooms are especially good subjects for water-color and pencil studies, it would add much to the interest of the work if each pupil, or the school as a whole, should make a portfolio of sketches of all the species found. With each drawing there should be made on a supple-

George F. Atkinson

Inky-cap mushroom



George F. Atkinson

Rooted Collybia, Collybia radicata. *In woods, during summer, in groups or singly this mushroom is common. The stem extends into the ground for some distance, giving the appearance of a "tap root"*

mentary sheet a spore print of the species. White paper should be covered very thinly with white of egg or mucilage, so as to hold fast the discharged spores when making these prints for portfolio or herbarium.

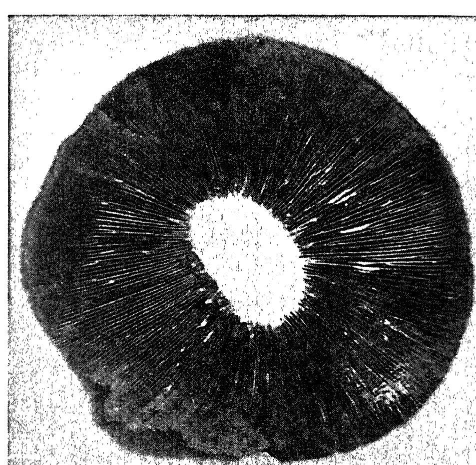
Observations — 1. Where was the mushroom found? If on the ground, was the soil wet or dry? Was it in open fields or in woods? Or was it found on rotten wood, fallen leaves, old trees or stumps, or roots? Were there many or few specimens?

2. Is the cap cone-shaped, bell-shaped, convex, plane, concave, or funnel-form? Has it a raised point at the center? How wide is it?

3. What is the color of the upper surface of the cap when young? When old? Has it any spots of different colors on it? Has it any striate markings, dots, or fine grains on its surface? Is its texture smooth or scaly? Is its surface dull, or polished, or slimy? Break the cap and note the color of the juice. Is it milky?

4. Look beneath the cap. Is the under surface divided into plates like the leaves of a book, or is it porous?

5. The plates which may be compared to the leaves of a book are called gills, although they are not for the purpose of breathing, as are the gills of a fish. Are there more gills near the edge of the cap than near the stem? How does this occur? What are the colors of the gills? Are the gills the same color when young as when old? Are the lower edges of the gills sharp, blunt, or saw-toothed?

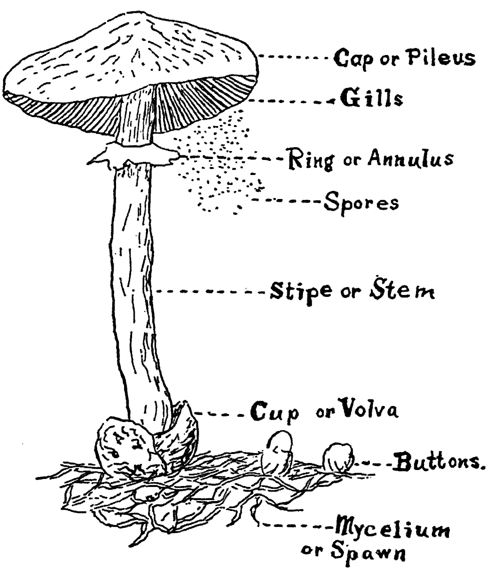


George F. Atkinson

A spore print from the common edible mushroom

6. Break off a cap and note the relation of the gills to the stem. If they do not join the stem at all they are termed "free." If they end by being joined to the stem, they are called "adnate" or "adnexed." If they extend down the stem they are called "decurrent."

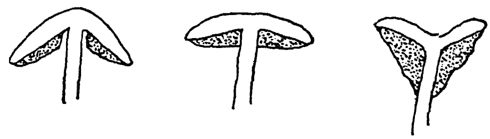
7. Take a freshly opened mushroom, cut off the stem even with the cap, and set the cap, gills down, on white paper; cover with a tumbler, or other dish to exclude draught; leave it for twenty-four hours and then remove the cover, lift the cap carefully and examine the paper. What color is the imprint? What is its



Mushroom with parts named

shape? Touch it gently with a pencil and see what makes the imprint. Can you tell by the pattern where this fine dust came from? Examine the dust with a lens. This dust is made up of mushroom spores, which are not true seeds, but which do for mushrooms what seeds do for plants. How do you think the spores are scattered? Do you know that one little grain of this spore dust would start a new growth of mushrooms?

8. Look at the stem. What is its length? Its color? Is it slender or stocky? Is its surface shiny, smooth, scaly, striate, or dotted? Has it a collar or ring around it near the top? What is the appearance of



this ring? Is it fastened to the stem, or will it slide up and down? Is the stem solid or hollow? Is it swollen at its base? Is its base set in a sac or cup, or is it covered with a membrane which scales off? Do you know that the most poisonous of mushrooms have the sac or the scaly covering at the base of the stem?

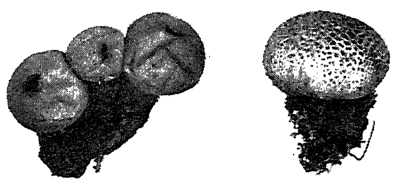
9. Examine with a lens the material on which the mushroom was growing; do you see any threads in it that look like mold? Find if you can what these threads do for the mushroom. If you were to go into the mushroom business what would you buy to start your beds? What is mushroom "spawn"?

10. If you can find where the common edible mushrooms grow plentifully, or if you know of any place where they are grown for the market, get some of the young mushrooms when they are not larger than a pea and others that are larger and older. These young mushrooms are called "buttons." Find by your own investigation the relation between the buttons and the threads. Can you see the gills in the button? Why? What becomes of the veil over the gills as the mushrooms grow large?

11. Do you know the common edible mushroom when you see it? What characteristics separate this from the poisonous species? What is the "death cup," as it is called, which covers the base of the stem of the most common poisonous species?

PUFFBALLS

The puffballs are always interesting to children, because of the " smoke " which issues from them in clouds when they are pressed between thumb and finger. The common species are white or creamy when young; and some of the species are warty or roughened, so that as children we called them " little lambs." They grow on the ground usually, some in wet, shady places, and others, as the giant species, in grassy fields in late summer. This giant puffball always excites interest when found. It is a smoothish, white, rounded mass, apparently resting on the grass as if thrown there; when lifted it is seen that it has a connection below at its center, through its mycelium threads, which form a network in the soil. It is often a foot in diameter, and specimens four feet through have been recorded. When its meat is solid and white to the very center, it makes very good food. The skin should be pared off, the meat sliced and sprinkled with salt and pepper and fried in hot fat until browned. All the puffballs are edible, but uninformed persons might mistake the button stages of some of the poisonous mushrooms for little puffballs, and it is not well to encourage the use of small puffballs for the table.



Dr. and Mrs. John Small

Puffballs. On the left is shown Lycoperdon, *on the right,* Scleroderma. *The mature spores escape through the openings to be seen on* Lycoperdon

A common species — " the beaker puffball " — is pear-shaped, with its small end made fast to the ground, which is permeated with its vegetative threads.

The interior of a puffball, " the meat," is made up of the threads and spores. As they ripen, the threads break up so that with the spores they make the " smoke," as can be seen if the dust is examined through a microscope. The outer wall may become dry and brittle and break open to allow the spores to escape, or one or more openings may appear in it as spore doors. The spores of puffballs were used extensively in pioneer days to stop the bleeding of wounds and especially for nosebleed.

In one genus of the puffball family, the outer coat splits off in points on maturing, like an orange peel cut lengthwise in six or seven sections but still remaining attached to the base. There is an inner coat that remains as a protection to the spores, so that these little balls are set each in a little star-shaped saucer. These star points straighten out flat or even curl under in dry weather, but when damp they lift up and again envelop the ball to a greater or less extent.

Suggested Reading — Readings on page 717.

Wm. P. Alexander

Cup-shaped puffball, Calvatia cyathiformis. *This edible puffball may reach* 6 *inches in diameter; it is found on open grassy ground in early autumn*

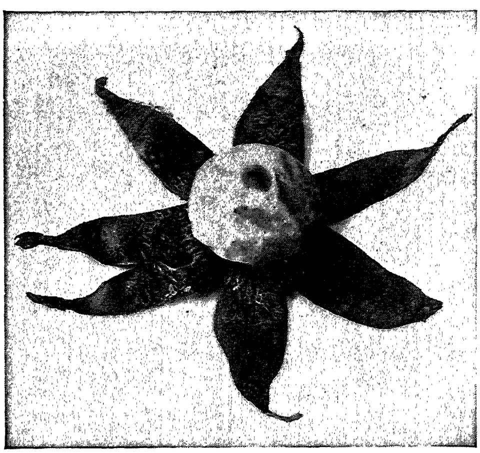
LESSON 199

PUFFBALLS

LEADING THOUGHT — The puffballs are fungi that grow from the threads or mycelia which permeate the ground or other matter on which the puffballs grow. The puffballs are the fruiting organs, and "smoke" which issues from them is largely made up of spores, which are carried off by the wind and thus sown and planted.

METHOD — Ask the pupils to bring to school any of the globular or pear-shaped fungi in the early stages when they are white, taking pains to bring them on the soil or wood on which they are growing.

OBSERVATIONS — 1. Where did you find the puffball? On what was it growing? Were there many growing in company? Remove the puffball, and examine the place where it stood with a lens to find the matted and crisscrossed fungus threads.



Verne Morton

An earthstar

2. What is the size and shape of the puffball? Is its surface smooth or warty? What is its color inside and outside?

3. Have you ever found the giant puffball, which may become four inches to four feet through? Where was it growing? Have you ever eaten this puffball sliced and fried? Do you know by the looks of the meat when it is fit to eat?

George F. Atkinson

Giant puffball, Calvatia gigantea. *It is not unusual to find these puffballs 10 to 20 inches in diameter. This is the largest puffball and is a great favorite among the edible varieties. In prime condition the flesh is white; it is edible as long as it remains white*

4. If the puffball is ripe, what is its color outside and in? What is the color of its "smoke"? Does the smoke come out through the broken covering of the puffball, or are there one or more special openings to allow it to escape?

5. Puff some of the "smoke" on white paper and examine it with a lens. What do you think this dust is? Of what use is it to the puffball?

6. Have you ever found what are called earthstars, which look like little puffballs set in star-shaped cups? If you find these note the following things:

(a) Of what is the star-shaped base made?

(b) Let this star saucer become very dry; how does it act?

(c) Wet it; how does it behave then?

(d) Where and how does the spore dust escape from the earthstars?

7. For what medicinal purpose is the "smoke" of the puffball sometimes used?

THE BRACKET FUNGI

There are some naturalists who think that one kind of life is as good as another and therefore call all things good. Perhaps this is the only true attitude for the nature lover. To such the bracket-like fungi which appear upon the sides of our

Verne Morton

A bracket fungus

forest and shade trees are simply an additional beauty, a bountiful ornamentation. But some of us have become special pleaders in our attitude toward life, and those of us who have come to feel the grandeur of tree life can but look with sorrow upon these fungus outgrowths, for they mean that the doom of the tree is sealed.

There are many species of bracket fungi. Three of these are very common. The gray bracket, gray above and with creamy surface below (*Polyporus applanatus*), is a favorite for amateur etchers, who with a sharp point make interesting sketches upon this naturally prepared plate; this species often grows to great size and is frequently very old. Another species (*P. lucidus*) is in color a beautiful mahogany or coral-red above and has a peculiar stem from which it depends; the stem and upper surface are polished as if burnished and the lower surface is yellowish white. Another species (*P. sulphureus*) is sulphur yellow above and below; usually many of these yellow brackets are grouped together, their fan-shaped caps overlapping. Many of the shelf fungi live only on dead wood, and those are an aid in reducing dead branches and stumps until they crumble and become again a part of the soil. However, several of the species attack living trees and do great damage. They can gain access to the living tree only through an injured place in the bark, a break caused perhaps by the wind, by a bruise from a falling tree, or more often from the hack of the careless wood-chopper; often they gain entrance through an unhealed knot hole. To one who understands trees and loves them, these wounds inflicted by forces they cannot withstand are truly pathetic. After the wound is made and before the healing is accomplished, the wind may sift into the wound the almost omnipresent spores of these fungi and the work of destruction begins. From the spores grows the mycelium, the fungus threads which push into the heart of the wood, getting nourishment from it as they go. When we see wood thus diseased we say that it is rotting, but rotting merely means the yielding up of the body substance of the tree to these voracious fungus threads. They push in radially and then grow upward and downward, weakening the tree where it most needs strength to withstand the onslaught of the wind. Later these parasitic threads may reach the cambium layer, the living ring of the tree trunk, and kill the tree entirely; but many a tree has lived long with the fungus attacking its heartwood.

George F. Atkinson

A bracket fungus, Polyporus versicolor. *This is a common form of* Polyporus *found on dead wood. When wet this fungus is flexible but when dry it is woody, and almost brittle*

A bracket fungus found by Professor Atkinson was eighty years old; however, this may have shortened the life of the tree a century or more.

After these fungus threads are thoroughly established in the tree, they again seek a wound in the protecting bark where they may push out and build the fruiting organ, which we call the bracket. This may be at the same place where the fatal entry was made, or it may be far from it. The bracket is at first very small and is composed of a layer of honeycomb cells, closed and hard above and opening below — cells so small that we can see the cell openings only with a lens. These cells are not hexagonal like the honeycomb, but are tubes packed together. Spores are developed in each tube. Next year another layer of cells grows beneath this first bracket and extends out beyond it; each year it is thus added to, making it thicker and marking its upper surface with concentric rings around the point of attachment.

George F. Atkinson

This woody type of pore fungi, Gandoderma, *usually found growing on old wood has a brittle polished crust*

The creamy surface of the great bracket fungus on which etchings are made is composed of a layer of these minute spore-bearing tubes. Not all bracket fungi show their age by these annual growths, for some species form new shelves every year, which decay after the spores are ripened and shed.

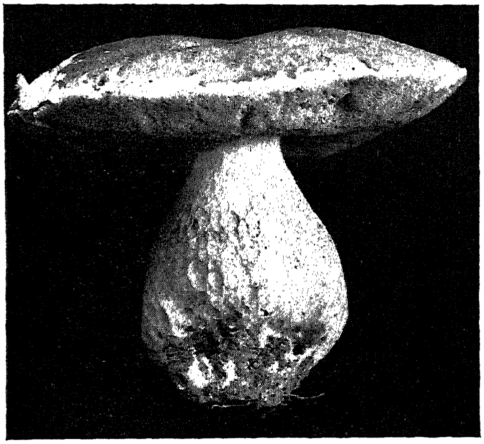
When once the mycelium of such a fungus becomes established, the tree is probably doomed and its lumber made worthless even though, as sometimes happens, the tree heals its wounds so that the fungus is imprisoned and can never send out fruiting brackets. Thus it is most important to teach the pupils how to protect trees from the attacks of these enemies, which are devastating our forests, and which sometimes attack our orchards and shade trees.

As soon as a tree is bruised, the wound should be painted or covered with a coat of tar. If the wind breaks a branch, the splinters left hanging should be sawed off, leaving a smooth stump, and this should be painted. While ordinary paint if renewed each year will suffice, experiment has shown that the coat of tar is better and should be used.

Especially should teachers impress on pupils the harm done by careless hacking with axe or hatchet. We shall do an invaluable service in the protection of our forests if we teach the rising generation the respectful treatment of trees — which

George F. Atkinson

Oyster mushroom, Pleurotus ostreatus



George F. Atkinson

Edible boletus, Boletus edulis. *This is a common plant in woods and open places during July and August. It has tubes instead of gills below the cap. The spores are developed within the tubes, as in the bracket fungi*

is due living conditions whose span of life may cover centuries.

Suggested Reading — Readings on page 717.

LESSON 200

Bracket Fungi

Leading Thought — The fungi which we see growing shelflike from trees are deadily enemies to the trees. Their spores germinate and penetrate at some open wound, and the growing fungus weakens the wood.

Method — It is desirable that a tree on which shelf fungus grows should be studied by the class, for this is a lesson on the care of trees. After this lesson the fungus itself may be studied at leisure in the schoolroom.

Observations — 1. On what kind of tree is the bracket fungus growing? Is it alive or dead? If living, does it look vigorous or is it decaying?

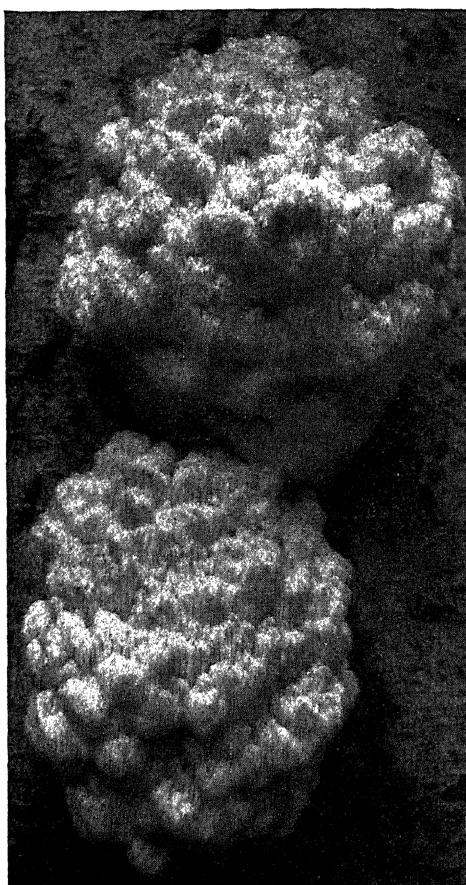
2. Is the fungus bracket growing against the side of the tree, or does it stand out on a stem?

3. Look at the place where the bracket joined the tree. Does it seem to be a part of the wood?

4. What color is the fungus on its upper surface? How large is it? How thick near the tree? How thick at the edge? Can you detect concentric layers or rings? If it is the large species used for etching, cut down through it with a knife or hatchet and count the layers; this should show its age.

5. Look at the lower surface. How does it appear to the naked eye? If you scratch it with a pin or knife does the bruise show? Examine the surface with a lens and describe what you see. Cut or break the fungus and note that each of these holes is an opening to a little tube. In each of these tubes spores are borne.

6. Have you ever seen toadstools that,



William P. Alexander

Bear's head fungus, Hydnum caput-ursi. *This beautiful fungus grows in white clumps of irregular shape and hangs from decaying trees or logs like clumps of icicles; the spores are produced on teeth instead of in pores or gills as in many other mushrooms* instead of having the leaflike gills, have beneath the cap a porous surface like a little honeycomb or like the under side of the shelf fungi?

7. How many kinds of shelf fungi can you find? Which of them is on living trees, and which on stumps or dead wood?

8. If the fungus is on a living tree, then the tree is ruined, for the fungus threads have worked through it and weakened it so that it will break easily and is of no use as lumber. There must have been an open wound in the tree where the fungus entered; see whether you can find this wound. There must also have been a wound where the shelf grew out; see whether you can detect it. If the tree should heal all its wounds after the fungus entered, what would become of the fungus?

9. What does the shelf fungus feed on? What part of it corresponds to the roots and leaves of other plants? What part may be compared to the flowering and fruiting parts of other plants?

10. What treatment must we give trees to keep them free from this enemy?

LESSON 201

Hedgehog Fungi

There is something mysterious about all fungi, but perhaps none of these wonderful organisms so strangely impresses the observer as the fountain-like masses of creamy white or the branching white coral that we see growing on a dead tree trunk. The writer remembers as a child that the finding of these woodland treasures made her feel as if she were in the presence of the supernatural, as if she had discovered a fairy grotto or a kobold cave. The prosaic name of hedgehog fungi has been applied to these exquisite growths. Their life story is simple enough. The spores falling upon dead wood start threads which ramify within it and feed on its substance, until strong enough to send out a fruiting organ. This consists of a stem, dividing into ascending branches; from these branches, depending like the stalactites in a cave, are masses of drooping spines, the surface of each bearing the spores. And it is so natural for these spines to hang earthward that they are invariably so placed, unless the position of the tree has changed since they grew. There is one species called the "satyr's beard," sometimes found on living trees, which is a mere bunch of downward-hanging spines; the coral-like species is called *Hydnum coraloides*, and the one that looks like an exquisite white frozen fountain, and may be seen in late summer or early autumn growing from dead limbs or branches, is the bear's-head fungus; it is often eight inches across.

Suggested Reading — Readings on page 717.

Observations — 1. These fungi come from a stem which extends into the wood.

2. This stem divides into many branchlets.

3. From these branchlets there hang long fleshy fringes like miniature icicles.

4. These fringes always hang downward when the fungus is in natural position.

5. These fringes bear the spores.

LESSON 202

The Scarlet Saucer

(*Sarcocypha coccinea*)

The heart of the child, searching the woods for hepaticas — woods where snow banks still hold their ground on north slopes — is filled with delight at finding these exquisite saucer-like fungi. They are most often found on fallen rotting branches which are more or less buried in leaves, and there are likely to be several of different sizes on the same stick. When they grow unhindered, and while

George F. Atkinson

The scarlet saucer, Sarcocypha coccinea

George F. Atkinson

An edible morel, Morchella esculenta

they are young, they are very perfectly saucer-shaped and range from the size of a pea to an inch or two across. But the larger they are the more likely are they to be distorted, either by environment or by the bulging of rapid growth. The underside of the saucer is beautifully fleshlike in color and feeling, and is attached at the middle to the stick. The inside of the saucer is the most exquisite scarlet, shading to crimson. This crimson lining bears the spores in little sacs all over its surface.

Suggested Reading — Readings on page 717.

Observations — 1. Where did you find the fungus?

2. What is the shape of the saucer? How large is it? Is it regular and beautiful or irregular and distorted?

3. What is the color inside?

4. What is the color outside?

5. Turn the saucer bottom side up — that is, scarlet side down — on a piece of white paper, and see whether you can get a spore harvest.

LESSON 203

The Morels

In May or June in open, damp places, such as orchards or the moist fence-corners of meadows, the morels may be found. This mushroom family contains no member that is poisonous, and the members are very unlike any other family in appearance. They are very pretty with their creamy white, thick, swollen stems and a cap more or less conical, made up of the deep-celled meshes of an unequal network. The outside edges of the network are yellowish or brownish when the morel is young and edible, but later turn dark as the spores develop. In some species the stems are comparatively smooth and in others their surface is more or less wrinkled. The spores are borne in the depressions of the network. These mushrooms should not be eaten after the cells change from creamy white to brownish.

Suggested Reading — Readings on page 717.

Observations — 1. Where did you find the morels?

2. Describe the stem. Is it solid or hollow? Is it smooth or rough?

3. What is the shape of the cap? How does it look? What color is the outer edge of the network? What is the color within the meshes?

George F. Atkinson

Stinkhorns

4. Take one of these fungi, lay it on a sheet of white paper, and note the color of the spores.

LESSON 204

The Stinkhorns

To give a nature-study lesson on the stinkhorn is quite out of the question, for the odor of these strange growths is so nauseating that even to come near to one of them in the garden is a disagreeable experience. The reason for mentioning them at all is because of the impression made by them that most mushrooms are ill smelling, which is a slander.

It is a pity that these fungi are so offensive that we do not care to come near enough to them to admire them, for they are most interesting in appearance. The scientific name of our commonest genus when translated means "the net bearers," and it is a most appropriate name. The stout, white stem is composed of network without and within. The outer covering of the stem seems to tear loose from the lower portion as the stem elongates, and is lifted so that it hangs as a veil around the bottom of the bell-shaped cap, which is always covered with a pitted network. The mycelium, or spawn, of the stinkhorn consists of strands which push their way through the ground or through the decaying vegetable matter on which they feed. On these strands are produced the stinkhorns, which at first look like eggs; but later the top of the egg is broken, and the strange horn-shaped fungus pushes up through it. The spores are borne in the chambers of the cap, and when ripe the substance of these chambers dissolves into a thick liquid in which the spores float. The flies are attracted by the fetid odor and come to feast upon these fungi and to lay their eggs within them, and incidentally they carry the spores away on their brushy feet, and thus help to spread the species.

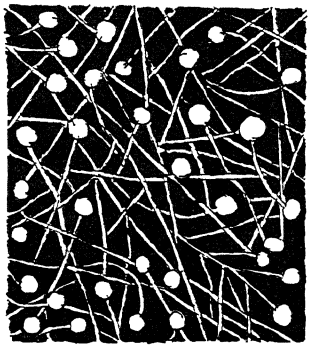
Suggested Reading — Readings on page 717.

George F. Atkinson

Bird's nest fungi

MOLDS

It is lucky for our peace of mind that our eyes are not provided with microscopic lenses, for then we should know that the dust, which seems to foregather upon our furniture from nowhere, is composed of all sorts of germs, many of them of the deadly kind. The spores of mold are very minute objects, the spore cases being the little white globes, not larger than the head of a small pin, which we see upon mold; yet each of these spore cases breaks and lets out into the world thousands of spores, each one ready to start a growth of mold and perfectly able to do it under the right conditions; almost any substance which we use for food, if placed in a damp and rather dark place, will prove a favorable situation for the development of the spore, which swells, bursts its wall, and sends out a short thread. This gains nourishment, grows longer, and branches, sending out many threads, some of which go down into the nutritive material and are called the mycelium. While these threads, in a way, act like roots, they are not true roots. Presently the tip ends of the threads, which are spread out in the air above the bread or other material, begin to enlarge, forming little gobules; the substance (protoplasm) within them breaks up into little round bodies, and each develops a cell wall and thus becomes a spore. When these are unripe they are white, but later they become almost black. In the blue mold the spores are borne in clusters of chains, and resemble tiny tas-



Bread mold

sels instead of growing within little globular sacs.

Molds, mildews, blights, rusts, and smuts are all flowerless plants and, with the mushrooms, belong to the great group of fungi. Molds and mildews will grow upon almost any organic substance, if the right conditions of moisture are present, and the temperature is not too cold.

Molds of several kinds may appear upon the bread used in the experiments for this lesson. Those most likely to appear are the bread mold — consisting of long, white threads tipped with white, globular spore cases, and the green cheese mold — which looks like thick patches of blue-green powder. Two others may appear, one a smaller white mold with smaller spore cases, and the other a black mold. However, the bread mold is the one most desirable for this lesson, because of its comparatively large size. When examined with a lens, it is a most exquisite plant. The long threads are fringed at the sides, and they pass over and through each other, making a web fit for fairies — a web all beset with the spore cases, like fairy pearls. However, as the spores ripen, these spore cases turn black, and after a time so many of them are developed and ripened that the whole mass of mold is black. The time required for the development of mold varies with the temperature. For two or three days nothing may seem to be happening upon the moist bread; then a queer, soft whiteness appears in patches. In a few hours or perhaps during the night, these white patches send up white fuzz which is soon dotted with tiny pearl-like spore cases. At first there is no odor when the glass is lifted from the saucer, but after the spores ripen, the odor is quite disagreeable.

The special point to teach the children in this lesson is that dryness and sunlight are unfavorable to the development of mold; and it might be well to take one of the luxuriant growths of mold developed in the dark, uncover it and place it in the sunlight, and see how soon it withers. The lesson should also impress upon them that dust is composed, in part, of living germs waiting for a chance to grow.

Suggested Reading — *The Book of Plants*, by Bertha M. Parker and Henry C. Cowles; *Fields and Fencerows*, by Walter P. Porter and Einar A. Hansen; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons*.

LESSON 205

Molds

Leading Thought — The spores of mold are everywhere and help to make what we call dust. These spores will grow on any substance which gives them nourishment, if the temperature is warm, the air is moist, and the sunlight is excluded.

Method — Take bread in slices two inches square, and also the juice of apple sauce or other stewed fruit. Have each pupil, or the one who does the work for the class, provided with tumblers and saucers. Use four pieces of bread cut in about two-inch squares, each placed on a saucer; moisten two and leave the other two dry. With a feather or the finger take some dust from the woodwork of the room or the furniture and with it lightly touch each piece of bread. Cover each with a tumbler. Set one of the moistened pieces in a warm, dark place and the other in a dry, sunny place. Place a dry piece in similar situations. Let the pupils examine these every two or three days.

Put fruit juice in a saucer, scatter a little dust over it and set it in a warm, dark place. Take some of the same, do not scatter any dust upon it, cover it safely with a tumbler, and put it in the same place as the other. A lens is necessary for this lesson, and it is much more interesting for the pupils if they can see the mold under a microscope with a three-fourths objective.

OBSERVATIONS — 1. When does the mold begin to appear? Which piece of bread showed it first? Describe the first changes you noticed. What is the color of the mold at first? Has it any odor?

2. At what date did the little branching mold threads with round dots appear? Is there an odor when these appear? What are the colors of the dots, or spore cases, at first? When do these begin to change color? How does the bread smell then? What caused the musty odor?

3. Did the mold fail to appear on any of the pieces of bread? If so, where were these placed? Were they moist? Were they exposed to the sunlight?

4. Did more than one kind of mold appear on the bread? If so, how do you know that they are different kinds? Are there any pink or yellow patches on the bread? If so, these are made by bacteria and not by mold.

5. From the results of the experiments, describe in what temperature mold grows best; in what conditions of dryness or moisture? Does it flourish in the sunlight or in the dark?

6. Where does the mold come from? What harm does it do? What should we do to prevent the growth of mold? Name all of the things on which you have seen mold or mildew growing.

7. Examine the mold through a microscope or a lens. Describe the threads. Describe the little round spore cases. Look at some of the threads that have grown down into the fruit juice. Are they like the ones which grow in the air?

8. If you have a microscope cut a bit of the mold off, place it in a drop of water on a glass slide, and put on a cover glass. Examine the mold with a three-fourths objective, and describe the spores and spore cases.

BACTERIA

The yellow, pink, or purple spots developed upon the moist and moldy bread may be caused by bacteria and yeast. Bacteria are one-celled organisms; they are the smallest known living things, and can be seen only through a high-power microscope.

Bacteria are found almost everywhere — in the soil, on foods and fruits, in the water of ponds, streams, and wells, in the mouths and stomachs of all animals, and in fact in almost all possible places. They occur also in the air. Most of them are harmless, some of them are useful, and many produce disease in both plants and animals, including man.

What bacteria do would require many large volumes to enumerate. Some of them develop colors or pigments; some produce gases, often ill-smelling; some are phosphorescent; some take nitrogen from the air and fix it in the soil; some produce putrefaction; and some produce disease. Nearly all of the contagious diseases are produced by bacteria. Diphtheria, scarlet fever, typhoid fever, tuberculosis, influenza, grippe, colds, cholera, lockjaw, leprosy, blood poisoning, and many other diseases are thought to be the result of bacteria. On the other hand, many of the bacteria are beneficial to man. Some forms ripen the cream before churning, others give flavor to butter; some are an absolute necessity in making cheese. The making of cider into vinegar is the work of bacteria; some help to decompose the dead bodies of animals, so that they return to the dust whence they came.

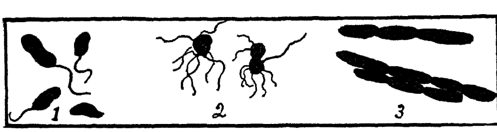
We have in our blood little cells whose business it is to destroy the harmful bacteria which get into the blood. These little fighting cells move everywhere with our blood, and if we keep healthy and vigorous by right living, right food, and exercise, these cells may prove strong enough to kill the disease germs before they harm us. Direct sunlight also kills some of the bacteria. Exposure to the air is also a help in subduing disease germs. Bichloride of mercury, carbolic acid, formaldehyde, and burning sulphur also kill germs. We can do much to protect ourselves from harmful bacteria by being very clean in our persons and in our homes, by bathing frequently, and washing often with soap. We should eat only pure and freshly cooked food, we should get plenty of sleep and admit the sunlight to our homes; we should spend all the time possible in the open air and be careful to drink pure water. If we are not sure that the water is pure, it should be boiled for twenty minutes and then cooled for drinking.

In Experiment A the milk vials and the corks are all boiled, so that we may be sure that no other bacteria than the ones we chose are present, since boiling kills these germs. As soon as the milk becomes discolored we know that it is full of bacteria.

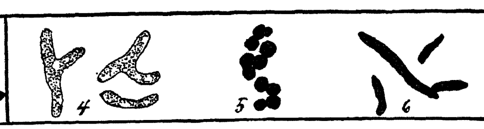
Experiment B shows that bacteria can be transplanted to gelatin, which is a material favorable for their growth. But the point of this experiment is to show the child that a soiled finger will have upon it germs which, by growing, cloud the gelatin. They should thus learn the value of washing their hands often or of keeping their fingers out of their mouths.

Experiment C shows the way the destructive bacteria attack the potato. The discolored spots show where the decay begins, and the odor is suggestive of decay. If a potato thus attacked is put in the bright sunlight the bacteria are destroyed, and this indicates a value of sunshine.

Suggested Reading — *The Book of Plants*, by Bertha M. Parker and Henry C. Cowles; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 4, *Through Four Seasons.*



1, *A bacillus which causes cholera.* 2, *A bacillus which causes typhoid.* 3, *A bacillus found in sewage*
All these are much enlarged



4, *Bacteria from tubercle on white sweet clover, much enlarged.* 5 *and* 6, *Bacteria of lactic acid ferments in ripening of cheese, much enlarged*

LESSON 206

Bacteria

Leading Thought — Bacteria are such small plants that we cannot see them without the aid of a microscope, but they can be planted and will grow. The object of this lesson is to enforce cleanliness.

Method — Experiment A — The bread used for the mold experiment is likely to develop spots of yellow, red, or purple upon it, and cultures from these spots may be used in this lesson as follows: Take some vials, boil them and their corks, and nearly fill them with milk that has been boiled. Take the head of a pin or hairpin, sterilize the point by holding in a flame, let it cool, touch one of the yellow spots on the bread with the point, being careful to touch nothing else, and thrust the point with the bacteria on it into the milk; then cork the vials.

Experiment B — Prepare gelatin as for the table but do not sweeten. Pour some of this gelatin on clean plates or saucers. After it has cooled let one of the children touch lightly the gelatin in one saucer for a few seconds with his soiled finger. Note the place. Ask him to wash his hands thoroughly with soap and then apply a finger to the surface of the gelatin in the other plate. Cover both plates to keep out the dust and leave them for two or three days in a dark place. The plates touched by the soiled finger will show a clouded growth in the gelatin; the other plate will show a few irregular, scattered growths or none.

EXPERIMENT C — Take a slice of boiled potato, place it in a saucer, leave it uncovered for a time or blow dust upon it, label it with the date, then cover it with a tumbler to keep it from drying and place it in a cool, somewhat dark place.

The pupils should examine all these cultures every day and make the following notes:

EXPERIMENT A — How soon did you observe a change in the color of the milk? How can you tell when the milk is full of the bacteria? How do you know that the bacteria in the milk were transplanted by the pin?

EXPERIMENT B — Can you see that the gelatin is becoming clouded where the soiled finger touched it? This is a growth of the bacteria which were on the soiled finger.

EXPERIMENT C — What change has taken place in the appearance of the slice of potato? Are there any spots growing upon it? What is the odor? What makes the spots? Describe the shape of the spots. The color. Are any of them pimple-shaped? Make a drawing of the slice of potato showing the bacteria spots. What are the bacteria doing to the potato? Take a part of the slice of potato with the bacteria spots upon it, and put it in the sunshine. What happens? Compare this with the part kept in the dark.

After this lesson the children should be asked the following questions:

1. Why should the hands always be washed before eating?

2. Why should the fingernails be kept clean?

3. Why should we never bite the fingernails or put the fingers in the mouth?

4. Why should we never put coins in the mouth?

5. Why should wounds be carefully cleansed and dressed at once?

6. Why should clothing, furniture, and the house be kept free from dust?

7. Why should house cleaning be done as far as possible without raising dust?

8. Why are hardwood floors more healthful than carpets?

9. Why is a damp cloth better than a dry duster for removing dust?

10. Why should the prohibition against spitting in public places be strictly enforced?

11. Why should the dishes, clothes, and other articles used by sick persons be kept distinctly separate from those used by well members of the family?

12. Why should food not be exposed for sale on the street?

13. Why, during an epidemic of such a disease as typhoid fever, should water be boiled before drinking?

This habit of looking first at what we call the beauty of objects is closely associated with the old conceit that everything is made to please man: man is only demanding his own. It is true that everything is man's because he may use it or enjoy it, but not because it was designed and "made" for "him" in the beginning. This notion that all things were made for man's special pleasure is colossal self-assurance. It has none of the humility of the psalmist, who exclaimed, "What is man, that thou art mindful of him?"

"What were these things made for, then?" asked my friend. Just for themselves! Each thing lives for itself and its kind, and to live is worth the effort of living for man or bug. But there are more homely reasons for believing that things were not made for man alone. There was logic in the farmer's retort to the good man who told him that roses were made to make man happy. "No, they wa'n't," said the farmer, "or they wouldn't a had prickers." A teacher asked me what snakes are "good for." Of course there is but one answer: they are good to be snakes.

— "THE NATURE-STUDY IDEA,"
L. H. BAILEY

PART IV
EARTH AND SKY

EARTH AND SKY

SUGGESTED READING — *Along the Hill,* by Carroll Lane Fenton; *Autobiography of the Earth,* by John H. Bradley; *The Boys' Book of the Earth,* by Sidney A. Small; *The Earth Changes,* by Jannette M. Lucas; *The First Book of the Earth,* by Harold O. Rugg and Louise Krueger; *Nature and Science Readers,* Edith M. Patch and Harrison E. Howe, Books 3, 4, 5, 6; *Old Mother Earth,* by Kirtley F. Mather; *Our Planet the Earth; Then and Now,* by Lillian Rifkin; *Pathways in Science,* by Gerald S. Craig and Co-authors, Books 2 to 6; *Science Stories,* by Wilbur L. Beauchamp and Co-authors, Books 1, 2, 3; *The Story of a Billion Years,* by W. O. Hotchkiss; *The Story of Earth and Sky,* by Carleton W. Washburne and Heluiz C. Washburne; *The Story of Earthquakes and Volcanoes,* by Gaylord Johnson; *Stories in Stone,* by Willis T. Lee; *The Strange Adventures of a Pebble,* by F. B. Atkinson (Hallam Hawksworth, pseud.); *This Earth of Ours,* by Jean-Henri C. Fabre; *Our Amazing Earth,* by Carroll Lane Fenton; additional references are to be found in the bibliography at the end of this Handbook.

The moving of this sand was probably caused by removal of vegetation. The forest which it seems about to overwhelm may put an end to its further progress in this direction

THE BROOK

Little brook, sing a song of a leaf that sailed along,
Down the golden braided center of your current swift and strong.

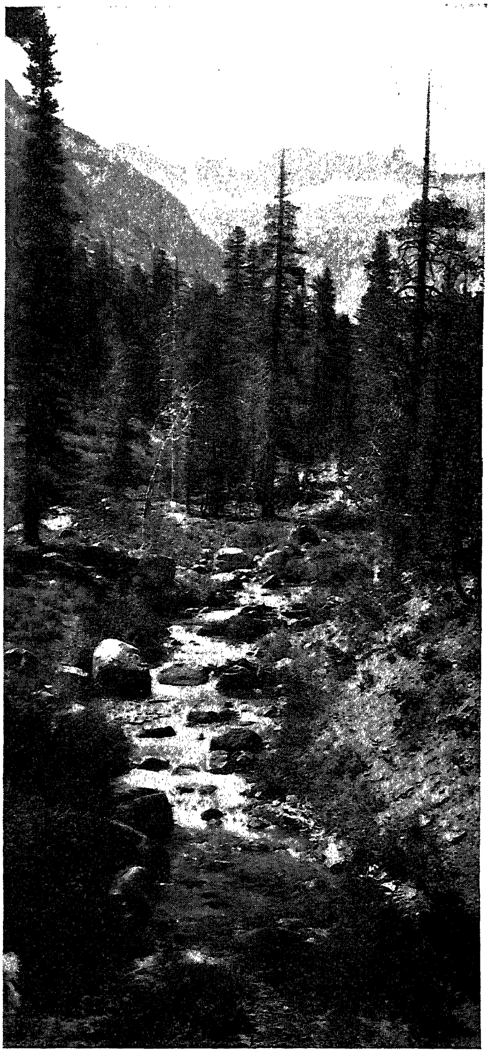
— J. W. Riley

A brook is undoubtedly the most fascinating bit of geography which the child encounters; and yet how few children who happily play in the brook — wading, making dams, drawing out the crayfish by his own grip from his lurking place under the log, or watching schools of tiny minnows — ever dream that they are dealing with real geography. The geography lesson on the brook should not be given for the purpose of making work out of play, but to conserve all the natural interest in the brook, and to add to it by revealing other and more interesting facts concerning the brook. A child who thus studies it will master some of the fundamental facts of physical geography, so that ever after he will know and understand all streams, whether they are brooks or rivers. An interesting time to study a brook is after a rain; and May or October gives attractive surroundings for the study. However, the work should be continued now and then during the entire year, for each season gives it some new features of interest.

Each brook has its own history, which can be revealed only to the eyes of those who follow it from its beginning to where it empties its water into a larger stream or pond. At its source the brook usually is a small stream with narrow banks; not until it receives water from surrounding slopes does it gain enough power to cut its bed deep in the earth. Where it flows with swift current down a hillside, it cuts its bed deeper, because swift-moving water has great power for cutting and carrying away the soil. However, if the hillside happens to be in the woods, the roots of trees or bushes will help to keep the soil from being washed away. Unless there are obstacles, the course of the brook is likely to be more direct in flowing down a hillside than when crossing level fields. The delightful way in which brooks meander across level areas is due to some obstruction, such as a tree, a stone, or a bunch of grass or shrubs, which interferes more with the movement of water on a plain than on a hillside. Gravity, which forever pulls water down a steep slope, acts upon it less forcibly on gently sloping or nearly level lands. After a stream has thus started its crooked course, in time of flood the current strikes with great force on the outside of the curves, thereby cutting them back and making the stream course still more crooked. The places on the banks where the soil is bare and exposed to the force of the current are the points where the banks are cut most rapidly at flood time.

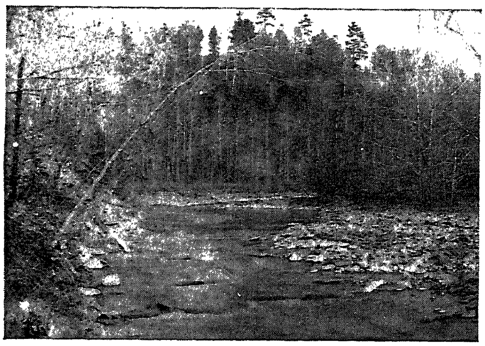
But the brook is not simply an object to look at and admire; it is a very busy worker, its chief labor being that of a digger and carrier. When it is not carrying anything — that is, when its waters are perfectly clear — the stream is doing the least work. The poets, as well as common people, speak of the playing of the brook when its limpid waters catch the sunbeams on their dimpling surface; but when the waters are roily, the brook is working very hard. This usually occurs after a rain, which adds much more water to the volume of the brook; the action of gravity upon this larger volume forces it to flow more swiftly, and every drop in the stream that touches the bank or bottom snatches up a tiny load of earth and carries it along. And every drop thus laden, when it strikes against a corner of the bank, tears more soil loose through the impact, and other drops snatch it up and carry it on down the stream. Thus, after a time there are so many drops carrying loads and bumping along, knocking loose more earth, that the whole brook, which is made up of drops, looks muddy. In its work as a digger, every drop of water that touches the soil at the bottom or on the banks of the brook uses its own little load of earth or gravel as a crowbar or pickaxe to loosen other bits of dirt and gravel; and all the drops hastening on, working hard together, cut the channel of the brook wider and deeper. In some steep places, so many of the drops are working together that they are able to pick up pebbles or stones, with which they batter and tear down larger pieces of the bank and scrape out greater holes in the bottom of the stream. And when the drops have torn loose a rock or a pebble, they do not merely carry it; they pound and grind it with other rocks and pebbles, wearing away its sharp edges and breaking it into smaller and smaller pieces, until it may finally be a rock or a pebble no longer, but only a powder as fine as flour. On and on the brook flows, a gang of workers each of which is using its own load as a tool, all in close procession, and working double quick. But as soon as the brook reaches a plain or level, it slows down and the drops act tired; they have no ambition to pick up more soil, and each lets fall its own load as soon as possible, dropping the larger pieces of gravel and rock first, carrying the finer soil farther, but finally letting that down also. If we examine the sediment of a flooded brook, we find that the gravel is always dropped first, and that the fine mud is carried farthest before it is deposited.

The roar of a flooded stream is very different from the murmur of its waters when they are low. It is not to be wondered at, when we once think of all that is going on in the brook during periods of flood. There are some simple experiments to show what the force of water can do when turned against the soil. Pour water from a pitcher into a bed of soft soil, and note how quickly a hole will be made; if the pitcher is held near the soil, a smaller hole will be formed than if the pitcher is held high up; this shows that



The brook. Its snowbank source, its tools, and its workshop

the farther the water falls, the greater is its force. This explains why the banks of streams are undermined when a strong current is driven against them. The swift current, of course, tears away more earth at bends and curves than when it is flowing in a straight line; for ordinarily, when flowing straight, the current is swiftest in the bed of the stream, and is therefore only digging at the bottom; but when it flows around curves, it is directed against the banks, and therefore has much more surface to work upon. Thus it is that bends are cut deeper and deeper. If the bare arm is thrust into a flooded brook, we find



Even the large stones along the bank were probably brought there by the brook when it was working hard. When it works hard again, it may carry them somewhere else

that many pieces of gravel strike against it; and if we reach the bottom, we can feel the pebbles being moved along over the brook bed.

LESSON 207

The Brook

Leading Thought — The water from the little brook near our school is flowing toward the ocean, and is meanwhile digging out and carrying along with it the soil through which it flows.

Method — The best time to study a brook is after a rain, and October or May is an interesting time for beginning this lesson. The work should be continued during the entire year. It may be done at noon or recess, if the brook is near at hand; or there may be excursions after school, if the brook is at some distance. The observations should be made by the class as a whole.

Observations — 1. Does the brook have its source in a spring or a swamp, or does it receive its water as drainage from surrounding hills? Follow it back to its very beginning. Do you find this in open fields or in woods? Is the land about it level, or does it slope?

2. Are its banks deeper at the beginning, or is the brook at first almost on a level with the surrounding fields? Do the banks become deeper farther from the source? Are the banks higher where the brook flows down hill, or where it is on a level?

3. Is the course of the brook more crooked on a hillside or when it is flowing through a level area? Are the banks more worn away and steep where the brook flows through woods or bushes than where it is flowing through the open fields?

4. Can you find the places where the water is cutting the banks most, when the brook is flooded? Why does it cut the banks at these particular points?

5. Into what stream, pond, or lake does the brook flow? If you should launch a toy boat upon the waters of this brook, and it should keep afloat, through what streams would it pass to reach the ocean? Through what townships, counties, states, or countries would it pass?

6. When is the brook working and when is it playing? What is the difference between the color of the water ordinarily and when the brook is flooded? What causes this difference?

7. Make the following experiment to show what the brook is carrying after a storm when the water is roily. Dip from the swift portion of the stream a glass fruit jar full of water. Place it on a window sill and do not disturb it until the water is clear. How much sediment has settled at the bottom of the jar? Where was this sediment when you dipped up the water? If this quart of water could carry so much soil or sediment, how much, do you think, would the whole brook carry?

8. Where did the brook get the soil to make the water roily? Study its banks in order to answer this question. Do you think the soil in the water came from the banks that are covered by vegetation or from those which are bare?

9. How did the brook pick up the soil

that it carried when it was flooded? Do you think that one of the tools the brook digs with is the current? Try to find a place where the swift current strikes the bank, and note if the latter is being worn away.

10. Does the swift current take more soil where it is flowing straight, or where there are sharp bends? How are the bends in the brook or creek made?

11. Thrust your bare hand or arm into the swift current of the brook when it is flooded. Do you feel the gravel strike against your arm or hand? Wade in the water. As the pebbles are being rolled along the bed of the stream, do you feel them strike against your feet or legs?

12. Does the water, loaded with soil and pebbles, dig into the banks more vigorously than just the water alone could do? Which washes away more earth and carries it downstream — a fast or a slow current?

13. Does the brook flow fastest when its waters are low or high? When the brook is at its highest flood, do you think it is working the hardest? If so, explain why. When it is working the hardest and carrying most soil and gravel, does it make a different sound than when it is flowing slowly and its waters are clear?

14. How does the brook look when it is doing the least amount of work possible?

15. Make a map of your brook showing every pool, indicating the places where the current is swiftest, and showing the bends in its course. To test the rapidity of the current, put something afloat on it and measure how far it will go in a minute.

16. How many kinds of trees, bushes, and plants grow along the banks of your brook? How many kinds of fish and insects do you find living in it? How many kinds of birds do you see frequently near it?

A Brook Puzzle for Pupils to Solve — When we have a load to carry we go slowly because we are obliged to; and the heavier the load, the slower we go. On the other hand, when we wish to run very swiftly we drop the load so as not to be weighted down; when college or high school boys run races in athletic games, they do not wear even their ordinary clothing, but dress as lightly as possible; they also train severely so that they do not have to carry any more flesh on their bones than is necessary. How is it that in the case of a brook just the opposite is true? The faster the brook runs, the more it can carry; and the heavier it becomes the faster it runs; and the faster it runs the more work it can do.

LIFE IN THE BROOK

By any body of water, whether brook, river, pond, lake, canal, or sea, there will be found many kinds of plant and animal life, which constitute a wealth of nature material. The plant life is somewhat different from that which grows far away from bodies of water; the forms of animal life vary with the quantity and condition of the water.

All bodies of water serve as highways, over which not only man but other animals travel from one region to another. Even many birds follow watercourses in their migrations. Plants growing along a watercourse often have their seeds carried by the water and dropped at points many miles downstream. The seeds of plants growing near large bodies of water may be carried by waves to distant shores.

Information about many forms of life occurring in or near water may be found in the parts of this book dealing with plants and animals.

Suggested Reading — *Along the Brook*, by Raymond T. Fuller; also, readings on pages 144 and 400.

In the bottom of the valley is a brook that saunters between oozing banks. It falls over stones and dips under fences. It marks an open place on the face of the

In such a situation may be found many kinds of plant and animal life

earth, and the trees and soft herbs bend their branches into the sunlight. The hangbird swings her nest over it. Mossy logs are crumbling into it. There are still pools where the minnows play. The brook runs away and away into the forest. As a boy I explored it but never found its source. It came somewhere from the Beyond and its name was Mystery.

The mystery of this brook was its changing moods. It had its own way of recording the passing of the weeks and months. I remember never to have seen it twice in the same mood, nor to have got the same lesson from it on two successive days: yet, with all its variety, it always left that same feeling of mystery and that same vague longing to follow to its source and to know the great world that I was sure must lie beyond. I felt that the brook was greater and wiser than I. It became my teacher. I wondered how it knew when March came, and why its round of life recurred so regularly with the returning seasons. I remember that I was anxious for the spring to come, that I might see it again. I longed for the earthy smell when the snow settled away and left bare brown margins along its banks. I watched for the suckers that came up from the river to spawn. I made a note when the first frog peeped. I waited for the unfolding spray to soften the bare trunks. I watched the greening of the banks and looked eagerly for the bluebird when I heard his curling note somewhere high in the air.

— "The Nature-Study Idea,"
L. H. Bailey

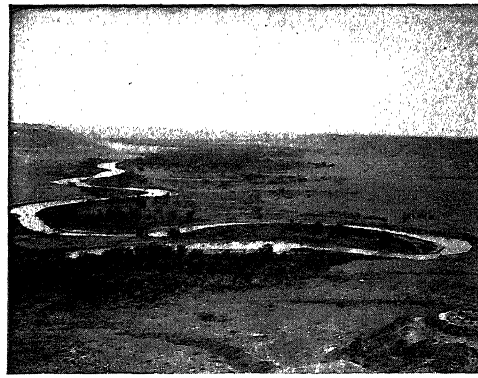
HOW A BROOK DROPS ITS LOAD

The brook is most discriminating in the way it takes up its burdens, and also in the way it lays them down. With quite superhuman wisdom, it selects the lightest material first, leaving the heaviest to the last; and when depositing the load, it promptly drops the heaviest part first. And thus the flowing waters of the earth are eternally lifting, selecting, and sifting the soils on its surface.

The action of rain upon the surface of the ground is in itself an excellent lesson in erosion. If there is on a hillside a bit of bare ground which has been recently cultivated or graded, we can plainly see, after a heavy rain, where the finer material has been sorted out and carried away, leaving the larger gravel and stones. And if we examine the pools in the brook, we shall find deltas as well as many examples of the way the soil is sifted as it is dropped. The water of a rill flowing through pasture and meadow is clear, even after a hard rain. This is owing, not so much to the fact that the roots hold the banks of the brook firmly, as that the grass on the surface of the ground acts as a mulch and protects the soil from the erosive impact of the raindrops. On the other hand, and for a reverse reason, a rill through plowed ground is muddy. On a hillside, therefore, contour plowing is practiced — that is, plowing crosswise the hillside instead of up and down. When the furrow is carried crosswise, the water after showers can not dash away, carrying off in it all the finer and more fertile portions of the soil. There are many instances in our southern states where this difference in the direction of plowing has saved or destroyed the fertility of hillside farms.

The little experiment suggested at the beginning of the following lesson should show the pupils clearly the following points: It is through motion that water takes up soil and holds it in suspension. The tendency of still water is to drop all the load which it is carrying, and it drops the heaviest part first. We find the pebbles at the bottom of the jar, the sand and gravel next, and the fine mud on top. The water may become perfectly clear in the jar and yet, when stirred a little, it will become roily again because of the movement. Every child who wades in a brook knows that the edges and the still pools are more comfortable for the feet than is the center of the stream under the swift current. This is because, where the water is less swift at the sides, it deposits its mud and makes a soft bottom; while under the swifter part of the current, mud is washed away leaving the larger stones bare. For the same reason, the bottom of a stream crossing a level field is soft, because the silt, washed down from the hills by the swift current, is dropped when the waters come to a more quiet place. If the pupils can build across a stony brook a dam that will hold for two or three months in the fall or spring when the brook is flooded, they will be able to note that the stones will soon be more or less covered with soft mud; for the dam, stopping the current, causes the water to drop its load of silt. It would have to be a very recently made pool in a stream which would not have a soft mud bottom. The water at times of flood is forced to the side of the streams in eddies; its current is thus checked, and its load of mud dropped.

It should be noted that at points where the brook is narrowest the current is swiftest, and where the current is swiftest the bottom is more stony. Also, where there is a bend in the stream, the brook digs deeper into the bank where it strikes the curve, and much of the soil thus washed out is removed to the other side of the stream where the current is very slow, and there is dropped. If possible, note that where a muddy stream empties into a pond or lake, the waters of the latter are made roily for some distance out, but beyond this the water remains clear. The pupils should be made to see that the swift current of the brook is checked when its waters empty into a pond or lake, and because of this they drop their load. This happens year after year, and a point extending out into the lake or pond is thus built up. In this manner the great river deltas are formed.



W. G. Pierce, U. S. Geological Survey

A meandering stream. In time of flood, this stream brought down much of the soil of the flood plain through which it wanders

LESSON 208

How a Brook Drops Its Load

Leading Thought — The brook carries its load only when it is flowing rapidly. As soon as the current is checked, it drops the larger stones and gravel first and then the finer sediment. It is thus that deltas are built up where streams empty into lakes and ponds.

Method — Study the rills made in freshly graded soil directly after a heavy rain. Ask the pupils individually to make observations on the flooded brook.

Experiment — Take a glass fruit jar nearly full of water from the brook, add gravel and small stones from the bed of the brook, sand from its borders, and mud from its quiet pools. Have it brought into the schoolroom, and shake it thoroughly. Then place it in a window and ask the pupils to observe the following things:

(a) Does the mud begin to settle while the water is in motion; that is, while it is being shaken?

(b) As soon as it is quiet, does the settling process begin?

(c) Which settles first — the pebbles, the sand, or the mud? Which settles on top — that is, which settles last?

(d) Notice that as long as the water is in the least roily, it means that the soil in it has not all settled; if the water is disturbed even a little it becomes roily again, which means that as soon as the water is in motion it takes up its load.

Observations — 1. Where is the current swiftest, in the middle or at the side of the stream?

2. What is the difference, in the bottom of the brook, between the place below the swift current and the edges? That is, if you were wading in the brook, where would it be more comfortable for your feet — at the sides or in the swiftest part of the current? Why?

3. Does the brook have a more stony bed where it flows down a hillside than where it flows through a level place?

4. Place a dam across your brook where the bottom is stony, and note how soon it will have a soft mud bottom. Why is this?

5. Can you find a still pool in your brook that has not a soft, muddy bottom? Why is this?

6. Does the brook flow more swiftly in the steep and narrow places than in the wide portions and where it is dammed?

7. Do you think if water, flowing swiftly and carrying a load of mud, were to come to a wider or more level place, like a pool or millpond dam, that it would drop some of its load? Why?

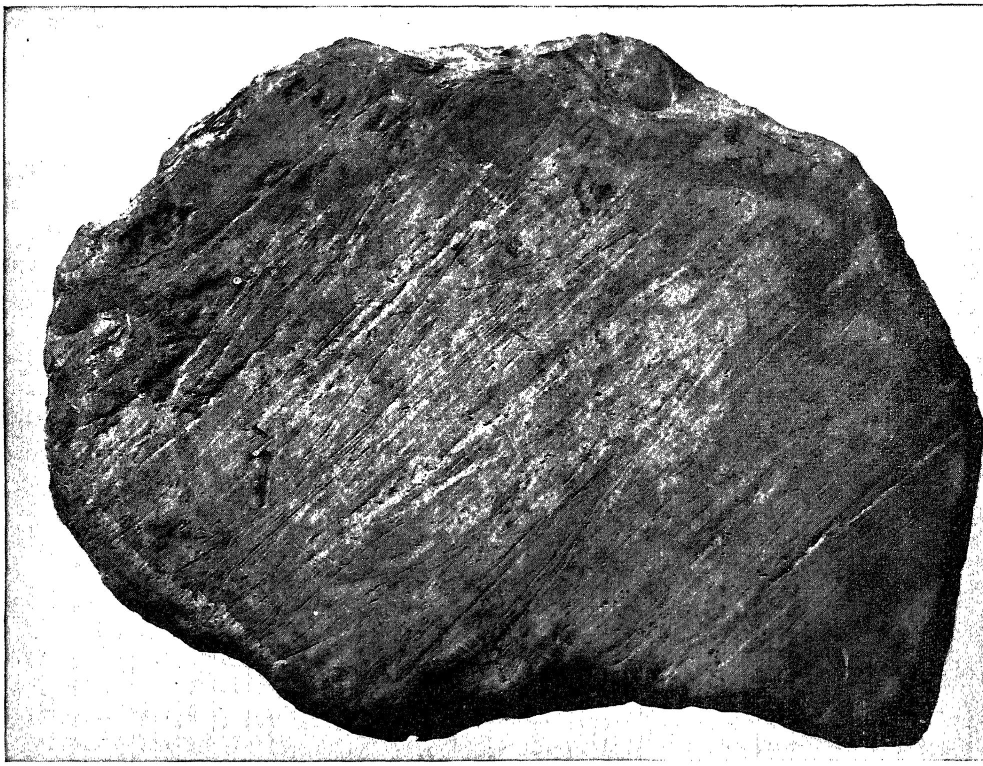
8. If the water flows less swiftly along the edges than in the middle, would this make the bottom below softer and more comfortable to the feet than where the current is swiftest? If so, why?

9. If you can see the place where a brook empties into a pond or lake, how does it make the waters of the latter look after a storm? What is the water of the brook doing to give this appearance, and why?

10. What becomes of the soil dropped by the brook as it enters a pond or lake? Do you know of any points of land extending out into a lake or pond where the stream enters it? What is the delta of a stream?

ROCKS AND MINERALS

REVISED BY H. RIES
Professor of Geology in Cornell University



J. K. Hillers, U. S. Geological Survey

Rock showing glacial striæ — the scratches made by other rocks and gravel carried in the ice

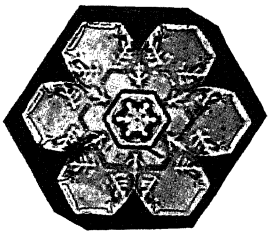
Any brook or stream which you may have observed has doubtless been rolling on its way for countless ages; and, however small and insignificant its appearance, it has probably caused great changes in the countryside through which it flows. Somewhere along its course it may have cut deep gorges; and where it empties into a lake or into another stream, it may have built out great points or sandbars. Through all these years, it has been carrying with it great masses of the materials which it excavates, transports, and redeposits, and it will probably continue to do so for centuries to come.

In a general way, the materials that it carries are of two types, coarse and fine, the first consisting of rocks, pebbles, and sand, and the second of silty and clayey substances. Both of these types, and the brook's way with them, are of great importance to human life.

As we have seen, the brook both picks things up and lays them down. Both these acts are of benefit to man; they have given us, for instance, the rich bottom lands of the Mississippi and Missouri valleys. But they can also be of great harm, for water may carry off the soil which it or some other agency long ago deposited; and when it has done so, centuries will pass before that soil can be replaced.

Many children are naturally interested in stones. The peculiar shapes, odd markings, and colorings of stones attract a child's attention and arouse in him a desire to know more about them.

I once knew two children, aged seven and five, who could almost invariably recognize the different boulders and pebbles of rock which they found scattered over the surface in the region about Ithaca, New York. They also could tell, when the pebbles were broken, which parts were quartz and which mica. They had incidentally asked about one of these stones, and I had told them the story of the glacial period and how these stones were torn away from the mountains in Canada and brought down by glaciers and dropped in Ithaca. It was a story they liked, and their interest in these granite voyagers was always one of the many elements that helped to make our walks in the field delightful.



Photomicrograph by W. A. Bentley

Snow crystal. Many minerals are crystalline in form

The term *mineral* is not generally used in its broadest sense; it really means any substance which is neither plant nor animal. To be specific we will restrict its use to the more limited meaning — "an inorganic substance occurring in nature, having a definite chemical composition, and usually a distinct crystalline form." A *mineral* may also be defined as a single chemical element, or two or more elements chemically combined, forming a part of the earth's crust.

Some eight or ten chemical elements, in various combinations, make up most of our common rock-forming minerals; they are oxygen, silicon, aluminum, iron, calcium, magnesium, sodium, potassium, sulphur, and carbon.

A rock is an aggregation of minerals: it may be made up entirely of a single mineral, as is rock salt; but more often a rock contains two or more minerals. Granite, for example, is composed of feldspar, quartz, and mica, and may contain hornblende.

Suggested Reading — *Along the Hill*, by Carroll Lane Fenton; *The Book of Minerals*, by Alfred C. Hawkins; *Field Book of Common Rocks and Minerals*, by Frederic B. Loomis; *Getting Acquainted with Minerals*, by George L. English; *Story Book of Earth's Treasures*, by Maude F. and Miska Petersham; *The Story of the Minerals*, by Herbert P. Whitlock; also, readings on page 734.

I. ROCKS

Perhaps you have heard someone use the expression "rock bottom" to mean the foundation, base, or beginning of something. The words are very expressive, and have their meaning buried in the earth. When we look out over a lawn, park, field, or even a large body of water, we see the surface and do not stop to think that far beneath are beds of solid rock. We can see exposures of various types of rock in such places as cuts made for highways or railroads, along deeply cut stream banks, in quarries, or sometimes outcropping in the slope of a mountain.

To understand what is meant by the term *rock*, we need to recall what was said in the discussion of minerals. *Rocks are aggregations of minerals, and minerals are composed of elements or chemical combinations of elements.*

The study of rocks is treated under that branch of science called geology. In a textbook on that subject will be found much interesting information on rocks; but for our purposes it seems best to consider only few of the more common rocks, or stones, as they are sometimes called.

It will be well to mention, however, that rocks are divided into three main groups; these divisions are determined by their origin, their position in the earth's crust, and their location in respect to each other. The three groups are *sedimentary rocks*, formed from sediments deposited chiefly by water, sometimes by wind or glaciers; *igneous rocks*, formed by the solidification of molten rock; and *metamorphic rocks*, formed from the other two groups, by processes which produced such changes in them as to warrant placing them in a separate group.

SEDIMENTARY ROCKS

The materials in these rocks are in layers; they were deposited by the water or wind assisted by the force of gravity; they were laid down according to size or weight of individual particles. The materials vary according to the places where they were laid down, such as deserts, river beds, deltas, beaches, or ocean bottoms. (See also The Brook, p. 735.)

If you will put some muddy water in a glass tumbler and watch the mud settle, you will notice that some of the larger particles settle very soon, while some of the finer particles will be held for hours before they are dropped. This simple experiment shows, in a general way, what takes place in a muddy stream. During and after a hard rain, a stream carries much more sediment than at any other time. Some of the finer particles are not dropped until they reach the body of water into which the stream is flowing, and there in quiet water they settle down. Thus sediment may build up deltas or settle on the ocean or lake bottoms.

In the ocean there live many animals which secrete shells, and there are fishes with bony skeletons. When these animals die, their hard parts settle to the bottom, where they are covered with sediment which preserves them. Later, when this sediment has hardened to rock, we find these animal remains preserved as fossils. A plant organism may leave an impression of its form in the sediment, even though the vegetable matter has decayed. The

C. D. Walcott, U. S. Geological Survey

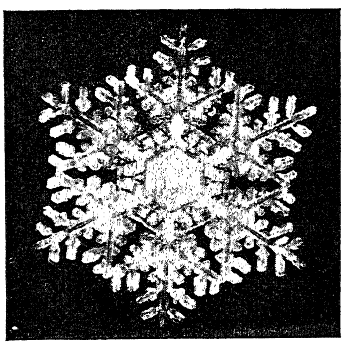
A large piece of sandstone showing the uneven effects of weathering

various kinds of fossils serve as a sort of key or index to aid scientists in determining at what time, in the history of the earth, the particular rock-forming materials were laid down. In shale, a rock formed from old clay beds, we sometimes find footprints of prehistoric animals and impressions of raindrops that fell many ages ago.

Some common examples of sedimentary rock are limestone, shale, and sandstone; even iron ore beds, coal, and rock salt are included in this group.

IGNEOUS ROCKS

These rocks have been formed, by cooling, from materials that have been forced up from the interior of the earth. These materials are in the form of molten lava, which does not always reach the surface before it cools. They do not show assortment and stratification as do sedimentary rocks, but have, instead, a crystalline texture. The size of the grains is determined by the position in which the molten material cooled; the portions cooling at or near the surface of the earth contain smaller crystals than do the materials which cooled more slowly at points far below the surface of the earth. Granite is one of the most common igneous rocks.



Photomicrograph by W. A. Bentley
Snow crystal

GRANITE

In granite, the quartz may be detected by its fracture, which is always conchoidal and never flat; that is, it has no cleavage planes. It is usually white or smoky, and is glassy in luster. It cannot be scratched with a knife. The feldspar is usually whitish or flesh-colored and the smooth surface of its cleavage planes shines brilliantly as the light strikes upon it; it can be scratched with a knife but this requires effort. The mica is in pearly scales, sometimes whitish and sometimes black. The scales of these mica particles may be lifted off with a knife, and it may thus be distinguished. If there are black particles in the granite which do not separate, like the mica, into thin layers, they probably consist of hornblende.

Granite is used extensively for building purposes and for monuments. It is a very durable stone; when polished it endures better than when rough-finished, since the polished surface gives less opportunity for water to lodge and freeze. If granite, by prolonged weathering, is broken down to grains of sand and clay, these may be washed away and carried into lakes or the ocean where they settle down in more or less sorted forms. If the sand grains form a deposit of appreciable size and extent, this becomes a sandstone rock.

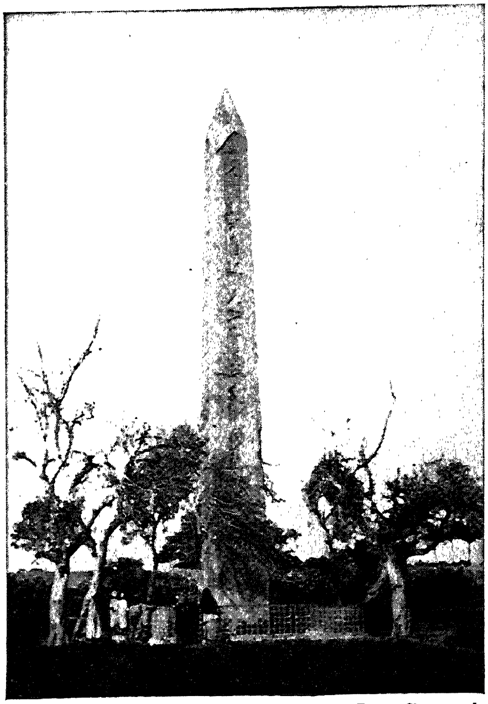
Cleopatra's Needle, which stood for thousands of years in the dry climate of Egypt, soon commenced to weather and crumble when placed in Central Park, New York. The Department of Parks of the City of New York has furnished the following information concerning the treatment given to the monument:

After the obelisk had been standing in its new home about two years, the surface began to chip. In 1885, four years after its erection, a coating of paraffin wax was recommended for its surface. It was found that there were many loose flakes of large size; all such flakes that could be saved were left in place. To have removed these flakes would have damaged the hieroglyphics to a serious degree. Within a few months the entire monument was coated with wax.

In 1893 these areas were treated by pressure to insure that a solid body of paraffin wax would fill all openings and prevent any accidental movement. The flakes are mapped and numbered for the purpose of ascertaining at any time whether they have increased in area or whether new ones have developed. A thorough examination in 1913 showed no further deterioration; but as a precautionary measure a coating of liquid veneer was applied to the surface; this veneer did not penetrate and was soon washed away by the rain.

In 1930, forty-five years after the application of the preservative, no indication could be found of any need for renewing the treatment. The preservative had absolutely stopped and prevented what would have been the rapid disintegration of the oldest and perhaps the most interesting monument in America.

This shaft has a most interesting history. It was quarried near Assuan, in the most famous of all the granite quarries of ancient Egypt. It was cut as a solid shaft in the quarry and carried down the Nile River for 500 miles — an engineering feat which would be hard to accomplish today, with all our modern appliances. It was one of the obelisks that graced the ancient city of On, later called Heliopolis, situated on a plateau near the present city of Cairo; On was the city where Moses was born and reared. One of these obelisks still stands where it was first placed as a part of a magnificent temple, the temple a part of a magnificent city. It now stands alone in the middle of a great fertile plain, which is vividly green with growing crops; a road shaded by tamarisk and lebbakh trees leads to it; nearby is a sakiah, creaking as the blindfolded bullock walks around and around, turning the wheel that lifts the chain of buckets from the well to irrigate the crops; and a hooded crow, whose ancestors were contemporaries of its erection, caws hoarsely as it alights on the beautiful apex of this ancient shaft, which has stood there nearly four thousand years and has seen a great city go down to dust to fertilize a grassy plain.



J. H. Comstock

The granite obelisk still standing on the site of the ancient city of On

LESSON 209

Igneous Rocks: Granite

Leading Thought — Granite is composed of feldspar, quartz, and mica, and often contains hornblende.

Method — Specimens of coarse granite and a pocket knife are needed.

Observations — 1. What minerals do you find in granite? How can you tell what these minerals are? Look at the granite with a lens. How can you tell the quartz from feldspar? Take a knife and scratch the two. Can you tell them apart in that way? How can you tell the mica? How can you tell the hornblende?

2. What buildings made of granite have you seen? What monuments made from it have you seen?

3. What is weathering? Mention some of the characteristics of weathering. Why does the rough-finished granite weather sooner than that which is polished?

4. Examine some sand with a lens. What mineral do you find present in it in the greatest quantity?

5. Write the story of the Cleopatra's Needle in Central Park, New York City.

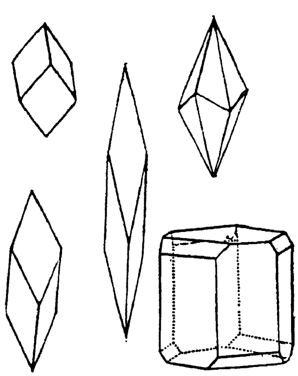
METAMORPHIC ROCKS

Metamorphic means changed; it is therefore to be understood that metamorphic rocks are those rocks whose texture and mineral composition have been changed since they were originally formed as igneous or sedimentary rocks. They may have decayed or they may have been made stronger by the process; but in general the term is used to mean changes that have occurred in rocks as a result of great weight, heat, movement, and pressure, in the presence of water and gases. The depth within the earth's crust at which the process took place determines chiefly which factor was most important in bringing about the change.

Some common metamorphic rocks are slate, formed from clay; marble, from limestone; quartzite, from sandstone; and anthracite coal from soft coal.

CALCITE, LIMESTONE, AND MARBLE

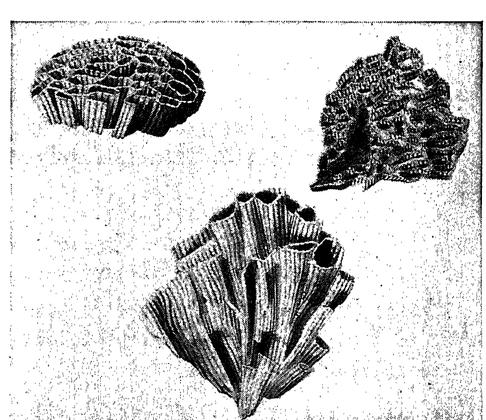
Calcite or calc spar, which is calcium carbonate, is a mineral and is the material of which marble, limestone, and chalk are



Forms of calcite crystals

made. The faces of the calcite crystal are always arranged in groups of three or multiples of three — a three-sided pyramid or two pyramids joined base to base. When acute and formed of three pairs of faces, the crystals are called dogtooth spar. The crystals appear in a great variety of forms, but they all have the common quality of splitting readily in three directions, the fragments forming rhombs. When these cleaved or split pieces are transparent, they are called Iceland spar. When an object is viewed through Iceland spar at least one-quarter inch thick, it appears double. The calcite crystal is often transparent with a slight yellowish tinge, but it also shows other colors; and it has a slightly cloudy or slightly pearly or almost glassy luster like feldspar. It is easily scratched with a knife and will not scratch glass. If a drop of strong vinegar or weak hydrochloric (muriatic) acid is dropped on it, it will effervesce.

Limestone has often been formed on the bottoms of oceans; its substance came chiefly from the skeletons of corals and the shells of other sea creatures, since seashells and coral skeletons are calcium carbonate in composition. In the water, the shells and corals were broken down,



Buffalo Museum of Science

Fossilized Coral: the skeletons of coral animals and then deposited in layers on the bottom of the sea; in addition some carbonate of lime has been precipitated from sea water. Layers of limestone are now being deposited off the shores of Florida, where corals grow in great abundance. Limestone is used extensively for building purposes, and in many climates is very durable. The great pyramids of Egypt are of limestone. It is slowly dissolved in water, especially if the water be acid; thus, in limestone regions, there are caves where the water has dissolved out the rock; and attached to their roofs and piled upon their floors may be large icicle-shaped stalactites and stalagmites, which were made by the lime-bearing water dripping down and evaporating, leaving its burden in crystals behind it. When the roof of a cave falls in, the cavity thus made is called a sink hole and is often dangerous. The famous Natural Bridge in Virginia is all that is left of what was once the roof of such a cavern. Other famous caves are Luray and Mammoth in the East and Carlsbad Caverns of New Mexico. The water of limestone regions is always hard, because of the lime which it holds in solution; and in such regions the streams usually have no silt, but have clean bottoms; moreover, the springs are likely to become contaminated because the water has run through long caves instead of filtering through sand.

Chalk is similar in origin to limestone; it is made up of the shells of minute sea creatures, so small that we can only see them with the aid of a microscope. Try to think how many years it must have required for the shells of such tiny beings to build up the beds which make the great chalk cliffs of England!

Marble is formed inside the earth from limestone, under the influence of heat and pressure; it differs from limestone chiefly in that the grains are of crystalline structure, and are larger; it is usually white or gray in color, and sometimes is found in differing colors. The most famous marbles are the Carrara of Italy, the Parian from the Island of Paros, and the Pentelican from the mountain of that name near Athens. The reason why these marbles are so famous is that in ancient times sculptors carved beautiful statues from them, and the architects used them for building magnificent temples. The principal marble deposits in the United States are in Vermont, Georgia, and Tennessee. Some marbles do not last well when exposed to severe climatic conditions. Marble is also used to make lime. When either marble or limestone is heated very hot, it separates into two parts, one of which is lime, and the other carbonic acid gas — the same that is used for charging soda water.

LESSON 210

Calcite, Limestone, and Marble

Leading Thought — Calcite or calc spar is lime carbonate. The best known forms of its crystals are rhombic; but instead of having twelve right-angled edges, the sides are lozenge-shaped, and are set together with six obtuse angles and six acute. Dogtooth spar is one form of calcite crystal. Limestone is a solid form of calcite. Marble is granular limestone, which is made of crystalline grains of calcite. Chalk is soft, fine-grained limestone.

Method — Specimens of dogtooth spar, limestone, marble, shells of oysters or other sea creatures, and coral should be provided for this lesson; also a bottle of dilute hydrochloric acid, and a piece of glass tubing about six inches long with which to drop the acid on the stones. Some strong vinegar will do instead of the acid.

Marbles which are composed of mineral dolomite, a carbonate of lime and magnesia, will not effervesce with cold acid.

Observations — 1. What is the form of the calcite crystal? What is the luster of the crystal? Is it the same as the inside of sea-shells? Will calcite scratch glass? Can you scratch it with a knife? What happens to calcite if you put a drop of weak hydrochloric acid upon it?

2. Is marble made up of crystals? Examine it with a lens to see. What is its color? Have you seen marble of other col-

ors than white? Do you know the reason why marble is sometimes clouded and streaked?

3. What are the uses of marble? What have you ever seen made from marble? Why is it used for sculpture? What famous statues which were made of marble have you seen? Name some of the famous ancient marble buildings.

4. Test a piece of limestone for hardness. Can you scratch it with a knife? Is it as soft as marble? Put a drop of acid on it. Does it effervesce? If there are any fossils in your piece of limestone, test them with acid and see if they will effervesce. Any other mineral that you have which will effervesce when touched with acid is probably some form of calcite.

5. Are there any buildings in your town made of limestone? How do you know the stone is limestone? Where was it obtained? Is it affected by the weather?

6. Why is water in limestone regions hard? Why are limestone regions likely to have caves within the rocks? How are stalactites and stalagmites formed in caves? What are sink holes? How are they formed? In what county of your state is limestone found?

7. How is the lime which is used for plastering houses made?

8. Write a theme on how the chalk rocks are made.

9. Test a shell with acid; test a piece of coral with acid. How does it happen that these, which were once a part of living creatures, are now limestone? Of what material are the bones of our own bodies made?

A great chapter in the history of the world is written in the chalk. Few passages in the history of man can be supported by such an overwhelming mass of direct and indirect evidence as that which testifies to the truth of the fragment of the history of the globe, which I hope to enable you to read, with your own eyes, to-night. Let me add, that few chapters of human history have a more profound significance for ourselves. I weigh my words well when I assert, that the man who should know the true history of the bit of chalk which every carpenter carries about in his breeches-pocket, though ignorant of all other history, is likely, if he will think his knowledge out to its ultimate results, to have a truer, and therefore a better, conception of this wonderful universe, and of man's relation to it, than the most learned student who is deep-read in the records of humanity and ignorant of those of Nature.

During the chalk period, or "Cretaceous epoch," not one of the present great physical features of the globe was in existence. Our great mountain ranges, Pyrenees, Alps, Himalayas, Andes, have all been upheaved since the chalk was deposited, and the Cretaceous sea flowed over the sites of Sinai and Ararat. All this is certain, because rocks of Cretaceous or still later date, have shared in the elevatory movements which give rise to these mountain chains; and may be found perched up, in some cases, many thousand feet high upon their flanks.

— Thomas Huxley

II. MINERALS

For the pupils in the elementary grades it seems best to limit the study of minerals to those which make up our common rocks. In order to teach about these minerals well, the teacher should have at least one set of labeled specimens. Such a collection may be obtained from a supply house. These collections vary in number of specimens and price. The teacher should have one or two perfect crystals of quartz, feldspar, and calcite. An excellent practice for a boy is to copy these crystals in wood for the use of the teacher.

The physical characteristics used in identifying minerals are briefly as follows:

1. *Form.* This may be crystalline, which shows the shape of the crystals definitely; granular, as in marble, the grains having the internal structure, but not the

external form, of crystals; compact, which is without crystalline form, as in limestone or flint.

2. *Color.*

3. *Luster* or *shine*, which may be glossy like quartz, pearly like the inside of a shell, silky like asbestos, dull, or metallic like gold.

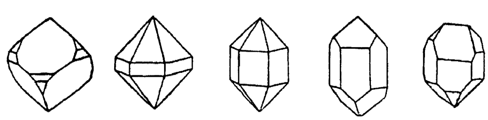
4. *Hardness* or resistance to scratching, thus: easily scratched with the fingernail; cannot be scratched by the fingernail; easily scratched with steel; with difficulty scratched with steel; not to be scratched by steel. A pocket knife is usually the implement used for scratching.

SUGGESTED READING — Page 744.

CRYSTAL GROWTH

To watch the growth of a crystal is to witness a miracle; involuntarily we stand in awe before it, as a proof that of all truths mathematics is the most divine and the most inherent in the universe. The teacher will fail to make the best use of this lesson if she does not reveal to the child through it something of the marvel of crystal growth.

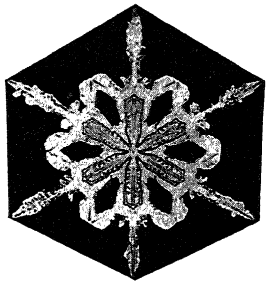
That a substance which has been dissolved in water should, when the water evaporates, assemble its particles in solid form of a certain shape, with its plane surfaces set exactly at certain angles one to another, always the same whether the crystal be large or small, is quite beyond our understanding. Perhaps it is no more miraculous than the growth of living beings, but it seems so. The fact that when an imperfect crystal, unfinished or broken, is placed in water which is saturated with



Forms of quartz crystals

the same substance, it will be built out and made perfect, shows a law of growth so exquisitely exemplified as to again make us glad to be part of a universe so perfectly governed. Moreover, when crystals show a variation in numbers of angles and planes it is merely a matter of division or multiplication. A snow crystal is a six-rayed star, yet sometimes it has three rays.

The window sill of a schoolroom may be a place for the working of greater wonders than those claimed by the alchemists of old, when they transmuted baser metals to gold and worthless stones to diamonds. It may be a place where strings of gems are made before the wondering eyes of the



Photomicrograph by W. A. Bentley

Snow crystal

children; gems fit to make necklaces for any naiad of the brook or oread of the caves.

It adds much to the interest of this lesson if different colored substances are used for the forming of the crystals. Blue vitriol, potassium bichromate, and alum give beautiful crystals, contrasting in shape as well as in colors.

Copper sulphate and blue vitriol are two names for one substance; it is a poison when taken internally and, therefore, it is best for the teacher to carry on the experiment before the pupils instead of trusting the substance to them indiscriminately. Blue vitriol forms an exquisitely beautiful blue crystal, which is lozenge-shaped with oblique edges. Often, as purchased from the drug store, we find it in the form of rather large, broken, or imperfect crystals. One of the pretty experiments is to place some of these broken crystals in a saucer containing a saturated solution of the vitriol, and note that they straightway assert crystal nature by building out the broken places, and growing into perfect crystals. Blue vitriol is used much in the dyeing and in the printing of cotton and linen cloths. It has quite wonderful preservative qualities; if either animal or vegetable tissues are permeated by it, they will remain dry and unchanged.

Copper sulphate solutions have also been effectively used in treating seeds of some farm crops to kill spores which might be present and would later cause smuts or other fungus diseases to develop on the growing crops.

Potassium bichromate is also a poison, and therefore the teacher should make the solution in the presence of the class. It forms orange-red crystals, more or less needle-shaped. It crystallizes so readily that if one drop of the solution be placed on a saucer the pupils may see the formation of the crystals by watching it for a few moments through a lens.

The common alum we buy in crystal form; however, it is very much broken. Its crystals are eight-sided and pretty. Alum is widely used in dyes, in medicines, and in many other ways. It is very astringent, as every child knows who has tried to eat it, and has found the lips and tongue much puckered thereby.

Although we are more familiar with crystals formed from substances dissolved in water, yet there are some minerals, like iron, which crystallize only when they are melted by heat; and there are other crystals, like the snow, which are formed from vapor. Thus, substances must be molten hot, or dissolved in a liquid, or in the form of gas, in order to grow into crystals.

LESSON 211

Crystal Growth

Leading Thought — Different substances when dissolved in water will re-form as crystals; each substance forms crystals of its own peculiar color and shape.

Method — Take three test tubes, long vials, or clear bottles. Fill one with a solution made by dissolving one part of blue vitriol in three parts of water; fill another by dissolving one part of bichromate of potash with twenty-five parts of water; fill another with one part of alum in three parts of water. Suspend from the mouth of each test tube or vial a piece of white twine, the upper end tied to a toothpick which is placed across the mouth of the vial; the other end should reach the bottom of the vial. If necessary tie a pebble to the lower end so that it will hang straight. Place the bottles on the window sill of the schoolroom, where the children may observe what is happening. Allow them to stand for a time, until the string in each case is encrusted with crystals; then pull out the string and the crystals. Dry them with a blotter, and let the children observe them closely. Care should be taken to prevent the children from trying to eat these beautiful crystals, by telling them that the red and blue crystals are poisonous.

Observations — 1. In which bottle did the crystals form first? Which string is the heaviest with the crystals?

2. What was the color of the water in which the blue vitriol was dissolved? Is it as brilliant in color now as it was when it was first made? Do you think that the growth of the crystals took away from the blue material of the water? Look at the blue vitriol crystals with a lens, and describe their shape. Are the shapes of the large crystals of the vitriol the same as those of the small ones?

3. What is the shape of the crystals of the potassium bichromate? What is the color? Are these crystals as large as those of the blue vitriol or of the alum?

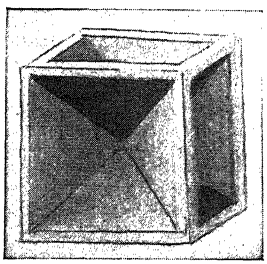
4. What shapes do you find among the crystals of alum?

5. Do you think that vitriol and potassium bichromate and alum will, under favorable circumstances, always form each its own shape of crystal wherever it occurs in the world? Do you think crystals could be formed without the aid of water?

6. How many kinds of crystals do you know? What is rock candy? Do you think you could make a string of rock candy if you dissolved sugar in water and placed a string in it?

SALT

"Saturated solution" is an uninspiring term to one not chemically trained; and yet it merely means water which holds as much as it can take of the dissolved substance; if the water is hot, it dissolves more of most substances. To make a saturated solution of salt we need two parts of salt or a little more, for good measure, to five parts of water; the water should be stirred until it will take up no more salt.



Form of a salt crystal

A slip of paper placed in a saucer of this solution will prove a resting place for the crystals as they form. In about two days the miracle will be working, and the pupils should now and then observe its progress. Those saucers set in a draft or in a warm place will show crystals sooner than others, but the crystals will be smaller; for the faster a crystal grows, the smaller is its stature. If the water evaporates rapidly, the crystals are smaller, because so many crystals which do not have material for large growth are started. When the water is evaporated, to appreciate the beauty of the crystals we should look at them with a lens or microscope. Each crystal is a beautiful little cube, often with a pyramid-shaped depression in each face or side. After the pupils have seen these crystals, the story of where salt is found should be told them.

Salt is obtained by several methods. The more common ones include mining of large deposits of rock salt, evaporation of lake or ocean water which is salty; and the pumping of water down to a salt deposit and thereby dissolving the salt. In the latter case, the salt solution is brought to the surface and evaporated. The oldest salt works in this country were in Syracuse, New York, where the salt was obtained from salt springs which were famous among the American Indians. At Ithaca, New York, the salt deposits are about 2,000 feet below the surface of the earth. Salt is obtained in a number of states, either from wells or through mines. Salt is obtained by evaporating sea water on San Francisco Bay, and from lake water at Salt Lake City. The largest salt mines in the world include those of Germany and Poland; these have been worked for many, many years.

When the United States was first settled, salt was brought over from England; but this was so expensive that people could not afford it, and so they soon began to make their own salt by evaporating sea water in kettles on the beach. In those countries where it is scarce, salt is said to be literally worth its weight in gold. The necessity for salt to preserve the health of both people and animals has tempted the governments of some countries to place a special tax upon it.

Salt lakes are found in natural basins of arid lands, and are always without outlets. The water which runs in escapes by evaporation, but the salt it brings cannot escape, and accumulates. A salt lick is a place where salt is found on the surface of the earth, usually near a salt spring. Animals will travel a long distance to visit a salt lick, which gained its name through their attentions.

LESSON 212

Salt

Leading Thought — Salt dissolves in water, and as the water evaporates the salt appears in beautiful crystals.

Method — Let each pupil, if possible, have a cup and saucer, a square of paper small enough to go into the saucer, and some salt and water. Let each pupil take five teaspoonfuls of water and add to this two spoonfuls of salt, stirring the mixture until it is dissolved. When the water will take no more salt, let each pupil write his name and the date on the square of paper and lay it in the saucer, pressing it down beneath the surface. Let some place their saucers in a warm place, others where they may be kept cool, and others in a draft. If it is impossible for each pupil to have a saucer, two or three pupils may be selected to perform the experiments.

Observations — 1. When you pour the salt into the water, what becomes of it? How do you know when the water will hold no more salt?

2. After a saucer filled with the salt water has stood exposed to the air for several days, what becomes of the water? From which saucers did the water evaporate fastest — those in the warm places, or those in the cold? In which did the crystals form first?

3. Which saucers contained the largest crystals — those from which the water evaporated first, or those from which it evaporated more slowly?

4. Could you see how the crystals began? What is the shape of the perfect salt crystal? Do the smallest crystals have the same shape as the largest ones?

5. What happens to people who cannot get salt to eat?

6. How are dairy salt and table salt obtained? What is rock salt? What are salt licks? Where are the salt mines found? Why is the ocean called "the briny deep"?

7. Name and locate some salt lakes. Why are some lakes salt? Why is the ocean salt?

QUARTZ

Quartz is the least destructible and is one of the most abundant materials in the crust of the earth as we know it. It is made up of two elements chemically united — the solid silicon and the gas oxygen. It is the chief material of most sand and sandstones, and it occurs, mixed with grains of other minerals, in granite, gneiss, and many lavas; it also occurs in the form of veins, and sometimes in crystals ornamenting the walls of cavities in rocks. Subterranean waters often contain a small amount of silica, the substance of quartz, in solution; from such solutions it may be deposited in fissures or cracks in the rock, thus forming bodies called "veins." Other materials are often deposited at the same time, and in this way the ores of the precious metals came to be associated with quartz. Sometimes silica is deposited from hot springs or geysers, forming a spongy substance called geyserite. In this case, some of the water is combined with the silica, making what is called opal. Quartz will cut glass.

Quartz occurs in many varieties: (a) In crystals or masses like glass. If colorless and transparent it is called rock crystal; if smoky brown, it is called smoky quartz; if purple, amethyst. (b) In crystals or masses, glassy but not transparent. If white, it is milky quartz; if pink, rose quartz. (c) As a compact crystalline structure without luster, waxy or dull, opaque or translucent, when polished. If bright red, it is carnelian; if brownish red, sard; if in various colors in bands, agate; if dull red or brown, jasper; if green with red spots, bloodstone; if smoky or gray, breaking with small, shell-like, or conchoidal fractures, flint.

Rock crystals are used in jewelry and especially are made to imitate diamonds. The amethyst is much prized as a semiprecious stone. Carnelian, bloodstone, and agate are also used in jewelry; agate is used also in making many ornamental objects, and to make little mortars and pestles for grinding hard substances.

One of the marvels of the world is the petrified forest of Arizona, now set aside by the government as a national reserve. Great trees have been changed to agate and flint, the silica having permeated the plant tissue so that the texture of the wood is preserved.

When our country was first settled, flint was used to start fires by striking it with steel and letting the sparks fly into dry, fine material, called tinder. It was also used in guns before the invention of cartridges, and the guns were called flintlocks. The Indians used flint to make hatchets and for tips to their arrows. The making of flint implements dates far back into prehistoric times; it was probably one of the first steps upward which man achieved in his long, hard climb from a level with the brute creation to the heights attained by our present civilization.

Quartz sand is used in making glass. It is melted with soda or potash or lead, and the glass varies in hardness according to the minerals added. Quartz is also used for sandpaper; and, ground to a fine powder, it is combined with japans and oils and used as a finish for wood surfaces. Much mineral wool is now made from glass, and is widely used for insulation in the walls of houses. Quartz combined with sodium or potassium and water forms a liquid called water-glass, which is used for waterproof surfaces; it is also fireproof to a certain degree. Water-glass is the best substance in which to preserve eggs; one part of commercial water-glass to ten parts of water makes a proper solution for this purpose.

LESSON 213

Quartz

Leading Thought — Quartz is one of the most common of minerals. It occurs in many forms. As a crystal it is six-sided, and the ends terminate in a six-sided pyramid. It is very hard and will scratch and cut glass. When broken, it has a glassy luster and it does not break smoothly, but shows an uneven surface.

Method — The pupils should have before them as many varieties of quartz as possible; at least they should have rock crystal, amethyst, rose and smoky quartz, and flint.

Observations — 1. What is the shape of quartz crystals? Are the sides all of the same size? Has the pyramid-shaped end the same number of plane surfaces as the sides?

2. What is the luster of quartz? Is this luster the same in all the different colored kinds of quartz?

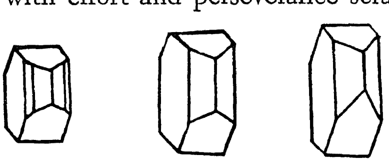
3. Can you scratch quartz with the point of a knife? Can you scratch glass with a corner or piece of the quartz? Can you cut glass with quartz?

4. Describe the following kinds of quartz and their uses: amethyst, agate, flint.

5. How many varieties of quartz do you know? What has quartz to do with the formation of the petrified forests of Arizona?

FELDSPAR

We most commonly see feldspar as the pinkish portion of granite. This does not mean that feldspar is always pink, for it may be the lime-soda form known as labradorite, which is dark gray, brown or greenish brown, or white; or it may be the soda-lime feldspar called oligoclase, which is grayish green, grayish white, or white; but the most common feldspar of all is the potash feldspar — orthoclase — which may be white, nearly transparent, or pinkish. Orthoclase is different from other feldspars in that, when it splits, its plane surfaces form right angles. Feldspar is next in the scale of hardness to quartz, and will with effort and perseverance scratch



Forms of feldspar crystals

glass but will not cut it; it can be scratched with a steel point. Its luster is glassy and often somewhat pearly.

FOSSILS

In very early times fossils were considered more or less as freak relics of an ancient past; but now a fossil may be defined as an organism or anything indicating the former presence of an organism which has been preserved in any natural deposit in or on the earth's crust. In fact, any vestige of life of a former age may be considered a fossil.

The types of fossils vary greatly in their nature and in their completeness. There are instances of animals having been preserved as unaltered remains. *Such is the case of the rare mammoths found in Siberia and the insects caught in the tree resin which we now find as amber.* Petrifactions *are fossils in which some of the original portions of the organisms have been replaced at least in part by a mineral. A* mold *is an interesting type of fossil; it is the impression of a plant or animal left formerly in soft mud. After the body decayed or was removed in some manner the impression still remained and became permanently preserved. A shell formerly buried in rock and later dissolved by water leaves a cavity bearing the shape of the shell; if later that cavity becomes filled with some mineral substance the result is a fossil called a* cast. Trails *of marine animals,* tracks *of dinosaurs, or* burrows *of worms are all considered as fossils.*

The sea is the most favorable place for the burial of organisms; many forms of life are present, much sediment is available to cover the dead bodies, and decay is checked by the salt water. There are few places where good preservation of land animals has been possible; but fossils of land animals have been found in caves, under lava flows, and in swamps; in some instances the bodies have been washed out to sea and preserved there.

By means of fossils man has been able to unravel much interesting earth history. In fact some fossils and combinations of fossils have come to be known as "guide fossils," and these can be used to determine very definitely the geologic age of the rock strata in which they are found. From fossils much can be learned about the factors of the environment in which the plant or animal lived — whether the atmosphere was moist or dry, cool or warm, whether the water was fresh or salty.

1. Hypohippus *skeleton found in rocks in Colorado.*

2. Brachiopods, Lingula. *These soft-bodied animals had two shells not quite equal in size. See No.* 7 *and No.* 9.

3. Crane Fly, Tipula. *We can see that this insect was very similar to the present-day crane fly.*

4. Trilobites, Phacops. *These crustaceans were among the first fossils to attract the attention of naturalists and are used as "guide fossils" in the rock formations of the Cambrian period. The trilobites varied in length from a fraction of an inch to two feet.*

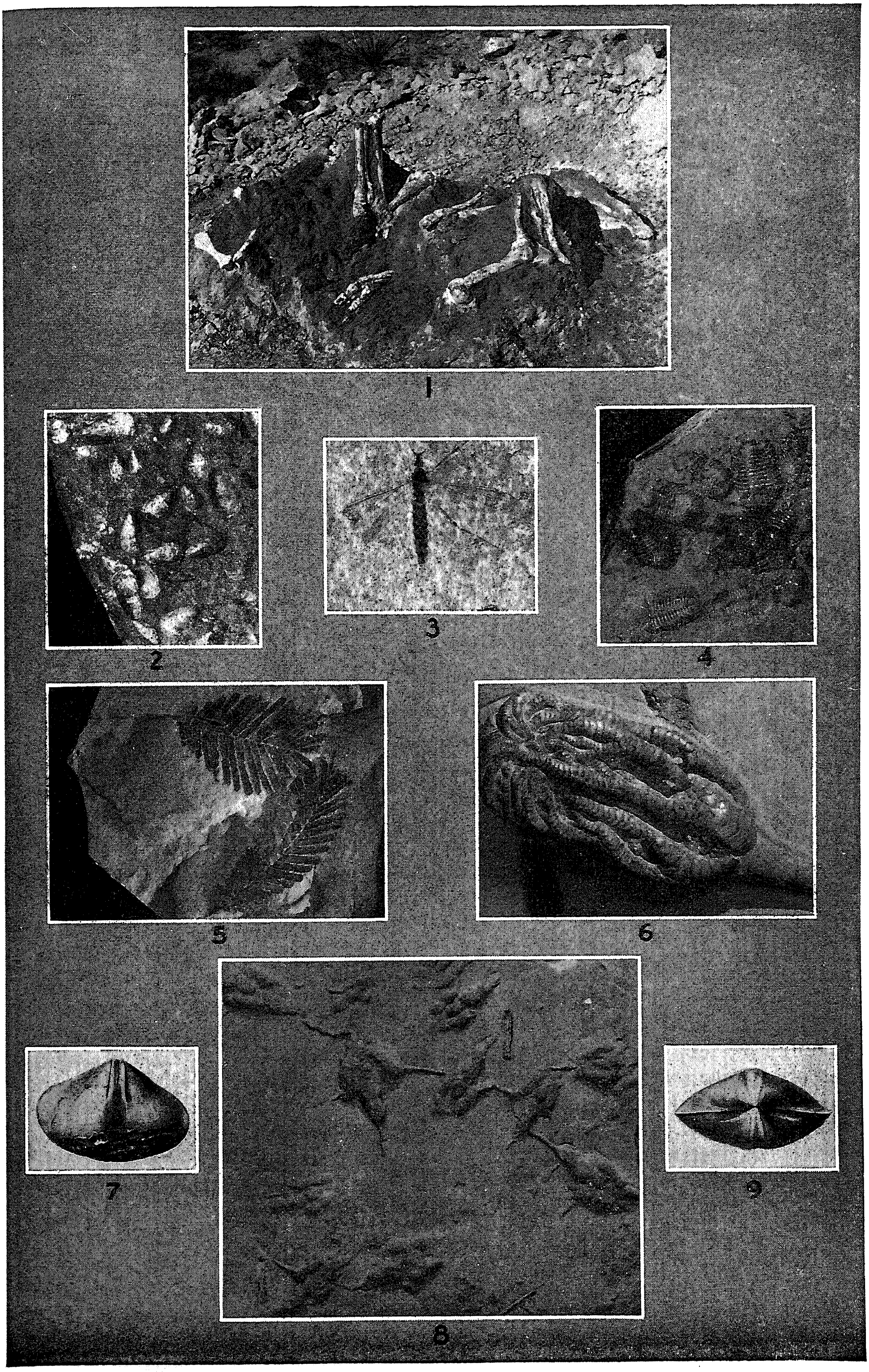
5. Cycads, Otozamites. *These plants were similar to pines and spruces in structure but their palmlike leaves were somewhat on the order of ferns. A few tropical forms of cycads are to be found living today.*

6. Crinoid or Sea Lily, Taxocrinus. *This animal was named from its resemblance to a lily. It had a long stem, at the upper end of which was a cluster of plumelike arms as shown in the picture.*

7 and 9. Brachiopod. *Pictured here are different aspects of this very abundant fossil. The animal has an "upper" and "lower" valve rather than a "right" and a "left" as have the oyster, clam, and mussel. More than* 200 *kinds of living brachiopods are known; but in the Paleozoic time there were more than* 2500 *known forms in what is now North America. They do not move about but are fixed to one place in the sea by a stalk from the lower valve.*

8. Dinosaur Tracks. *These tracks were found on the brownstone of Connecticut Valley; the fossil shown in this picture is in the collection at Amherst College. Dinosaurs were reptiles which ran about on their hind legs as do birds. They were so abundant and were such extraordinary animals that the time in which they lived has been called the Age of Reptiles. These creatures were at least as much diversified in size, form, and adaptations as are the mammals of today. Some had birdlike feet with great claws; others which lived in swampy areas had huge ducklike bills. Still other dinosaurs reached a length of* 60 *feet or more and weighed as much as* 40 *tons.*

Photographs by courtesy of the American Museum of Natural History
and the Buffalo Museum of Science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North Carolina leads all other states in the production of feldspar; but considerable quantities are produced in South Dakota, New Hampshire, and Colorado. It is quarried, crushed, and ground to powder as fine as flour to use with the clay from which china and most kinds of white pottery are made. Kaolin, which has been used so extensively in making the finest porcelain, is the purest of all clays, and is formed of weathered feldspar. Moonstone is clean soda-lime feldspar, whitish in color, and with a reflection something like an opal.

LESSON 214

Feldspar

Leading Thought — Feldspar is an exceedingly common mineral in some rocks. When broken, orthoclase feldspar splits in two directions nearly at right angles to each other, making pieces that are obliquely brick-shaped. It is next in hardness to quartz; it will scratch glass but will not cut it.

Method — If possible have the common feldspar (orthoclase), and some of the less common kinds like oligoclase and labradorite.

Observations — 1. What is the shape of the feldspar crystal?

2. What colors are your specimens of feldspar? How many kinds have you?

3. What is the luster of feldspar?

4. Can you scratch feldspar with the point of a knife? Can you scratch it with quartz? Can you scratch glass with it?

5. When you scratch feldspar with steel what is the color of the streak left upon it?

6. If feldspar is broken, does it break along certain lines, leaving smooth faces? At what angles do these smooth faces stand to each other?

7. How can you tell feldspar from quartz? Write a comparison of feldspar and quartz, giving clearly the characteristics of both.

8. Hunt over the pebbles found in a sand-bank. Which ones are quartz? Do you find any of feldspar?

MICA

The mica crystal when perfect has six sides and flat ends, because it splits very easily at angles to the sides. In color, mica varies through shades of brown, from a pale smoked pearl to black. Its luster is pearly, and it can be scratched with the thumbnail. Its distinguishing characteristic is that the thin layers into which it splits bend without breaking. When mica flakes decay, they take on a golden luster and are frequently mistaken for gold.

Mica was used in antiquity for windows. Because it is transparent and not affected by heat, it has been used in the doors of stoves and furnaces and for lamp chimneys. Powdered mica is the artificial snow that is scattered over cotton batting for the decoration of Christmas trees.

Mica mines are scarce in this country; but the mining of mica is important in North Carolina and New Hampshire. India and Canada are also sources of supply. The entire production of this mineral in the United States for the year 1936 was valued at almost a million dollars. Most of this output was used in the electrical industries, since mica is one of the best insulating materials known.

LESSON 215

Mica

Leading Thought — Mica is a crystal which flakes off in thin scales parallel with the base of the crystal. We rarely see a complete mica crystal but simply the thin plates which have split off. The ordinary mica is light colored, but there is a black form.

Method — If it is not possible to obtain a mica crystal, get a thick piece of mica which the pupils may split off into layers.

Observations — 1. Describe your piece

of mica. Pull off a layer with the point of your knife. See if you can separate this layer into two layers or more.

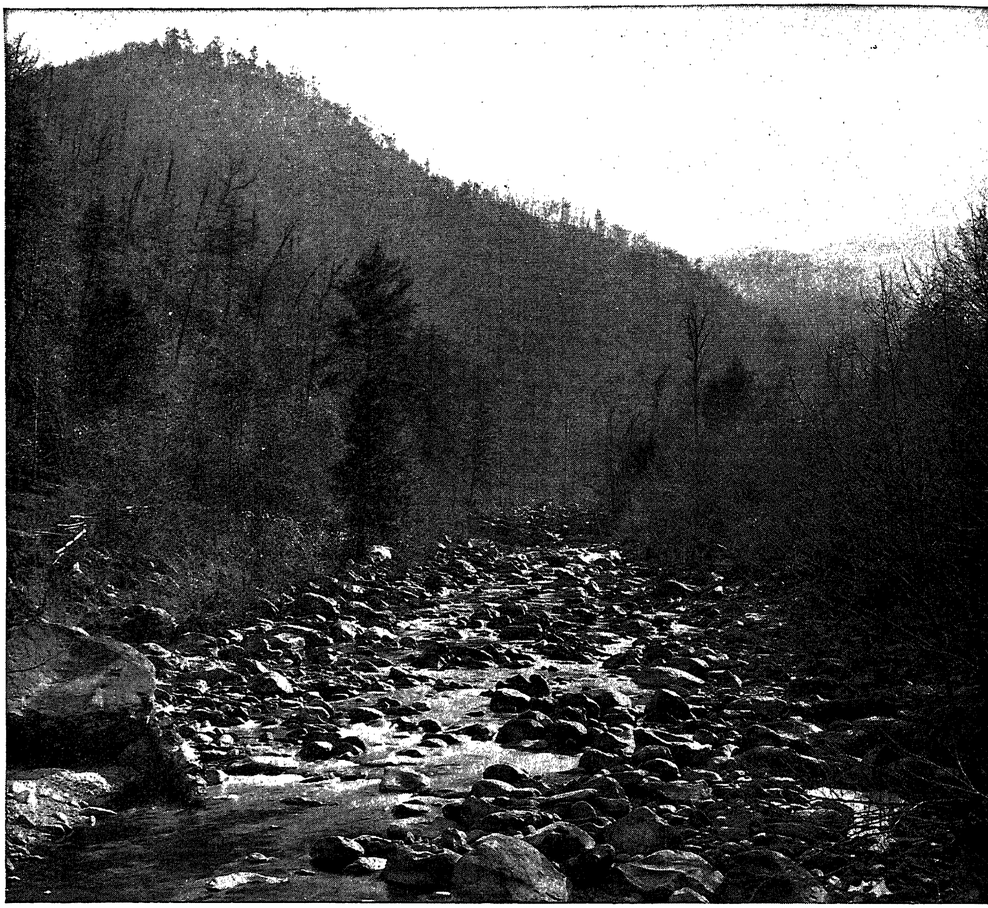
2. Can you see through mica? Can you bend it? Does it break easily? What is the color of your specimen? What is its luster? Can you cut it with a knife? Can you scratch it with the thumbnail? What color is the streak left by scratching it with steel?

3. What are some of the uses of mica? How is it especially fitted for some uses?

4. Write a theme on how and where mica is obtained.

THE SOIL

REVISED BY H. O. BUCKMAN
Professor of Soil Technology, Cornell University

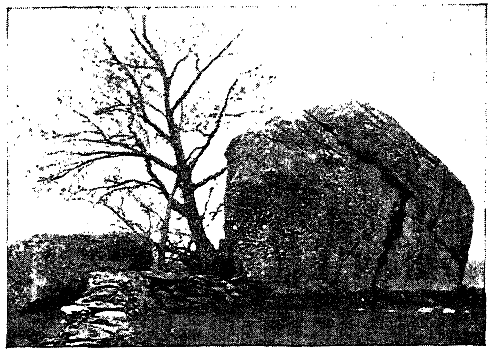


Arthur Keith, U. S. Geological Survey

The brook mill even at low water grinds ceaselessly, sorting out the finer products and carrying them away to serve as soil material

The soil is the sepulcher and the resurrection of all life in the past. The greater the sepulcher the greater the resurrection. The greater the resurrection the greater the growth. The life of yesterday seeks the earth to-day that new life may come from it to-morrow. The soil is composed of stone flour and organic matter (humus) mixed; the greater the store of organic matter the greater the fertility. — JOHN WALTON SPENCER

While the coarser burden of streams is of great consequence, as the preceding sections have shown, the finer materials so carried are of even greater human importance. Few people realize the significance of the soil and the part that it plays in the life of man. Because a child, after making mud pies, is told that his face is dirty, he naturally concludes that soil is mere dirt. But it is only when out of place that soil is dirt; for in place and performing its normal and natural functions, it is the home of miracles — the seat of the intricate chemical and biochemical changes that make possible the nourishment of higher plants on which all animal life depends. The study of soil is a fundamental introduction to agriculture.

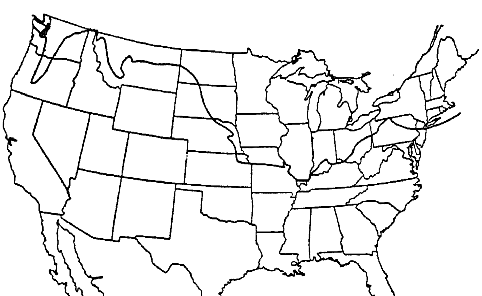


W. C. Alden, U. S. Geological Survey

Boulders, sand, and rock flour were carried southward by the glacial ice. Climatic agencies have since changed the finer of such materials into soils, some of them the most fertile in the United States. Even this great boulder is slowly yielding to the attacks of the weather

Soil Material

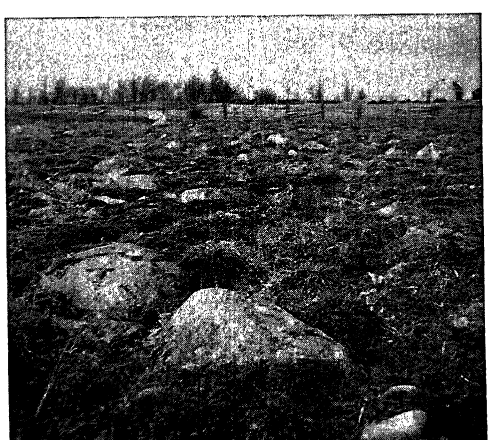
If we should go back to the very beginning, we should find that soil formation is initiated by rock fragments of various kinds — some coarse, some fine, some very fine. In our study of the brook, it was noted that certain stones with sharp corners were just entering the water mill while others had been reduced to gravel, sand, or even rock flour. We saw how this grinding action is done, why it is so effective, and how the mineral grist is sorted and sifted as it is carried along. And finally we saw it deposited ready for the next step in soil formation.



Map of the United States, showing the southern extent of glaciation

It must not be inferred that running water is the only grinding and carrying agency engaged in the preparation of soil material. The United States, north of a line roughly traced by the Ohio and Missouri rivers, was at one time covered by an immense ice sheet that pushed over our lands from the north. This great ice mantle, many hundreds of feet in thickness, scoured the bedrocks, tearing, rending, and grinding, often to the fineness of powder. Millions of tons of rock material, varying in size from boulders to gravel, sand, and clay, were carried southward for miles, often hundreds of miles, finally to be dumped indiscriminately as the ice melted away. Perhaps one-fifth of the United States was covered by such rock debris ready to be changed by weathering agencies into soil.

Soil material, once it is sufficiently fine, is also subject to transportation by wind. In fact, thousands of square miles in our Middle West are covered by such finely divided materials, the result of ancient and violent "dust storms." This silty deposit, often many feet in thickness, is called



Agronomy Dept. Cornell U.

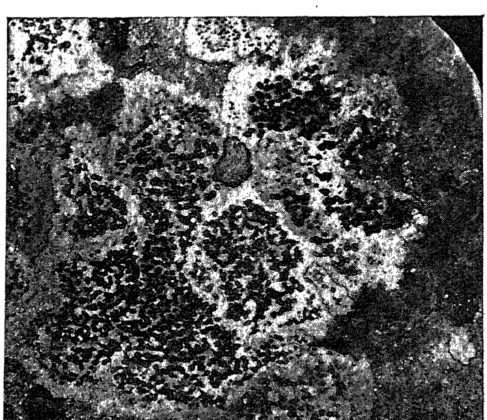
Boulders left by a glacier

A. F. Gustafson

A soil formed by the weathering of the wind-carried "loess" of Illinois. The fertile land on either side is being eroded by the stream

"loess" and has produced some of our most fertile soils.

But there are other agencies besides running water, glacial ice, and restless winds that help grind the bedrock into soil material. If we visit some rocky cliff, we are sure to find at its base heaps of stones, which the geologist calls "talus." These we know were pried loose by temperature changes aided by freezing water — Jack Frost and his ice wedges. This stone-cracking goes on everywhere in regions where the temperature drops below the freezing point, and not only furnishes soil material in place but also aids the scouring of the winds and the grinding, mill-like action of ice and water.

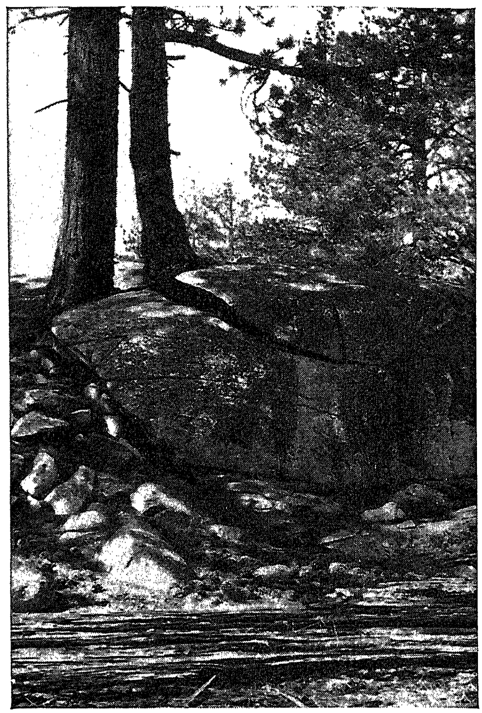


Charles E. Mohr

A common rock lichen, Lecidia albocærulescens

Soil Formation

The mere fining of rock material, whether in place or transported, does not produce a soil; far from it. Other and more complex changes must occur. The action of atmospheric gases, especially oxygen and carbon dioxide, is particularly effective. We know how iron rusts and falls away, and how limestone slowly etches and dissolves. In a similar way rock ma-



G. K. Gilbert, U. S. Geological Survey

A rock split by the roots of a tree. The log in the foreground is also being reduced to soil

terials decompose and form fine earth, the mother substance of our soil.

As this decay progresses another and a very different material gradually appears — organic matter. First, perhaps, lichens gain a foothold on the soil material. Then higher plants appear. And as they die and regenerate, their tissue is left mixed with the decomposing mineral fragments. This organic matter, acted on by bacteria, molds, and other micro-organisms, decays, and "humus," the dark coloring matter of soil, is produced. One of the essential differences between a fertile soil and a mere mass of rock fragments lies in the organic content of the former. This point should be kept constantly in mind, especially when soil productivity is the issue.

Humus intensifies the chemical processes already described, stimulates the life within the soil, and initiates certain biochemical changes essential to higher plants. Gradually the raw soil material supplies a more suitable foothold for higher plants and provides nutrients more abundantly for their growth. Thus a soil is slowly evolved from the lifeless rock and the residues of living matter — a soil that should present, if properly handled, the loose, mellow seed-bed that brings joy to a farmer's heart.

Kinds of Soil

Soils may be divided for convenience into four groups, according to the predominant sizes of mineral particles. Thus we readily recognize "gravel," "sands," "loams," and "clay." Gravel soil is very coarse and not of great value in growing plants. Sand soils are loose and open and easy to till. Water drains through such soil very rapidly and its moisture-holding capacity is usually low. It is likely to be droughty. But when it contains plenty of humus it is a very satisfactory soil, especially for certain vegetables.

Clay soils are sticky and cohesive when wet and are likely to be cloddy when dry. It is often difficult to create a suitable seed-bed on such soils; besides, they drain very slowly. A loam, which combines the desirable properties of both a sand and a clay without their disadvantages, is perhaps the ideal soil for general purposes. Most field soils are loams of some kind.

Suggested Reading — *The Adventures of a Grain of Dust*, by F. B. Atkinson (Hallam Hawksworth, pseud.); also, readings on pages 734 and 770.

LESSON 216

The Soil

Leading Thought — The soil usually is composed of a mixture of different sizes of mineral particles (sand, silt, and clay) with variable amounts of humus depending on circumstances. Soil, to supply most plants satisfactorily, should be well drained and porous so that roots may penetrate it easily, and readily obtain from it sufficient water and nutrients.

Method — The children should bring in as many different samples of soil as possible. Then classify them as gravel, sand, loam, or clay as the case may be. Now try to find some loams that are especially sandy — they should be called "sandy loams." In like manner identify some "clay loams" — that is, soils that contain more fine material than a typical loam but less than a real clay.

Now select a soil that is quite sandy and one that is decidedly clayey. Wet both moderately and knead them with the fingers. Add more water if necessary. Note the differences in the feel and other physical properties. The clay, if rightly selected and properly moistened, should be sticky and plastic. When dry it becomes hard. Try making marbles with this soil. The sand, on the other hand, is hardly sticky at all and a marble made of it usually falls apart when dried. Now the class is ready for further observations.

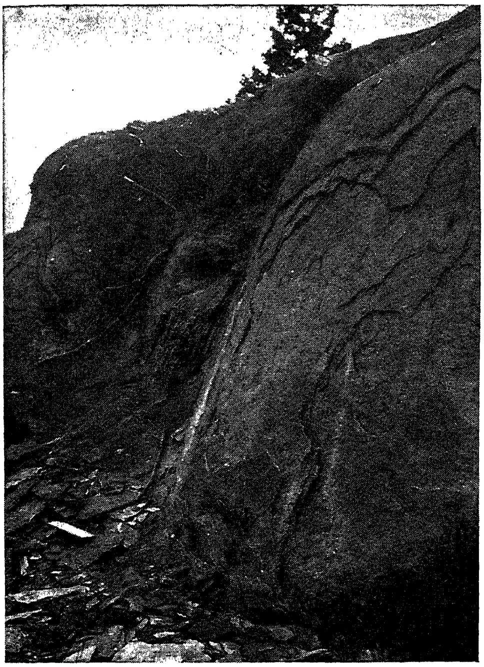
Observations — 1. Examine a sandy soil under a hand lens and tell why you think that it contains different sizes of mineral particles. The more numerous mineral fragments that you see are probably quartz.

2. Examine this soil, or some other soil more suitable, for humus. Humus is quite dark and acts as a coloring matter by coating the sand particles and by mixing with clay. It furnishes plant food and improves the physical condition of soils in which it is present.

3. Compare the sand and the clay that were used to make marbles under the hand lens. Describe the differences most apparent.

4. Take a piece of fresh rock such as shale or soft limestone and pound it into fine pieces. Does the fine material look like soil? Would it grow plants very satisfactorily? In what respects does a soil differ from fresh rock powder?

5. How does water grind up rocks and



G. K. Gilbert, U. S. Geological Survey

Jack Frost is busy here with his ice wedges, flaking, scaling, and cracking the rocks, adding little by little to the talus slope at their base. His effect in the soil itself is even more marked, especially in the spring when freezing and thawing occur in rapid succession

help make soil material? Is the brook a good rock mill?

6. What part does wind perform in supplying soil material? Where is "loess" found?

7. How does Jack Frost take a hand in soil formation? Why are his ice wedges so effective?

8. If there is a cliff or a gorge in your neighborhood, look for the work of Jack Frost. Find a "talus."

9. Have you ever noticed old headstones in a cemetery that are crumbling to pieces or are so worn that the carving can hardly be seen? This is the work of the gases of the air — oxygen and carbon dioxide. Examine such tombstones again carefully. The gases of the air affect soil minerals in just the same way.

10. Find a road cut where a suitable soil is exposed for a considerable depth. The dark surface layer on top is called "surface" soil. Below, extending perhaps to a depth of three feet, is the "subsoil." Underneath is "soil material" and perhaps farther down may be seen "bedrock." Examine the various layers. They show the changes that occur as "soil material" is changed to soil.

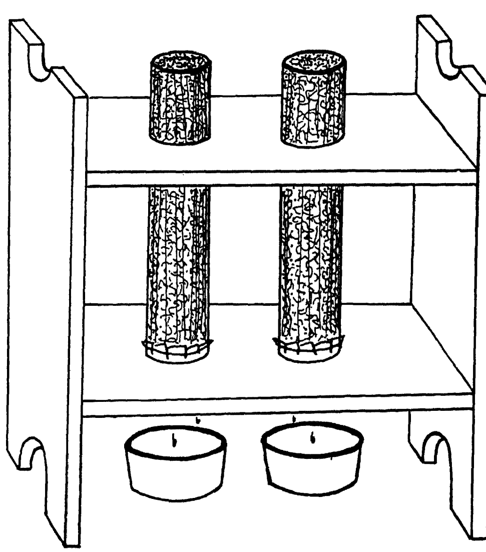
11. Now explain in your own words how soil material is prepared and how it is changed to a fertile soil. This would be a good subject for a short essay.

Experiment 1. *To show what kind of soil drains most readily and which holds the most water.*

Take two straight glass lamp chimneys or pieces of tubing six or eight inches long (see sketch), tie cheesecloth over the bottoms, and trim it neatly. Then fill one with a dry, sandy soil and the other with a fine, dry, clayey one. Compact the soils by jarring. Then set the chimneys (see sketch) so that any water coming through the soils may be caught in glasses or pans.

Now carefully pour water from a measured quantity on the sandy soil just fast enough to keep the soil surface nicely covered. Consult a watch and note how long it takes for the water to run through and drip from the bottom of the column. At this time cease adding water and make note of the total amount of water added.

Do the same with the clay. Compare



Apparatus for Experiment 1

the time necessary for drainage to occur in the two cases.

After water has ceased dripping through the soils, measure the amount caught in each case. Now see if you can determine which soil held more water. Ease of drainage and moisture-holding capacity are both important in a practical way.

Hint to teacher — Water usually passes through sand much more rapidly than through clayey soils. But clayey soils have a much greater water capacity, especially if humus is present in sufficient amounts. To show this difference in moisture capacity the water added and that coming through should be carefully measured.

Sands are well-drained soils, while clays often give difficulty in this respect. This is important in the spring when an early seed-bed is necessary. But clays resist drought better because of their high water capacity. These practical points should be brought out as the object lessons of this experiment.

EXPERIMENT 2. *To show that soil can lift water from below.*

Fill two chimneys as already directed in Experiment 1, but instead of pouring water on the soils, set the chimneys in a shallow pan of water (see sketch). Watch what happens. In which soil does the water rise more rapidly? In which does the water rise higher after several days?

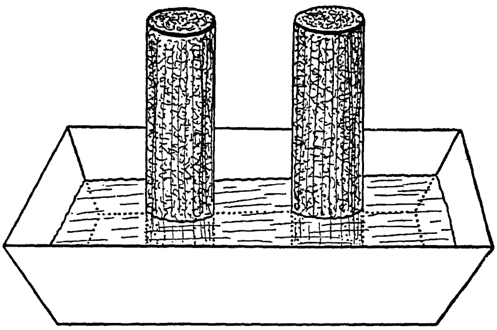
Hint to teacher — Water rises through a sandy soil more rapidly than through a clayey one, but if time enough is given, the upward distance will be greater in the clay. It would seem, therefore, that clay will move water farther for the use of plants and convey more because of its greater moisture capacity. The object of this experiment obviously is to learn the capacity of soils to supply crops with moisture. Apply this thought as practically as possible.

EXPERIMENT 3. *To show the effect of organic matter on the physical condition of a clayey soil.*

Go to the woods, scrape away the surface accumulation of leaves and other undecayed matter, and get some of the dark humus (leaf mold) below. Mix this with the heaviest clay soil that has been collected. Use one part of humus to three parts of clay.

First, take some of the original clay, add water slowly, and work the soil into the very best condition possible for plant growth. Apply just the right amount of water. Treat the soil just as though you were going to pot it and use it for growing plants.

Now work up the humus-treated clay in the same way. Which soil works up better



Apparatus for Experiment 2

and more easily? Compare the two samples. Why should a good supply of organic matter be kept in a field soil? Can you guess how humus affects the water-holding power of soil? Will it lower or raise it?

Hint to teacher — If leaf mold is not available for this exercise, use well decomposed organic matter of any kind. Humus makes soils easier to work and lessens the labor of seed-bed preparation. It also increases the water-holding capacity of soils and renders land less susceptible to drought. These are the practical points that should be stressed in this experiment.

Beside the moist clods the slender flags arise filled with the sweetness of the earth. Out of the darkness — under that darkness which knows no day save when the ploughshare opens its chinks — they have come to the light. To the light they have brought a colour which will attract the sunbeams from now till harvest.

— RICHARD JEFFERIES

Here is a problem, a wonder for all to see.
Look at this marvelous thing I hold in my hand!
This is a magic surprising, a mystery
Strange as a miracle, harder to understand.

What is it? Only a handful of dust: to your touch
A dry, rough powder you trample beneath your feet,
Dark and lifeless; but think for a moment, how much
It hides and holds that is beautiful, bitter, or sweet.

Think of the glory of color! The red of the rose,
Green of the myriad leaves and the fields of grass,
Yellow as bright as the sun where the daffodil blows,
Purple where violets nod as the breezes pass.

Strange, that this lifeless thing gives vine, flower, tree,
Color and shape and character, fragrance too;
That the timber that builds the house, the ship for the sea,
Out of this powder its strength and its toughness drew!

— From "Dust," Celia Thaxter

Some years ago there was received at Cornell University a letter from a boy working upon a farm in Canada. In this letter he said:

"*I have read your leaflet entitled, 'The Soil, What It Is,' and as I trudged up and down the furrows every stone, every lump of earth, every shady knoll, every sod hollow had for me a new interest. The day passed, the work was done, and I at least had had a rich experience.*"

HOW VALUABLE SOIL IS LOST

By A. F. Gustafson
Professor of Soil Technology, Cornell University

Were the soil indestructible and everlasting, as so many people imagine, its study would be of general interest only. Unfortunately, however, our lands are subject to ravages and losses so extensive and far-reaching that not only is their crop producing capacity much reduced but also they oftentimes are threatened with total destruction. Because man formerly did not realize that this was true, he took no steps to prevent such losses; and when he finally became conscious of the danger, much damage had already been done.

Many years ago, when the white man came to this country, he found the eastern part of what is now the United States covered with forest trees. In the central Mississippi Valley area there were forests along many of the larger streams, and tall-growing prairie grasses on the wide open spaces between them. To the westward on the Great Plains, where the rainfall was less, the land was covered with short grasses. In the mountains farther west and along the western coast, trees grew at lower elevations wherever the rainfall was sufficient for them. Thus, in nature, the land was covered, protected, and held in place by vegetation; and that form of vegetation for the growth of which conditions were most favorable predominated.

The trees covered the soil somewhat like leaky umbrellas. Rain fell on the leaves, twigs, and branches; thus the fall of the raindrops was broken and some of the water ran down the branches and trunks of the trees directly into the soil, which held part of it for the use of the trees. Likewise, the rain fell on the prairie grasses and ran down into the soil very much as it did in the forest.

The leaf and twig litter in the forest caught the water, so that much of it could be absorbed by the soil. The old dead grasses on the prairies and plains held water in much the same way. Under both

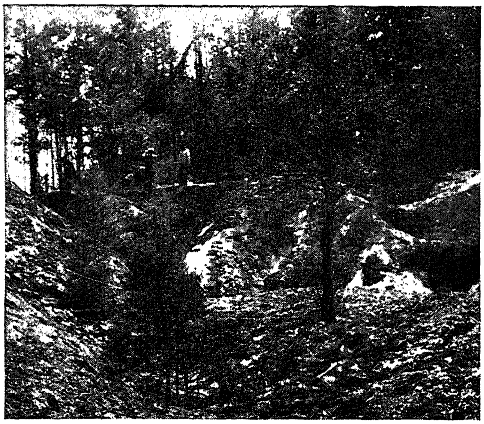
W. C. Mendenhall, U. S. Geological Survey

The work of the wind. Wind erosion is irresistible. The wind has covered forests, farmsteads, and even cities with sand

grass and trees the soil was loose and open. Decaying roots left openings in the soil. The remains of leaves and grasses were broken down by earthworms and other organisms living in the soil; as these animals moved about, they left many openings in the soil. Moreover, the decaying litter kept the soil in a loose condition, and so enabled it to absorb the rain rather rapidly. The litter itself also absorbed considerable water, so that less was lost as run-off to the streams. The old dead grass and the growing grass kept the water from running off until much of the rainfall soaked into the soil. The absorbed rain water came back to the surface of the soil at lower elevations, in the form of springs. During long periods between rains, the springs supplied water for man and for his livestock; the excess, then as now, flowed off to form streams which in turn fed the larger bodies of water.

The white man cut down the forest trees and then plowed the land; a little later he broke the sod on the prairies. Once Nature's protecting cover for the soil was plowed under it soon rotted and was lost. Immediately after the forest was cleared, good yields of wheat, corn, and other farm crops were produced even on rather steep slopes. But when the roots of trees and grasses and the other organic matter in the soil had decayed and disappeared, the supply could not be quickly renewed; and as a result, the soil was no longer loose and open but became hard and closely packed. In this condition it would not readily absorb water, which consequently ran off the fields into the brooks.

When the topsoil was thus left without protection, the raindrops fell directly on the bare surface and churned it into a thin mud. This mud ran down the slopes and filled up the small openings in the soil called pores. In the forest or un-



U. S. Soil Conservation Service (N. C.)

The sides of these old gullies have been seeded and mulched with pine needles; this helps keep the soil moist and encourages the growth of the young seedlings. Vegetation will soon cover the soil and protect it from further washing. Pine trees are usually planted in the mulch

der the prairie grasses these pores and wormholes were loosely covered with litter, and being open they permitted the rain to enter the soil freely. But after cultivation and rains had clogged the openings in the soil, much rain water ran off the sloping fields. It is the running off of this surface water that causes erosion or the loss of soil. In the farmer's sloping, clean-cultivated fields, the water collects

J. S. Cutler, U. S. Soil Conservation Service (Ohio)

Rows of cultivated crops running up and down the slope often permit loss of soil. The stubble in the foreground stopped the wasting of the soil. Strip cropping usually prevents such loss

between the rows, and if these run down hill, much water and soil are lost. As more water runs in one place, it runs faster and faster; this gives it added cutting and carrying power, so that the top soil may be readily carried away. Often slight depressions such as wheel tracks or furrows become rills and even small gullies during a single rain.

Heavy rains cause more loss of soil than do light showers. More soil is lost from steep slopes than from gentle ones. If heavy rain falls on wet soils, they can take up but little of it and most of the rain

W. C. Lowdermilk, U. S. Forest Service

Badly gullied slope, Oak Creek drainage area, California. This washing resulted from the Tehockapi cloudburst, October, 1933. *Note that one of the men in the foreground is up to his waist in one of the smaller gullies*

must run off over the surface. Much more erosion occurs, therefore, if rain falls on wet soil than if it falls on dry soil. Bare soils, clean-cultivated orchard soils, or soils growing cultivated crops such as vegetables, corn, cotton, and tobacco have little protection and suffer greater losses by washing than do soils protected by forests or pasture or hay grasses.

Soils that are well supplied with all of the plant foods and that are in good condition in every way produce large yields. Large yields which are accompanied by a thick thrifty growth help protect and hold the soil. Moreover, soil in good tilth is open and porous and thus takes up rain water, so that less runs off carrying soil and plant food away with it. Water absorbed by the soil is saved for future use; that which runs off the surface causes the erosion. Anything, therefore, that slows down the flow of water over cultivated land checks the loss of soil by erosion.

During dry periods, the finest material in bare soils, especially sandy ones, may be carried away by the wind. It drifts into roads and ditches and onto farmsteads and crops so as to cause untold damage.

U. S. Soil Conservation Service (N. C.)

Sheet erosion and gullies in a North Carolina pasture. Severe sheet erosion usually precedes this type of gullying. Active erosion in places of this sort may usually be checked by means of grass and legumes and woody vines or brushy shrubs. Immediate attention is needed here

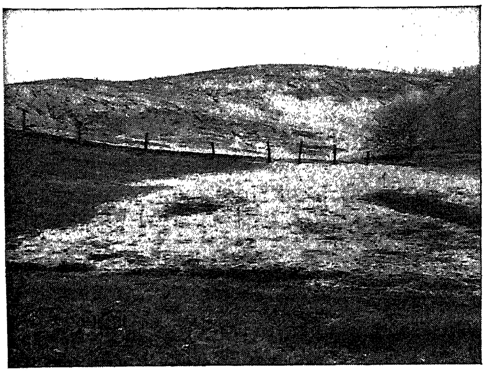
Soil Erosion, an Old Problem

As far back as colonial days, Washington and Jefferson as farmers recognized erosion on their lands in Virginia. Geologists have long believed that soil losses through erosion are so serious as to threaten mankind with starvation at some time in the future. Farmers and workers in experiment stations have recognized the menace of soil erosion for more than half a century; as long ago as 1885 Priestly H. Mangum built on his own North Carolina farm his first terrace, modeled on methods of terracing already in use in Georgia. (For further discussion of the Mangum terrace, as it is called after its inventor, see p. 774.) Bulletins discussing soil erosion were published soon after 1890 in Tennessee and Arkansas.

Not until 1934, however, did the federal government make a systematic attempt to control erosion. In that year the Soil Erosion Service was established in the United States Department of the Interior; it has since been broadened into the Soil Conservation Service and transferred to the Department of Agriculture. Dr. H. H. Bennett was called on to head this service; he was well qualified for this position by his long interest in and experience with soil erosion in the South, and by his recognition of the seriousness of the injury done by erosion to the fertile cotton lands of the South, the corn soils of the Middle West, and the wheat and orchard lands of the Far West.

One of the first tasks confronting the Soil Erosion Service was the making of a survey to learn the extent and seriousness of soil erosion by wind and water throughout the United States. The results of the survey were alarming. It was found that all but 30 per cent of the land area of the United States had been injured by erosion. Of the total area 45 per cent or 855,000,000 acres had lost from one-fourth to three-fourths of the top six inches of soil. Of this depleted portion 10 per cent had lost more than three-fourths of its topsoil. Wind erosion had damaged 233,000,000 acres or 17 per cent of the country. This survey was made in 1934; and, of course, much additional damage has occurred during 1935, 1936, 1937, and 1938; nearly 90,000,000 acres or one-twentieth of the country have been severely damaged or completely destroyed for agriculture by wind erosion. By far the most of the total damage to the soil has been done by the somewhat uniform removal of surface soil, known as sheet erosion; but almost one-half of the country has been damaged by gullying, and on the land actually occupied by gullies, they do greater injury than does sheet erosion; gullies too large to cross with ordinary farm implements make farming difficult and have greatly increased the cost of growing some crops.

SUGGESTED READING — *Conservation in the United States*, by A. F. Gustafson, H. Ries, C. H. Guise, and W. J. Hamilton, Jr.; *Conservation of the Soil*, by A. F. Gustafson; *Little Waters*, by H. S. Person; *The River*, by Pare Lorentz; *Soil Erosion and Its Control*, by Quincy C. Ayres; *Soil Erosion Control*, by Austin E. Burges; also, readings on page 734.



J. S. Cutler, U. S. Soil Conservation Service (Mich.)

The topsoil has all been washed away from the hill shown in the background. Now the under soil is washing down upon good soil and covering it up — a common occurrence in many parts of the United States

LESSON 217

How Valuable Soil Is Lost

LEADING THOUGHT — Soil on a sloping surface that lacks a protecting cover of some type of vegetation is easily washed away. This washing away of soil is called erosion.

METHOD — Erosion may be studied at any time, but perhaps the best time is immediately after a hard rain, in a place where there is some soil that is not covered with a protecting crop.

OBSERVATIONS — 1. When the white man came to our country, what conditions existed in the eastern and western sections? Where did great grassland areas exist?

2. What, in a general way, becomes of much of the rain that falls on land covered by trees or heavy grass? Why is the soil under trees and grass usually loose and open? How do earthworms serve in helping the soil to remain open? See The Earthworm, page 422.

3. Once rain water has been absorbed by the soil, under what conditions may we expect to see it again?

4. Why did the early settlers remove so many forest trees from the land? What changes occurred in the soil after several crops had been produced? Why does worn-out soil become hard and packed together?

5. Why does much of the water that falls on the bare soil of sloping fields run off? What is erosion?

6. Why does more erosion occur if rain falls on soil that is already wet, than if it falls on dry soil? Why do bare fields suffer more loss than do those that are covered by forests or grass? How do trees and grass conserve water and soil?

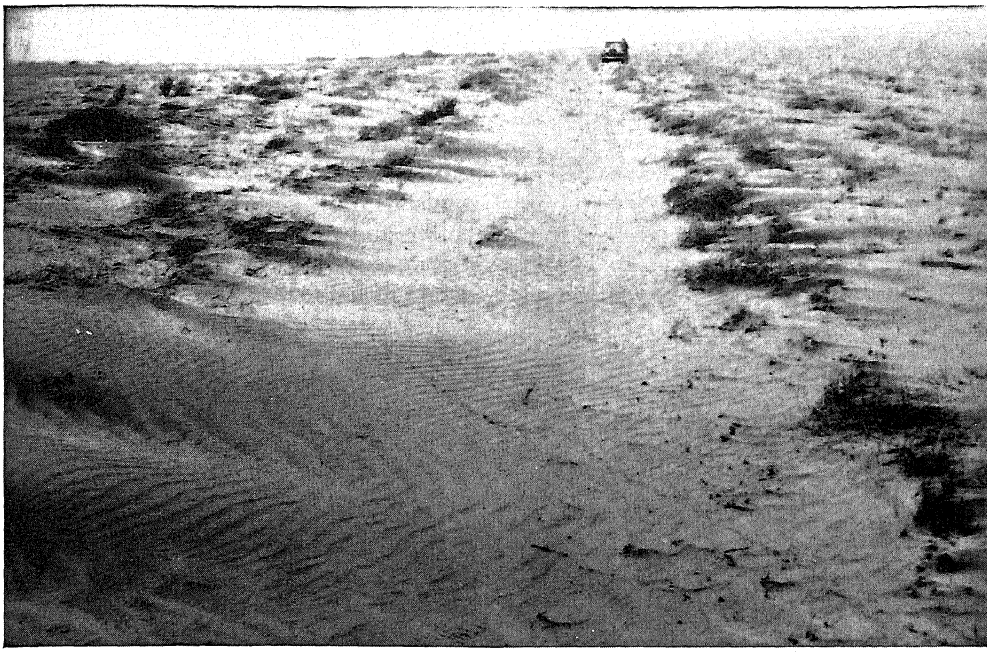
7. How long ago was erosion noticed in our country?

8. What has the federal government done in an effort to control erosion? How much of the land area of the United States has been damaged by erosion? How much has been damaged by wind erosion? In what ways do sheet erosion and gullying differ?

HOW TO CONSERVE OUR SOIL

BY A. F. GUSTAFSON

As already shown, sloping fields on which are grown clean-cultivated farm or garden crops and clean-cultivated orchards or groves are subject to extensive soil erosion, which may result either from rains or from water running off after the



H. A. Daniel, Oklahoma Agricultural Experiment Station

An Oklahoma country road filled with sand after a wind storm in April, 1936. *The grass and weeds hold the sand in drifts*

J. S. Cutler, U. S. Soil Conservation Service (Ohio)

Strip-cropping. On sloping land clean-cultivated crops are alternated with close-growing crops; all are farmed on the contour. This helps to prevent erosion, and to keep water on the land thawing of snow. How may this loss of valuable soil be prevented?

We may learn much about conservation from Nature. Seldom does Nature permit much of the soil to remain bare or exposed long in areas that receive rain enough for fairly good growth of crops. Land that is not under a crop, if not cultivated, is soon covered with weeds and grasses, and these plants help to hold the soil against washing. Grasses, however, give much better protection than do most weeds. In forests, or even in pastures or meadows that are making reasonably good growth, the vegetation protects and holds the soil. Keeping the soil covered and protected by close-growing vegetation, then, is one important way of controlling soil erosion by both wind and water.

W. R. Mattoon, U. S. Forest Service (Tenn.)

Before. Large gully with banks sloped, being planted to black or common locust, oaks, and Japanese honeysuckle vines. The brush dam in the foreground helps to hold soil until the plantings get well started

Of course, we cannot grow cotton, corn, or vegetable crops and at the same time keep the soil covered with grass. We must therefore develop ways and means of managing the land so that it will continue to produce food for man and his livestock and materials for man's clothing. Various methods have been developed and used during the past half-century.

Fertilization. To fertilize the soil to whatever extent is economical for the production of relatively large crop yields is a first step. Thrifty crops protect the soil better, and they leave on it more residue materials such as stalks of corn or cotton, potato tops, and wheat, oat, or barley stubble to protect it somewhat, until such materials are plowed under. These residue materials help to hold the soil together and upon decaying supply plant nutrients for the crops that follow. In some areas, economical fertilization consists of the addition of phosphorus alone, in such forms as superphosphate, basic slag, or rock phosphate; in other areas, especially on sandy soils, potash salts are needed in addition to phosphorus; and vegetables in general require the application of nitrogen as well as phosphorus and potash, or they may require a complete fertilizer.

W. R. Mattoon, U. S. Forest Service (Tenn.)

After. The gully shown in the opposite picture at the end of the first season. In another year or two the plantings will have checked erosion entirely

Growing legumes. In all extensive cropping systems, legumes are needed to help keep up the yield of grain and grass crops. Such legumes as red and alsike clover, alfalfa, lespedeza, and sweet clover can be used. Wherever the soil is too low in lime a dressing of an economical form of lime is needed to enable these legumes to protect the soil and to produce good yields.

Crop rotations. The growing of crops in rotation is usually good farm practice. Rotation means the growing of crops in regular order such as cotton, corn, potatoes, or other vegetable crop the first year, barley, oats, wheat, or other grain crop the second year, and a legume or grass the third year. Grass for hay the fourth year often follows. On lands that wash rather easily, grass for hay for several additional years makes a longer and better rotation. Thus the land is kept in a cultivated crop a smaller proportion of the time than if a three- or four-year rotation is followed.

On land which is steep and easily eroded, long-term meadows or pasture give good protection to the soil and should at the same time provide fair income for such lands. Both meadows and pastures require fertilization, at least with phosphorus and often with lime, in order that they may produce good yields and incidentally that they may provide suitable soil protection.

Planting trees. Steeper, more easily eroded, shallower, and less productive land may well be reforested. Care should be taken to make certain that erosion is brought under control before planting, because several years usually pass before the trees that are planted become large enough to hold the soil in place. Once young trees are well established, however, they afford excellent protection for the soil.

Contour farming. Many advantages accompany the carrying out of all tillage, seeding, and most harvesting operations on the contour, or crosswise on all the main slopes. To begin with, it is easier to plow across than up and down slopes. The crosswise depressions left by the plow catch and hold water until it soaks into the soil. If the soil is well plowed, seed-bed preparation may best be done on the contour,

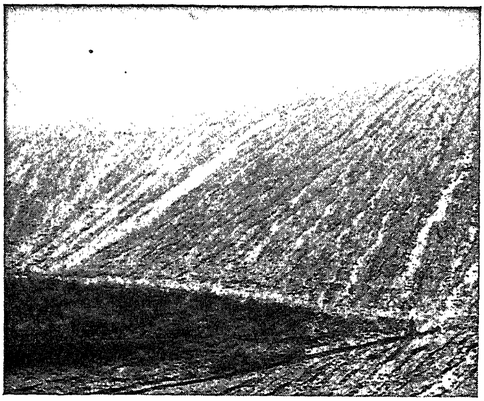
W. R. Mattoon, U. S. Forest Service (Tenn.)

Locusts not only hold the soil, but enrich it; they also produce useful wood

for the same reason that the plowing may best be done in this way.

Seeding crops across the slopes has many advantages. Any depressions and ridges left by seeding implements check the flow of water over the surface and give the soil more opportunity to absorb the water. Up- and downhill cultivation, on the other hand, often leads to heavy loss of soil both by sheet erosion and by gullying. When grains and grasses are seeded on the contour the plants are in rows across the slope. Thus much more water is held by the rows than would have been held if the rows had been seeded up- and downhill.

Contour harvesting is advantageous in that it requires less horse or tractor power than up- and downhill harvesting. Making wheel tracks down slopes should be avoided because these lead to the collec-



W. A. Rockie and P. C. McGrew, Washington Agricultural Experiment Station

One heavy rain caused this washing of soil. Note that the land under grass and shrubs to the left has not lost its productive topsoil

tion of water and often result in gully formation. Contour tillage saves much water for use in dry periods and thus often increases crop yields materially.

Contour strip cropping. Entire slopes are often plowed and planted all at the same time to a clean-tilled crop such as corn or cotton. Rain water falling on the slope collects in low places, and as it passes down over the surface, the streams grow larger and flow faster. Soon they attain great cutting and carrying power. Under these conditions the result of a heavy rain may be gullying as well as severe sheet washing.

Nowadays many long slopes are broken up into a number of strips laid out across the slope so that crop rows are on the level. Grass is alternated with clean-tilled crops on part of the sloping land. On the other land grain is alternated with clover or another legume, thus completing a four-year rotation. Some sheet washing is bound to take place on bare slopes under heavy beating rains, but the grass strips check the current and cause sedimentation. (For a fuller explanation of this process, see the lesson on the brook, p. 736.) The checking of the flow of water by the grass strips thus tends to prevent gully formation. The best width of strip to use varies with such factors as soil, type of rainfall, crops, and the steepness of slope.

Terracing. About 1885, Mr. Priestly H. Mangum, who lived near Wake Forest, North Carolina, after observing the effects of various hillside ditches, developed a terrace with a broad-bottomed channel so laid out as to give the channel a slight slope toward the outlet. The principles developed by Mangum have been extensively adopted: terraces are now usually laid out in accord with a definite plan for the field to be protected. Each terrace has its own channel, which is in fact a hillside ditch. These channels break up long slopes into a number of small watersheds. The water instead of "running off" rapidly in the usual way and causing severe sheet washing and gullying is made to "walk" slowly along the contour of the land.

In parts of the South, strip cropping is practiced on terraced land. One must study all the conditions and then employ such erosion-control measures as will reduce the loss of soil as much as possible and at the same time produce the crops needed by man for himself and his livestock.

Controlling wind erosion. Keeping the soil covered with vegetation, rotating crops, keeping the soil rough rather than

A. F. Gustafson

American beach grass planted on blowing beach sand on Long Island, New York. Even such weeds as the lowly cocklebur in the foreground help hold the soil against blowing smooth, strip cropping and seeding crops across the prevailing wind direction, making furrows across the slopes on the level for holding water, and planting tall crops or trees as windbreaks — all these help to check the blowing away of valuable soil, and the drifting of sands on to crops, roads, and farmsteads. The level furrows hold water that is badly needed for crops. The conservation of water, therefore, produces more plant growth and better cover for the protection of the soil; and, moreover, the water so saved keeps the soil moist longer and thus helps greatly in the control of wind erosion.

LESSON 218

How to Conserve Our Soils

Leading Thought — Soils may be conserved by fertilization and liming, the growing of legumes, rotation of crops, reforestation, contour cultivation, strip cropping, and the building of terraces.

Method — In most sections of the United States, it will be possible for pupils to locate some land that has sufficient slope to show the effects of erosion on bare soil after a hard rain.

Observations — 1. Can you find a clean-cultivated field on a slope that shows any loss of soil particles? What does Nature do to land from which a cultivated crop has been taken? In what way do meadows, pastures, and forests help prevent erosion?

2. In what way can fertilizers applied to the soil influence the amount of erosion that takes place?

3. How may legumes serve in the prevention of erosion?

4. What is meant by rotation of crops? Does this practice have any influence in preventing erosion?

5. If a farmer desires to prevent erosion is it better for him to plow, cultivate, and harvest his fields up- and downhill or on the contour?

6. What is strip cropping? How does this method tend to check erosion?

7. Where did Mr. Priestly Mangum build his first terrace? Describe a Mangum terrace. How do terraces check the rate of flow of run-off water? How does this lessen erosion? What kind of farming can be practiced on terraced land?

8. How can the blowing of soil, or wind erosion, be controlled?

9. Are some methods of control effective for both wind and water erosion?

THE MAGNET

Until comparatively recent times, the power of the magnet was so inexplicable that it was regarded as the working of magic. The tale of the Great Black Mountain Island magnet described in the *Arabian Nights Entertainments* — the story of the island that pulled the nails from passing ships and thus wrecked them — was believed by the mariners of the Middle Ages. Professor George L. Burr assures me that this mountain of lodestone and the fear which it inspired were potent factors in the development of medieval navigation. Even yet, with all our scientific knowledge, the magnet is a mystery. We know what it does, but we do not know what it is. That a force unseen by us is flowing off the ends of a bar magnet, the force flowing from one end attracted to the force flowing from the other and repellent to a force similar to itself, we perceive clearly. We also know that there is less of this force at a point in the magnet halfway between the poles; and we know that the force of the magnet acts more strongly if we offer it more surface to act upon, as is shown in the experiment of drawing a needle to a magnet by trying to attract it first at its point and then along its length. The child likes to demonstrate that this force extends out beyond the ends of the magnet by seeing across how wide a space the magnet, without touching the objects, can draw to it iron filings or tacks. That the magnet can impart this force to iron objects is demonstrated with curious interest, as the child takes up a chain of tacks at the end of the magnet; and yet the tacks when removed from the magnet have no such power of cohesion. That some magnets are stronger than others is shown in the favorite game of "stealing tacks," the stronger magnet taking them away from the weaker; it can also be demonstrated by a competition between magnets, noting how many tacks each will hold.

One of the most interesting things about a magnet is that like poles repel and opposite poles attract each other. How hard must we pull to separate two magnets that have the south pole of one against the north pole of the other! Even more interesting is the repellent power of two similar poles, which is shown by approaching a suspended magnetized needle with a magnet. These attractive and repellent forces are most interestingly demonstrated by the experiment in question 13 of the lesson. These needles floating on cork join the magnet or flee from it, according to which pole is presented to them.

Not only does this power reside in the magnet, but it can be imparted to other objects of iron and steel. By rubbing one pole of the magnet over a needle several times, always in the same direction, we convert the needle into a magnet. If we suspend such a needle by a bit of thread from its center, and the needle is not affected by the nearness of a magnet or other metal, it will soon arrange itself nearly north and south. It is well to thrust the needle through a cork, so it will hang horizontally, and then suspend the cork by a thread. The magnetized needle will not point exactly north, for the magnet poles of the earth do not quite coincide with the poles of the earth's axis.

The direction assumed by the magnetized needle may be explained by the fact that the earth is a great magnet, but the south pole of the great earth magnet lies near the north pole of the earth. Thus, a magnet on the earth's surface, if allowed to move freely, will turn its north pole toward the south pole of the great earth magnet. Then, we might ask, why not call the earth's magnetic pole that lies nearest our North Pole its north magnetic pole? That is merely a matter of convenience for us. We see that the compass needle points north and south, and the arm of the needle which points north we conveniently call its north pole.

The above experiment with a suspended needle shows how the mariner's compass is made. This most useful instrument is said to have been invented by the Chinese at least as early as 1400 B.C., and perhaps even longer ago. It was used by them to guide armies over the great plains, and the needle was made of lodestone. The compass was introduced into Europe about 1300 A.D., and has been used by mariners ever since. To "box the compass" is to tell all the points on the compass dial, and is an exercise which the children will enjoy.

We are able to tell the direction of the lines of force flowing from a magnet by placing fine iron filings on a pane of glass or a sheet of paper and holding one or both poles of a magnet close beneath; instantly the filings assume certain lines. If the two ends of a horseshoe magnet are used, we can see the direction of the lines of force that flow from one pole to the other.

The action of the magnetic force of the earth on the electrons streaming from the sun produces the auroral streamers called Aurora Borealis in North latitudes and Aurora Australis in high Southern latitudes.

Magnets made from lodestone are called natural magnets. A bar magnet or a horseshoe magnet has received its magnetism from some other magnet or from electrical sources. An electromagnet is of soft iron, and is only a magnet when under the influence of a coil of wire charged with electricity. As soon as the current is shut off, the iron immediately ceases to be a magnet.

LESSON 219

The Magnet

Leading Thought — Any substance that will attract iron is called a magnet, and the force which enables it to attract iron is called magnetism. This force resides chiefly at the ends of magnets, called the poles. The forces residing at the opposite ends of a magnet act in opposite directions; in two magnets the like poles repel and the unlike poles attract each other. The needle of the mariner's compass points north and south, because the earth is a great magnet which has its south pole as a magnet near the north pole of the world.

Method — Cheap toy horseshoe magnets are sufficiently good for this lesson, but the teacher should have a bar magnet, also a cheap toy compass, and a specimen of lodestone, which can be procured from any dealer in minerals. In addition, there should be nails, iron filings, and tacks of both iron and brass, pins, darning needles or knitting needles, pens, etc. Each child, during play time, should have a chance to test the action of the magnets on these objects, and thus be able to answer for himself the questions, which should be given a few at a time.

Observations — 1. How do we know that an object is a magnet? How many kinds of magnets do you know? Of what substance are the objects which the magnets can pick up made? Does a magnet pick up as many iron filings at its middle as at its ends? What does this show?

2. How far away from a needle must one end of the magnet be before the needle leaps toward it? Does it make any difference in this respect, if the magnet approaches the needle toward the point or along its length? Does this show that the magnetic force extends out beyond the magnet? Does it show that the magnetic force works more strongly where it has more surface to act upon?

3. Take a tack and see if it will pick up iron filings or another tack. Place a tack on one end of the magnet; does the tack pick up iron filings now? What do you think is the reason for this difference in the powers of the tack?

4. Are some magnets stronger than others? Will some magnets pull the iron filings off from others? In the game of

"stealing tacks," which can be played with two magnets, does each end of the magnet work equally well in pulling the tacks away from the other magnet?

5. Pick up a tack with a magnet. Hang another tack to this one end to end. How many tacks will it thus hold? Can you hang more tacks to some magnets than to others? Will the last tack picked up attract iron filings as strongly as the first next to the magnet? Why? Pull off the tack which is next to the magnet. Do the other tacks continue to hold together? Why? Instead of placing the tacks end to end, pick up one tack with the magnet and place others around it. Will it hold more tacks in this way? Why? If a magnet is covered with iron filings will it hold as many tacks without dropping the filings?

6. Take two horseshoe magnets and bring their ends together. Then turn one over and again bring the ends together. Will they cling to each other more or less strongly than before? Bring two ends of two bar magnets together; do they hold fast to each other? Change ends with one; now do the two magnets cling more or less closely than before? Does this show that the forces in the two ends of a magnet are different in character?

7. Magnetize a metal knitting needle or a long sewing needle by rubbing one end of a magnet along its length twelve times, always in the same direction, *and not back and forth*. Does a needle thus treated pick up iron filings? Why?

8. Suspend this magnetized needle by a thread from some object where it can swing clear, or, better, float a magnetized sewing needle on the surface of a glass of water. When it finally rests, does it point north and south or east and west?

9. Bring one end of a bar magnet or of a horseshoe magnet near to the north end of the suspended needle; what happens? Bring the other end of the magnet near the north end of the needle; what happens?

10. Magnetize two needles so that their eyes point in the same direction when they are suspended. Then bring the point of one of these needles toward the eye of the other; what happens? Bring the eye of one toward the eye of the other; what happens? When a needle is thus magnetized the end which turns toward the north is called the north pole, and the end pointing south is called the south pole.

11. Try this same experiment by thrusting the needles through the top of a cork and floating them on a pan of water. Do the north poles of these needles attract or repel each other? Do the south poles of these needles attract or repel each other? If you place the north pole of one needle at the south pole of the other do they join and make one long magnet pointing north and south?

12. Take a pocket compass; place the north end of one of the magnetized needles near the north arm of the compass needle; what happens? Place the south pole of the needle near the north arm of the compass needle; what happens? Can you tell by the action of your magnet upon the compass needle which end of your magnet is the north pole and which the south pole?

13. Magnetize several long sewing needles by rubbing some of them with the magnet from the point toward the eye and some from the eye toward the point. Take some small corks, cut them in cross sections about one-fourth inch thick, and thrust a needle down through the center of each leaving only the eye above the cork. Then set them afloat on a pan of water. How do they act toward each other? Try them with a bar magnet first with one end and then with the other; how do they act?

14. Describe how the needle in the mariner's compass is used in navigation.

15. Place fine iron filings on a pane of glass or on a stiff paper. Pass a magnet underneath; what forms do the filings assume? Do they make a picture of the direction of the lines of force which come from the magnet? Describe or sketch the direction of these lines of force, when the poles of a horseshoe magnet are placed below the filings. Place two similar poles of a bar magnet beneath the filings; what form do they take now?

16. What is lodestone? Why is it so called?

17. What is the difference between lodestone and a bar magnet? What is an electromagnet?

18. Write an English theme on "The Discovery and Early Use of the Mariner's Compass."

Now, chief of all, the magnet's power I sing,
And from what laws the attractive functions spring;
The magnet's name the observing Grecians drew
From the magnetic regions where it grew;
Its viewless potent virtues men surprise,
Its strange effects they view with wondering eyes,
When, without aid of hinges, links, or springs,
A pendant chain we hold of steely rings
Dropt from the stone — the stone the binding source, —
Ring cleaves to ring, and owes magnetic force:
Those held superior, those below maintain,
Circle 'neath circle downward draws in vain,
Whilst free in air disports the oscillating chain.

— "De Rerum Naturæ," Lucretius, 93–52 B.C.

Suggested Reading — *Discovering Our World*, Book 1, by Wilbur L. Beauchamp, Mary Melrose and Glenn O. Blough; *Easy Experiments in Elementary Science*, by Herbert McKay; *Magnetism and Electricity* (*Living in a World of Science Series*), by Morris Meister; *Science Related to Life*, by Frank Reh, Book 3, *Magnetism and Electricity*.

CLIMATE AND WEATHER

By Wilford M. Wilson
Late Section Director, U. S. Weather Bureau, and Professor of Meteorology in Cornell University.

Lightning flash behind a cloud

The atmosphere, at the bottom of which we live, may be compared to a great ocean of air, about two hundred miles deep, resting upon the earth. The changes and movements that take place in this ocean of air, the storms that invade it, the clouds that float in it, the sunshine, the rain, the dew, the sleet, the frost, the snow, and the hail are termed "weather."

Let us suppose we have just returned from a trip, of two or three months, to some distant part of the country. We can tell of the people we saw, the cities we visited, and the weather we found in the various places; but we cannot tell, from personal experience, about the climate of the places we visited. The weather is the condition of the atmosphere at the moment, while climate is the sum total of weather conditions over a period of several years. One season may be very dry, while another may be very wet, one may be exceedingly cold, and the next may be unusually hot; but climate is a term which includes all of these variations.

A study of weather quite naturally results in a study of climate, since climate includes, in addition to all the regular daily, monthly, seasonal, or annual averages, all the extreme departures from these general conditions. We live in weather; we partake of its moods; we reflect its sunshine and shadows; it invades the everyday affairs of life, influences every business and social activity, and molds the character of nations; and yet nearly everything we know about the weather has been learned within the lifetime of the present generation. Not that the weather did not interest men of early times, but the problem appeared to be so complicated and so complex that it baffled their utmost endeavors.

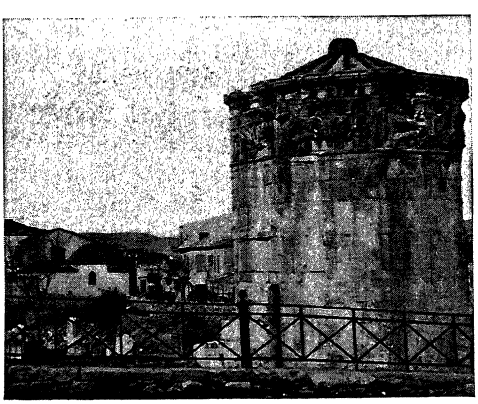
SUGGESTED READING — *A Book about the Weather*, by Charles F. Talman; *Exploring the Upper Atmosphere*, by Dorothy Fisk; *Meteorology*, by Donald S. Piston; *Weather*, by Gayle Pickwell; *Why the Weather?*, by Charles F. Brooks.

THE TOWER OF THE WINDS AT ATHENS

The Tower of the Winds, erected probably before 35 B.C., indicates the knowledge of the weather possessed by the ancient Greeks. This tower is a little octagon, the eight sides of which face the eight principal winds. On each of its eight sides is a human figure cut in the marble, symbolizing the kind of weather the wind from that particular direction brought to Athens.

Boreas, the cold north wind, is represented by the figure of an old man wearing a thick mantle, high buskins (boots), and blowing on a "wreathed horn." Cæcias, the northeast wind, which brought, and still brings to Athens, cold, snow, sleet, and hail, is symbolized by a man with a severe countenance who is holding a dish of olives, because this wind shakes down the olives in Attica.

Apeliotes, the east wind, which brought weather favorable to the growth of vegetation, is shown by the figure of a beautiful youth bearing fruit and flowers in his tucked-up mantle.

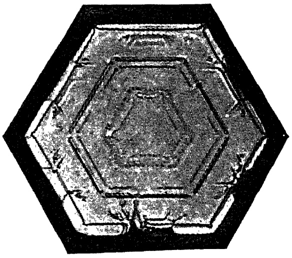


J. H. Comstock

The Tower of the Winds at Athens

Notus, the warm south wind, brought rain, and he is about to pour the water over the earth from the jar which he carries.

Lips, the southwest wind, beloved of the Greek sailors, drives a ship before him,



Photomicrograph by W. A. Bentley

Snow crystal

while Zephyrus, the gentle west wind, is represented by a youth lightly clad, scattering flowers as he goes.

Sciron, the northwest wind, which brought dry and usually cold weather to Athens, is symbolized in the figure of a man holding a vessel of charcoal in his hands, because this wind parched the vegetation. Thus, the character of the weather brought by each separate wind is fixed in stone, and from this record we learn that, even with the lapse of twenty centuries, there has come no material change.

HISTORICAL

There is no record of any rational progress having been made in the study of the weather until about the middle of the seventeenth century, when Torricelli discovered the principles of the barometer. This was a most important discovery and marks the beginning of the modern science of meteorology. Soon after Torricelli's discovery of the barometer his great teacher, Galileo, discovered the thermometer, and thus made possible the collection of data upon which all meteorological investigations are based. About one hundred years after the discovery of the barometer, Benjamin Franklin made a discovery of equal importance. He demonstrated that storms were eddies in the atmosphere, and that they progressed or moved as a whole, along the surface of the earth.

It might be interesting to learn how Franklin made this discovery. Franklin, being interested at that time in astronomy, had arranged with a friend in Boston to take observations of a lunar eclipse at the same time that he, himself, was to take observations at Philadelphia. On the night of the eclipse a terrific northeast wind and rain storm set in at Philadelphia, and Franklin was unable to make any observations. He reasoned, that as the wind blew from the northeast, the storm must have been experienced in Boston before it reached Philadelphia. But imagine his surprise, when he heard from his friend in Boston that the night had been clear and favorable for observation, but that a fierce wind and rain storm set in on the following morning. Franklin determined to investigate. He sent out letters of inquiry to all surrounding mail stations, asking for the time of the beginning and ending of the storm, the direction and strength of the wind, etc. When the information contained in the replies was charted on a map it showed that, at all places to the southwest of Philadelphia, the beginning of the storm was earlier than at Philadelphia, while at all places to the northeast of Philadelphia the beginning of the storm was later than at Philadelphia. Likewise, the ending was earlier to the southwest and later to the northeast of Philadelphia than at Philadelphia. He also found that the winds in every instance passed through a regular sequence, setting in from some easterly point and veering to the south as the storm progressed, then to the southeast and finally to the west or northwest as the storm passed away and the weather cleared.

A further study of these facts convinced Franklin that the storm was an eddy in the atmosphere, that the eddy moved as a whole from the southwest toward the northeast, and that the winds blew from all directions toward the center of the eddy, impelled by what he termed suction.

Franklin was so far in advance of his time that his ideas about storms made little impression on his contemporaries, and so it remained for Redfield, Espy, Loomis, Henry and Maury, and other American meteorologists, a hundred years later, to show that Franklin had gained the first essentially correct and adequate conception of the structure and movement of storms.

During the first half of the nineteenth century, considerable progress was made in the study of storms, principally by American meteorologists, among whom was William Redfield of New York, who first demonstrated that storms had both a rotary and a progressive movement. James Espy followed Redfield in the construction of weather maps, although he had already published much on meteorological subjects before the latter entered the field.

Professor Joseph Henry, secretary of the Smithsonian Institution at Washington, was the first to prepare a daily weather map from observations collected by telegraph. He made no attempt to make forecasts, but used his weather map to demonstrate to members of Congress the feasibility of a national weather service.

An incident occurred during the Crimean War that gave meteorology a great impetus, especially in Europe. On November 10, 1854, while the French fleet was at anchor in the Black Sea, a storm of great intensity occurred which practically destroyed its effectiveness against the enemy. The investigation that followed showed that the storm came from western Europe, and that if there had been adequate means of communication and its character and direction of progress been known, it would have been possible to warn the fleet of its approach and thus afford an opportunity for its protection.

This report created a profound impression among scientific men, and active measures were taken at once, which resulted in the organization of weather services in the principal countries of Europe between 1855 and 1860.

The work of Professor Henry Abbe, and others in this country would, doubtless, have resulted in such an organization in the United States in the early 60's, had not the Civil War intervened, absorbing public attention to the exclusion of other matters. It was not until 1870 that Dr. Increase A. Lapham of Milwaukee, in conjunction with Representative Paine of that city, was able so to present the claims for a national weather service that the act giving birth to the present meteorological bureau in the United States was finally passed by Congress. Dr. Lapham issued from Chicago, Illinois, on November 10, 1871, the first official forecast of the weather which was made in this country.

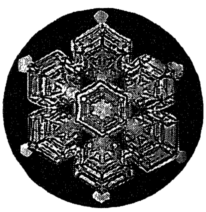
THE ATMOSPHERE

What is known about the atmosphere of our earth has been learned from the exploration of a comparatively thin layer at the bottom. There is reason to believe that the atmosphere extends upward about two hundred miles from the surface of the earth. We have a great mass of observations made at the surface, some on mountains, but few in the free air more than a few miles above the surface. Our knowledge of the upper atmosphere is, therefore, in the nature of conclusions drawn from such observations as are at hand, and is subject to changes and modifications as the facts become known by actual observation. During the past few years a concerted effort has been made in various parts of the world to explore the upper atmosphere by means of balloons, airplanes, and the radio meteorograph; temperature, pressure, and humidity can be recorded each minute. From observations thus obtained much has been learned about the upper atmosphere that was not even suspected before. Some theories have been confirmed and others destroyed, but this line of research, air mass analysis, is gradually bringing us nearer the truth.

The work is being carried on under the direction of the United States Weather Bureau, in co-operation with the United States Army and Navy.

Air as a Gas

Air is not a simple substance, as was once supposed, but is composed of a number of gases, each one of which tends to form an atmosphere of its own, just as it would if none of the other gases were present. The different gases of the atmosphere are not chemically combined but are very thoroughly mixed, as one might mix sugar and salt. Samples of air collected from all parts of the world show that the relative proportion of the gases forming the atmosphere is practically uniform.



Photomicrograph by W. A. Bentley

Snow crystal

The Composition of Air

Dry air is composed chiefly of oxygen and nitrogen. There are, however, small quantities of carbon dioxide, argon, helium, krypton, neon, hydrogen, and xenon, and probably other gases yet to be discovered.

The approximate proportion by volume is as follows: nitrogen 78 parts, oxygen 21 parts, argon 1 part, carbon dioxide .03 part, and krypton, helium, and xenon a trace. Pure dry air does not exist in nature, so there is always present in natural air a variable amount of water vapor, depending upon the temperature and the source of supply. Besides these, which may be termed the permanent constituents of the atmosphere, many other substances are occasionally met with. Lightning produces minute quantities of ammonia, nitrous acid, and ozone. Dust comes from the earth, salt from the sea, while innumerable micro-organisms, most of which are harmless, besides the pollen and spores of plants, are frequently found floating in the atmosphere. Recent investigations in atmospheric electricity lead to the conclusion that electric ions are also present, and perform important functions, especially with respect to precipitation.

Oxygen

Oxygen is one of the most common substances. It exists in the atmosphere as a transparent, odorless, tasteless gas. It combines with hydrogen to form the water of the oceans, and with various other substances to form much of the solid crust of the earth. Chemically, it is a very active gas, and because of its tendency to unite with other substances to form chemical compounds, it is believed that the volume of oxygen now in the atmosphere is less than during the early history of the earth. It supports combustion by combining with carbon and other substances, producing light and heat. It combines with some of the organic constituents of the blood, through the function of respiration, which is in itself a slow process of combustion, and thus supports life and maintains the bodily heat.

Nitrogen

Nitrogen forms the largest proportion of the atmosphere, but unlike oxygen it is a very inert substance, uniting with no element at ordinary temperatures, and at high temperatures with only a few; and when it is so united, the bonds that hold it are easily broken and the gas set free. For this reason, it is utilized in the manufacture of explosives, such as gunpowder, guncotton, nitroglycerine, dynamite, etc. Its office in the atmosphere appears to be to give the air greater weight and to dilute the oxygen, for in an atmosphere of pure oxygen a fire once started could not be controlled. Although nitrogen does not contribute directly to animal life, in that it is not absorbed and assimilated from the air direct as oxygen is, nevertheless it is a very important element of food for both animals and plants, and in combination with other substances forms a large proportion of animal and vegetable tissues.

Carbon Dioxide

Carbonic acid gas, known chemically as CO_2, is a product of combustion. It results from the burning of fuel and is exhaled by the breathing of animals. It also results from certain chemical reactions. The amount in the atmosphere varies slightly, being somewhat greater at night than by day and during cloudy weather than during clear weather. Air containing more than 0.06% of carbon dioxide is not fit to breathe, not because air loaded with carbon dioxide is poisonous, but because it excludes the oxygen and thus produces death by suffocation. It is considerably heavier than air, and in certain localities where it is emitted from the ground, accumulates in low places in such quantities as to suffocate animals. Death's Gulch, a deep ravine in Yellowstone Park, and Dog's Grotto near Naples, are examples. At the latter place, the gas, because it is heavier than air, lies so close to the ground that a man standing erect will have no difficulty in breathing, while a dog will die of suffocation. It also accumulates in unused wells, cisterns, and mines, and can usually be detected by lowering a lighted candle. If carbon dioxide is present in large quantities, the candle will be extinguished because of the lack of oxygen to support combustion.

Photomicrograph by W. A. Bentley

Snow crystal

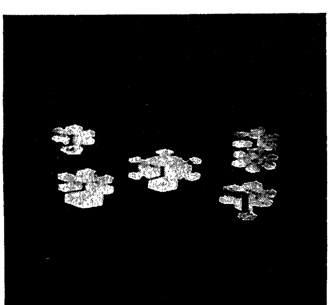
Although carbon dioxide forms but a small proportion of the atmosphere, it is a very important element in plant life. Animals consume oxygen and exhale carbon dioxide, while plants take in carbon dioxide and give off oxygen; thus, the amount of these gases in the atmosphere is maintained at an equilibrium. Plants, through their leaves, absorb the carbon dioxide, which is decomposed by the sunlight, returning the oxygen free into the air, while the carbon is used to build up plant tissue.

Other Gases

Argon, on account of its resemblance to nitrogen, was not discovered until 1894; it was included with the nitrogen in all previous analyses of air. It constitutes about 1% of air by volume. Krypton, neon, and xenon exist in minute quantities and have some interest chemically, but little for the meteorologists. Helium and hydrogen probably exist at great elevations in the atmosphere.

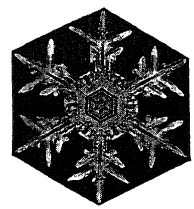
Water Vapor

The vapor of water in the atmosphere varies from about 1% for arid regions to about 5% of the weight of the air for warm, humid regions. It is a little over one-half as heavy as air, and moist air is, therefore, lighter than dry air; but the increase of moisture near the center of cyclones has only a slight effect in reducing the pressure. The amount of vapor decreases very rapidly with elevation, and probably disappears at an elevation of five or six miles above the surface. The amount of water in the form of vapor that can exist in the atmosphere increases with the temperature, being .54 grain Troy per cubic foot at zero temperature and 14.81 at 90°. When the air has taken up all the moisture it can contain at a given temperature it is said to be saturated.



Photomicrograph by W. A. Bentley

Compound snow crystals



Photomicrograph by W. A. Bentley

Snow crystal

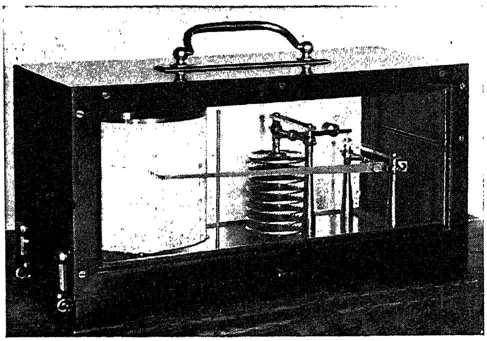
The dewpoint is the temperature at which saturation occurs. If the air is saturated, the temperature of the air and the dewpoint will be the same, but if the air is not saturated the dewpoint will be below that of the air.

Relative humidity is expressed in percentages of the amount necessary to saturate. If the air contains one-half enough vapor to saturate it, the relative humidity will be 50%; if one-fourth enough to saturate, 25%; if saturated, 100%, etc.

The absolute humidity is the actual amount of water in the form of vapor in the air, and is usually expressed by weight in grains per cubic foot or in inches of mercury, the weight of which would counterbalance the weight of the vapor in the air. The conditions present in a volume of saturated air at a temperature of 32° may be expressed as follows: Relative humidity 100%; dewpoint 32°; absolute humidity 2.11 grains per cubic foot or .18 inch.

Pressure of Atmosphere

Although the atmosphere is composed of these various gases, it acts in all respects like a simple, single gas. It is very elastic, is easily compressed, expands when heated and contracts when cooled. It is acted upon by gravity and, therefore, has weight



Weather Bureau, U. S. D. A.

Aneroid barograph

and exerts pressure, which at sea level amounts to about 14.7 pounds on each square inch of the surface. Because it is compressible and has weight, it is more dense at the surface than at any elevation above the surface, and as we ascend in the atmosphere, the weight or pressure decreases in proportion to the weight of that part of the atmosphere left below. The weight or pressure of the atmosphere is measured by means of a barometer and is expressed in terms of inches of mercury. The normal atmosphere at sea level will sustain a column of mercury about thirty inches high, and we therefore say that the normal pressure of the atmosphere is thirty inches. (See the lessons on air pressure and the barometer.)

LESSON 220

Experiments to Show Air Pressure

Leading Thought — The air presses equally in all directions.

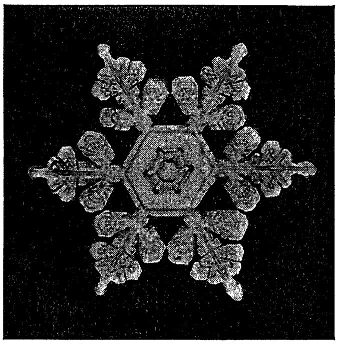
Experiment 1. *To show that air presses upward.*

Fill a tumbler which has an unbroken edge as full of water as possible. Take a piece of writing paper and cover the tumbler, pressing the paper down firmly upon the edge of the glass. Turn the glass bottom side up and ask why the water does not flow out. Allow a little air to enter; what happens? Why? Turn the glass filled with water and covered with paper sidewise; does the water flow out? If not, why?

Experiment 2. *To show that air passes downward.*

Ask some of the boys of the class to make what they call a sucker. This is a piece of leather a few inches across. Through its center a string is drawn which fits very closely into the leather and is held in place by a very flat knot on the lower side. Dampen the leather and press it against any flat surface, and try to pull it off. If possible, place the sucker on a flat stone and see how heavy a stone can be lifted by the sucker. Ask why a sucker clings so to the flat surface. If a little air is allowed to get between the sucker and the stone, what happens? Why?

Hints to the teacher regarding the experiments — The water is kept in the tumbler in Experiment 1 by the pressure of the atmosphere against the paper. If the tumbler is tipped to one side the water still remains in the glass, which shows that the air is pressing against the paper from the side with sufficient force to restrain the water, and if the tumbler is tipped bottom side up it shows the air is pressing upward with sufficient force to keep the water within the glass.



Photomicrograph by W. A. Bentley

Composite snow crystal; high cloud at the center and medium high cloud at the border

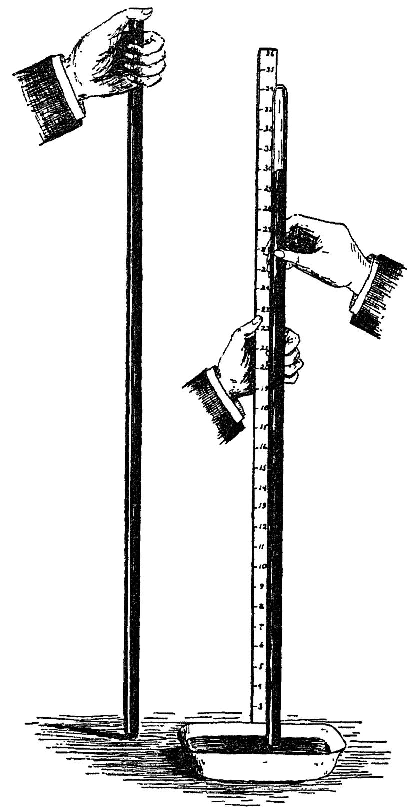
In the case of Experiment 2, we know that the leather pressing upon the floor or on the stone is not in itself adhesive, but it is made wet simply so that it shall press against the smooth surface more closely. The reason why we cannot pull it off is that the air is pressing down upon it with the force of about fifteen pounds to the square inch. If the experiment is performed at sea level, we should be able to lift by the string of the sucker a stone weighing fifteen pounds. The reason why the water falls out of the tumbler after a little air is let beneath the paper is that then the air is pressing on both sides of the paper; and the reason why the sucker will not hold if there is any air between it and the stone is that the air is pressing in both directions upon it.

LESSON 221

Experiment to Show Weight of Air: The Barometer

Leading Thought — The weight of our atmosphere balances a column of mercury about thirty inches high, and is equal to about fifteen pounds to the square inch. This pressure varies from day to day, and becomes less as the height of the place increases. The barometer is an instrument for measuring the atmospheric pressure. It is used in finding the height of mountains, and, to a certain extent, it indicates changes of the weather.

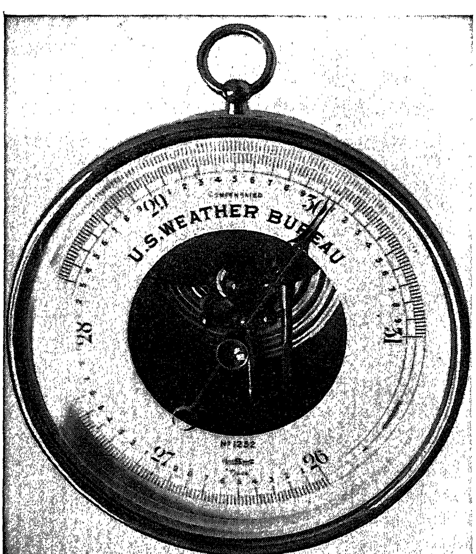
Method — A glass tube about 36 inches long, closed at one end; a little glass funnel about an inch in diameter at the top; a small cup — a bird's bathtub is a good size since it allows plenty of room for the fingers; mercury enough to fill the tube and have the mercury an inch or more deep in the cup. Be careful not to spill the



A barometer made by pupils

mercury in the following process, or you will be as badly off as old Sisyphus with his rolling stone.

Set the closed end of the tube in the empty cup so that any spilled mercury will not be lost; with the help of the funnel slowly and carefully fill the tube clear to the top with the mercury; empty the rest of the mercury into the cup; place the end of one of the fingers of the left hand tightly over the open end of the tube and keep it there; with the right hand invert the tube, keeping the end closed with the finger, and place the hand, finger and all, beneath the mercury in the cup, then remove the finger, keeping the open end of the tube all the time below the surface of the mercury. When the mercury has ceased to fall, measure the distance from



Weather Bureau, U. S. D. A.
Aneroid barometer

Weather Bureau, U. S. D. A.

Valley fog and cirro-stratus clouds seen from Mt. Wilson

the surface in the cup to the top of the mercury in the tube.

OBSERVATIONS — 1. How high is the column of mercury in the tube?

2. What keeps the mercury in the tube? Place the cup and the tube on a table in the corner of the room, place behind the tube a yardstick, and note whether the column of mercury is the same height day after day. If it varies, why?

3. Would the mercury column be as high in the tube if it were placed on top of a mountain as it would at the foot? Why?

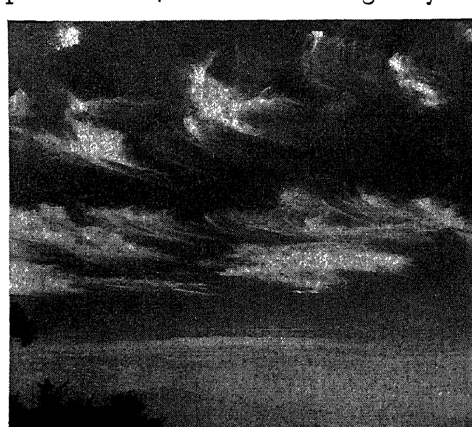
THE HEIGHT OF THE ATMOSPHERE

Atmosphere is the general term applied to the layer of air which surrounds the earth. It is about two hundred miles in height; and it is further divided into *troposphere*, *tropopause*, and *stratosphere*. The troposphere averages about ten miles in height and in it all storms are found. The tropopause is a region just beyond the troposphere, and almost no activity exists there. The stratosphere is the portion extending far out into space; it has no wind and no weather. In the stratosphere all is at rest.

As we have seen, the air near the surface is a mixture of eight gases. These gases are kept from flying off into space by the force of gravity, just as a piece of iron, stone, or a building is held fast to the earth by the same force. Gravity acts with greater force on some things than on others. For example, a piece of iron is pulled down by gravity with greater force than is a piece of wood of the same size; likewise, a piece of lead is pulled down with greater force than a piece of iron. We therefore say that iron is heavier than wood and that lead is heavier than iron, simply because gravity acts with greater force on the one than on the other. The weights of gases differ just as the weights of different solids, such as lead, wood, or iron differ. For instance, nitrogen is 14 and oxygen 16 times heavier than hydrogen.

Gases having the least weight extend upward the farthest, because the lighter the gas the greater its expansive force. Every boy who rides a bicycle takes advantage of the expansive force of air when he pumps his tires. The air is compressed by the pump into the tube and the expansive force exerted by the air in trying to expand makes the tire " stand up." If it requires 10 pounds pressure to compress the gas into the tube, the expansive force will be just 10 pounds.

There are two forces in constant operation on each gas that surrounds the earth, viz., expansive force and gravity. Expansive force pushes the gas up and gravity pulls it down, but the force of gravity de-



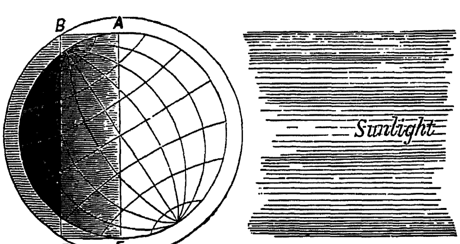
Weather Bureau, U. S. D. A.

Tufted cirrus clouds

creases as the distance from the center of the earth increases, so there is a point at a certain distance above the earth where the two forces just balance each other, and each gas will expand upward to that point but will not rise beyond it. Therefore, if we know the expansive force of a gas and the rate at which gravity decreases, it is possible to calculate the height to which the different gases that compose the air will rise.

In this way it has been determined that carbon dioxide, which is one of the heavier gases, extends upward about 10 miles, water vapor about 12 miles, oxygen about 30 miles, and nitrogen about 35 miles, while hydrogen and helium, the lightest gases known, do not appear at the surface at all, but probably exist at a height of from 30 miles to possibly 200 miles.

There are other ways in which we are able to gain some idea of the approximate height at which there is an appreciable atmosphere. When the rays of light from the sun enter our atmosphere they are broken up or scattered — diffracted — so that the atmosphere is partially lighted for some time before sunrise and after sunset. This is called twilight. If there were no atmosphere, there would be no twilight, and darkness would fall the instant the sun passed below the horizon. Twilight, which is caused by the sun shining on the upper atmosphere, is perceptible until the sun is about 16° below the horizon.

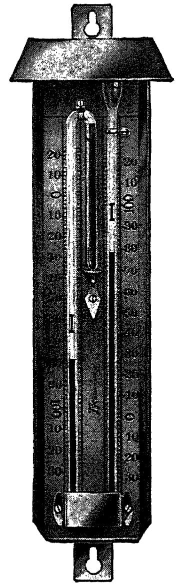


Todd's New Astronomy

The zone of twilight in midwinter

From this it is calculated that the atmosphere has sufficient density at a height of 40 miles to scatter, or diffract, sunlight.

Observations of meteors, commonly called shooting stars, indicate that there is an appreciable atmosphere at a height of nearly 200 miles. Meteors are solid bodies flying with great velocity through space. Occasionally they enter our atmosphere.



Taylor Instrument Companies

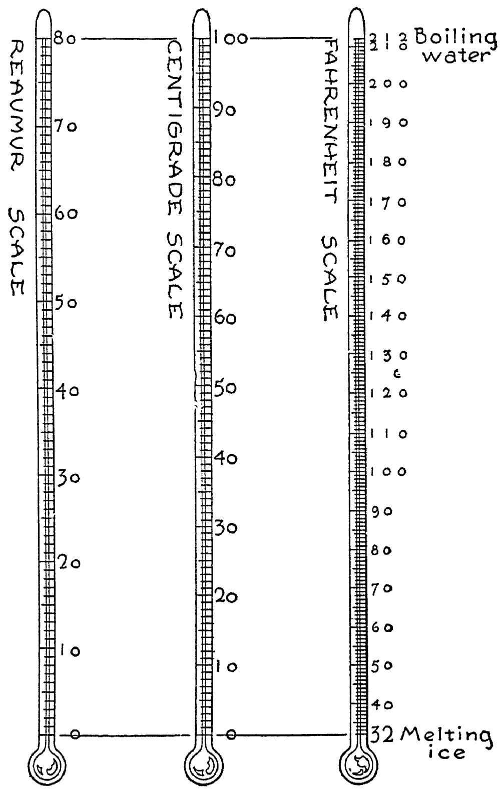
Maximum and minimum thermometer. The index, a miniature glass bottle with a piece of steel wire inside, is left at the highest and lowest points recorded; it can be pulled down with a magnet

Their velocity is so great that the slight resistance offered by the air generates enough heat by friction, or by the compression of the air in the path of the meteor, to make it red hot or to burn it up before it reaches the bottom of the atmosphere. Only the largest meteors reach the earth.

When a meteor is observed by two or more persons at a known distance from each other, and the angle which the line of vision makes with the horizon is noted by each, it is a simple matter to calculate the distance from the earth where the lines of vision intersect, and thus determine the height of the meteor. In this way, reliable observations have given the height at which there is sufficient density in the atmosphere to render meteors luminous as 188 miles.

Temperature of the Atmosphere

The condition of the atmosphere with respect to its temperature is determined by means of the thermometer. This instrument is in such common use that a detailed description is not necessary. It might be interesting to note that the instrument invented by Galileo was very different from those now in use. Galileo's original thermometer was what is know as an air thermometer, and its operation when subjected to different degrees of heat or cold depended upon the expansion and contraction of air instead of mercury or alcohol. It had one serious defect, viz., the length of a column of air is affected by pressure as well as by temperature and it was therefore necessary, when using this thermometer, to obtain the pressure of the atmosphere by means of the barometer before the temperature could be determined. This is obviated in the modern thermometer by the use of mercury or alcohol in a vacuum tube. Mercury is not used when very low temperatures must be registered, because it congeals at about 45 degrees below zero Fahrenheit.



Taylor Instrument Companies

The three standard thermometer scales

Thermometer Scales in Use

There are three systems in common use for marking the degrees on the scale, viz., Fahrenheit, Centigrade, and Reaumur.

The Fahrenheit scale was the invention of a German by that name, but it is worthy of note that this scale is used principally by English-speaking nations and is not in common use in Germany. Fahrenheit found that by mixing snow and salt he was able to obtain a very low temperature, and believing that the temperature thus obtained was the lowest possible he started his scale at that point, which he called zero. He then fixed the freezing temperature of water 32 degrees above this zero, and the boiling point of water at 212 degrees. There are, therefore, 180 divisions or degrees between the freezing and boiling point of water on the Fahrenheit scale.

The Centigrade scale starts with zero at the freezing point of water and makes the boiling point 100. Thus 180 degrees on the Fahrenheit scale equal 100 degrees on the Centigrade. The Fahrenheit degree is, therefore, only a little more than half as large, to be exact five-ninths of a degree, as a degree on the Centigrade scale. The Centigrade scale is in common use in France and is used almost exclusively in all scientific work throughout the world.

The Reaumur scale is not so common but is used in some parts of Europe. On this scale the zero is placed at the freezing point of water and the boiling point at 80 degrees. The divisions are, therefore, larger than those of the Centigrade scale and more than twice as large as the Fahrenheit. The general use of these different scales has led to endless confusion and made the comparison of records difficult, so that even at the present time when making a temperature record it is necessary to indicate the scale in use.

Distribution of the Temperature and Pressure

The heat received on the earth from the sun is the controlling factor in all weather conditions. If the earth were composed of all land or all water, and the amount of heat received were everywhere the same throughout the year, there would be no winds, no storms, and probably no clouds and no rain, because the force of gravity, which acts on everything on the earth's surface and on the air as well, would soon settle all differences and the atmosphere would become perfectly still. But the earth is composed of land and water, and the land heats up more rapidly under sunshine than the water and also gives off — "radiates" — its heat more rapidly than water. As a result, the air over the land is warmer in summer than the air over the water. During the winter this is reversed, and the air over the oceans is warmer than the air over the land. The great ocean currents, by carrying the heat from the equatorial regions toward the poles, and by bringing the cold from the polar regions toward the equator, assist in maintaining a constant difference in temperature between the continents and the adjacent oceans.

Furthermore, the facts that the path of the earth about the sun is not a circle but an ellipse, and that the axis of the earth is not perpendicular to the plane of its orbit, result in an unequal distribution of heat over the surface. It is always warmer near the equator than at the poles, and warmer in summer than in winter. All these differences in temperature cause corresponding differences in density, which, in turn, cause differences in weight or pressure over various parts of the earth's surface. These changes are in no way the result of chance but are determined by the operation of fixed natural laws, and with this in mind we may now take up the study of the winds of the world.

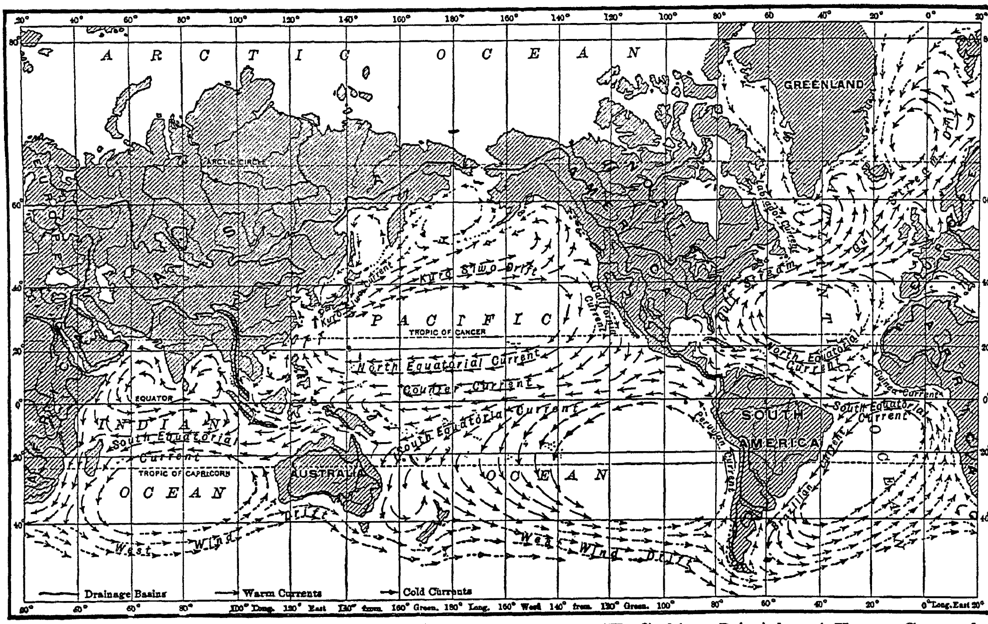
THE WINDS OF THE WORLD

The general circulation of the atmosphere may be best studied by disregarding those smaller differences of temperature and pressure that result from local causes and by viewing the earth and its atmosphere as a whole, considering only those larger differences which are in constant operation. In the great oceans of the world we find the water constantly moving in a very systematic manner, and we call this system of movements ocean currents. The Gulf Stream, the Equatorial Current, the Japan Current, sometimes called Kuro Siwo Current, and others may be likened to great rivers of water moving systematically on their courses in the ocean.

There are greater rivers of air in the atmosphere than any in the oceans, and they move on their courses with equally systematic precision and in obedience to fixed laws, which we may in a measure understand.

The air river at the bottom of which we live is broad and deep, extending in width from Florida northward nearly to the North Pole. It flows from west to east circling the globe and its name is the Prevailing Westerlies. The other air river in this hemisphere extends southward from latitude about 35° nearly to the equator. Its name is the Northeast Trade Winds.

In the southern hemisphere are two similar air rivers, one extending southward from latitude about 30° nearly to the South Pole with its current, like its counterpart in the northern hemisphere, flowing from west to east, circling the globe. It is also called the Prevailing Westerlies. The other air river in the southern hemisphere extends from about latitude 30° northward nearly to the equator and flows from the southeast toward the northwest, hence the name Southeast Trade Winds. The dividing line, or bank, between the air rivers in each hemisphere belts the earth at about 35° north and 30° south of the equator. Why does the air move,

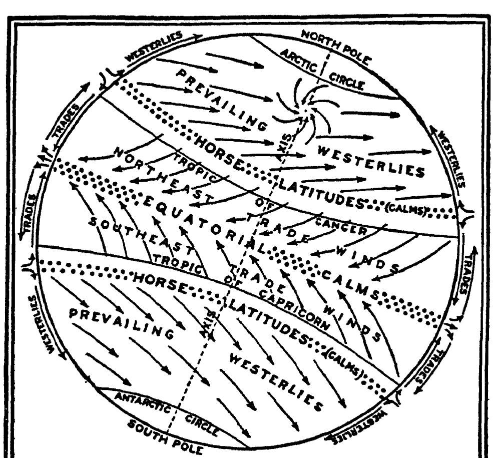


Ellsworth Huntington and Sumner W. Cushing, *Principles of Human Geography,* John Wiley and Sons, Inc.

Ocean currents

and why does it move in such a regular, systematic manner? To answer these questions we will rely upon gravity, the heat from the sun, and the effect of the rotation of the earth on moving wind currents.

Everyone knows that water flows down hill because of the force of gravity. Gravity is nature's great peacemaker. It is always trying to settle disturbances, even things up, smooth them over. If there were no winds to bring rain to the land or to stir up the ocean, gravity would soon run all the water into the lakes and the seas, and then smooth them out like sheets of glass; and if there were nothing to stir up the winds, gravity would soon settle all differences in the atmosphere and the air would become perfectly quiet. So gravity is kept busy trying to smooth out the water which the wind stirs up, at the same time trying to quiet the winds which are stirred up by the heat of the sun.

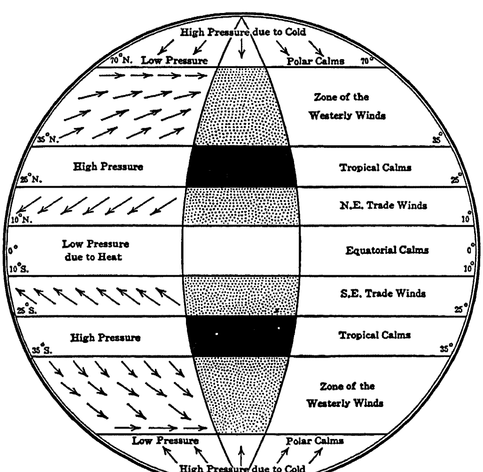


J. Russell Smith, *Human Geography,* The John C. Winston Co.

The earth's prevailing winds and air circulation

Tyndall says that heat is a mode of motion; that when heat is imparted to a substance, the molecules of which it is composed are set into very rapid vibration. They are continually trying to get away from each other and usually succeed in getting more space, and thus increase the size or volume of the substance, or, in other words, expand it. Iron, brass, copper, water, and many other substances expand under heat. Air is a gas and expands very rapidly when heated. One cubic foot of cold air becomes two cubic feet when heated. Now gravity pulls things down toward the center of the earth in accordance with their weight-density, and a cubic foot of cold air, being more dense and thus heavier than an equal volume of warm air, is pulled down with greater force. We therefore say that warm air is lighter than cold air, and if lighter it will rise. What it actually does is to press equally in all directions, and when a place is found where there is less resistance than elsewhere it moves in that direction. So when heat causes air to expand and become lighter than the surrounding cool air, it moves, and air in motion is *wind*.

Figure No. 1 represents a section of the atmosphere over a broad, level plain with the air at rest and pressing down equally on every part of the surface. The dotted line H represents the top of the quiet atmosphere. Such a condition occurs frequently at night after the heat



Ellsworth Huntington and Sumner W. Cushing, *Principles of Human Geography*, John Wiley and Sons, Inc.

Pressure belts on a simplified globe

from the sun is withdrawn and gravity has settled the atmosphere. When the rays of the sun fall on the earth upon which this quiet air rests they warm the earth first, and then the layer of air immediately in contact with the surface, so the atmosphere is heated from the bottom upward. We will assume that the layer of air between the earth and the dotted line G is thus heated to a higher temperature than the air above it. It will, therefore, expand. It cannot expand downward because of the earth. It cannot expand

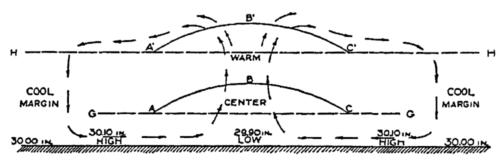


Fig. 1. *Diagram showing air currents set up by sun's heat*

much laterally because it is pressed upon by air that is also seeking more space. It therefore expands upward as represented by the line A B C. Now in expanding upward it lifts all the air above it, and the line H, representing the top of the atmosphere, will become bowed upward also as indicated by the line A′ B′ C′. As a result, the air at the top of the atmosphere over the warm center slides down the slopes on either side toward the cool margins. As soon as the flow of air away from the warm center begins, just that instant the pressure upon the heated layer at the surface is relieved and the warm air is pushed upward and the whole circulation, as indicated by the arrows, begins. It must be remembered that gravity is the really active force in maintaining this movement, because it pulls down the denser, heavier air at the cool margins with greater force than the warm, expanded, light air at the warm center. The descent of the cool air actually lifts the warm air.

The normal pressure, or weight, of the atmosphere at sea level is about 14.7 pounds on each square inch of surface. It is customary, however, to express the weight of the atmosphere in terms of inches of mercury instead of in pounds and ounces. A column of air one inch square from sea level to the top of the atmosphere will just counterbalance a column of mercury 30.00 inches high in a barometer tube of the same size. (See this type of barometer in the sketch shown on p. 787.) We, therefore, say that the normal pressure of the atmosphere at sea level is about 30.00 inches. If, for any reason, the atmosphere becomes heavier than normal, it will raise the column of mercury above the 30-inch mark, and we say that the pressure is "high." If the atmosphere becomes lighter than normal, we say that the pressure is "low." So high pressure means a heavy atmosphere and low pressure a light atmosphere.

At the beginning we assumed that the atmosphere over the broad, level plain was quiet and that it pressed down equally on every part of the surface. We will now assume that the pressure was normal, or 30.00 inches, and note the changes in pressure that result from the interchange of air between the warm center and the cool margins. So long as none of the air raised by the expanding layer at the surface moved away toward the cool margins, no change in pressure occurred; but the instant the air began to glide down the slopes away from the warm center, then the pressure at the surface decreased, because, some air having moved away, there was less to press down than before. The pressure at the warm center, therefore, became less than 30.00 inches, or in other words, low. Likewise, the air as it moved away from the warm center, having lost much of its heat during its ascent, was gradually pulled down by gravity because of its greater density, thus increasing the pressure over the cool margins. We therefore have low pressure at the warm center, 29.90 inches; and we have high pressure, 30.10 inches, at the cool margins. From this illustration we obtain the six principles of convectional circulation, viz.:

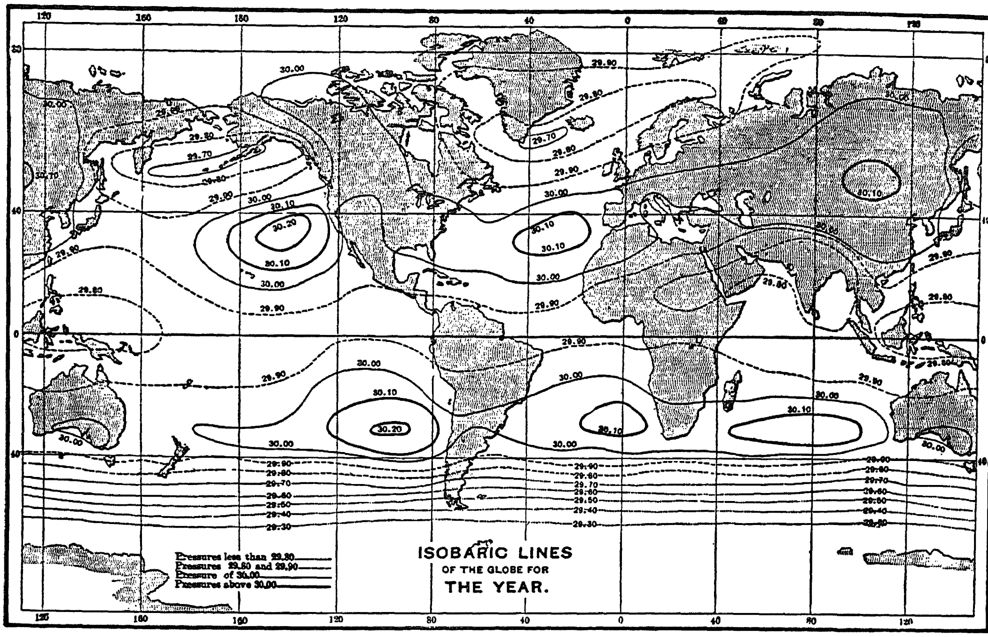


Fig. 2. Isobars of the world

1. Low pressure at warm center.
2. High pressure at cool margins.
3. Ascending currents at warm center.
4. Descending currents at cool margins.
5. Surface winds from high pressure to low pressure.
6. Upper currents from low pressure to high pressure.

Now we all know that the temperature of air is much higher at the equator than at the poles, and we may, therefore, let Fig. 1 represent a section of the atmosphere along any meridian from the North to the South Pole. The equator would then become the warm center and the poles the cool margins. We would then expect to find a belt of low pressure around the world near the equator because of the high temperature, and high pressure at the poles because of the low temperature. We would, also, expect to find ascending currents at the equator; upper currents flowing from the equator toward the poles; descending currents at the poles; and surface winds blowing from the poles toward the equator. Let us now test our theory by actual facts and see how far they are in accord.

The chart, Fig. 2, represents the normal, or average, pressure at sea level for the world, and if our theory is in accord with the facts, we should find a belt of low pressure all around the world near the

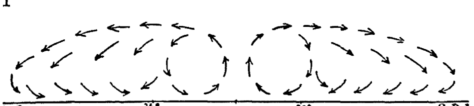


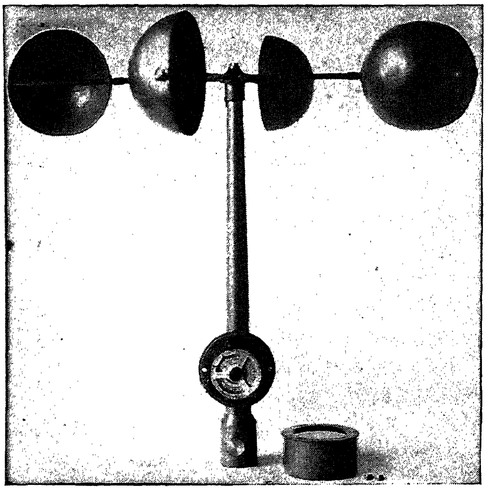
Fig. 3. Diagram showing air currents along any meridian

equator, with areas of high pressure at the poles. Let us examine the chart. Beginning at the equator, and bearing in mind that the normal pressure is about 30.00 inches, we find irregular lines, representing pressures of 29.90 inches — slightly below normal — around the world on both sides of the equator. Between these lines we find pressure as low as 29.80. It is, therefore, evident that there is a belt of low pressure around the world near the equator, as anticipated. Let us look for the high pressure at the poles. We have comparatively few observations near the poles, but the line nearest the South Pole is marked 29.30 inches, a surprisingly low pressure, much lower even than the low belt at the equator, and just the reverse of what we expected to find. When we look at the North Pole we find that the pressure is not so low as at the South Pole, but still below normal and about as low as at the equator. Going north and south from the equator we find that the pressure increases gradually up to about latitude 35° in the northern hemisphere and to about latitude 30° in the southern, after which it decreases toward the poles. So there are two well-marked belts of high pressure circling the globe; the one about 35° north, and the other about 30° south of the equator. May it not be significant that these belts of high pressure coincide so nearly with the margins, or banks, of the air rivers mentioned on page 791?

Thus far our theory does not accord very well with the facts. True, we found the low pressure at the equator as anticipated; but we also found low pressure at the poles, where the reverse was expected; and the high pressure that we anticipated at the poles, we found not far north and south of the equator. We will, therefore, have to discard our theory, or reconstruct it to accord with the facts. Let us reconstruct Fig. 1, and mark the pressure on the line representing the earth's surface along any meridian to accord with the facts as they appear on Fig. 2.

The diagram shown above now represents the true pressure along any meridian, as determined by actual observations, and we cannot escape the conviction that the requirements as to temperature and pressure at the warm center are fulfilled by the high temperature and low pressure found at the equator. Furthermore, the temperature decreases north and south from the equator, and thus the belts of high pressure near the tropics may be taken to represent the conditions at the cool margins. The first and second principles of a convectional circulation, viz., low pressure at the warm center and a high pressure at the cool margins, are thus fulfilled. To satisfy the remaining conditions, we should find ascending currents near the equator, upper currents flowing from the equator toward the tropical belts of high pressure, descending currents at the tropics, and surface winds blowing from the tropics toward the equator. Let us now examine the surface winds of the world as illustrated by the diagram on page 792.

On either side of the equator and blowing toward it, we find the famous trade winds — the most constant and steady winds of the world. Their northern and



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Cup anemometer. The dial cover is removed to show the mechanism

southern margins coincide with the tropical belts of high pressure. They blow from high pressure to low pressure and we cannot doubt that they act in obedience to the fifth principle of convectional circulation. From observation of the lofty cirrus clouds in the trade wind belts, we have abundant evidence of upper currents, flowing away from the equator toward the tropical belts of high pressure; thus the sixth principle is satisfied. The torrential rains and violent thunderstorms, characteristic of the equatorial regions, bear evidence to the rapid cooling of the ascending currents near the equator; while the clear, cool weather and light winds of the Horse Latitudes clearly indicate the presence of descending currents at the tropics. Thus, the six principles of a convectional circulation are satisfied, and the evidence is conclusive that the trade winds form a part of a convectional circulation between the tropical belts of high pressure and the equatorial belt of low pressure.

You have doubtless observed that the trade winds do not blow directly toward the equator but are turned to the west so that they blow from the northeast in the Northern Hemisphere, and from the southeast in the Southern. This peculiarity is not in strict accord with our ideas of a simple convectional circulation and suggests at least the presence of some outside influence. If we turn to Ferre's treatise on the winds, we find a demonstration of the following principle: a free moving body, such as air, in moving over the surface of a rotating globe, such as the earth, describes a path on the surface that turns to the right of the direction of motion in the Northern Hemisphere and to the left in the Southern. The curvature of the path increases with the latitude, being zero at the equator and greatest at the poles, and is independent of direction. With this in mind, if we take position at the northern limit of the trade winds in the Northern Hemisphere and face the equator (see p. 792) we find that the winds moving toward the equator turn to our right; likewise, if we face the equator from the southern limit of the southeast trades, we find them turning to our left. Observations of upper clouds in the trade wind belts show that the upper currents also turn to the right in the Northern Hemisphere, and to the left in the Southern. It is, therefore, clear that the systematic turning of the trade winds from the meridian is due to the rotation of the earth. The value of a force at various latitudes and for various velocities that would cause a body to turn away from a straight line is purely a problem in mathematics, and for the benefit of those versed in the science the formula is given. The amount of such a force is expressed by 2 MVW sin D, where M is the mass, V the velocity, W the angular rotation of the earth, and D the latitude.

Not all of us may be able to solve the problem, but we may understand something of the effect of the rotation of the earth on moving wind currents. It is a well-known principle of physics that if a body be given a motion in any direction, it will continue to move in a straight line by reason of its inertia, without reference to north, south, east, or west. A personal experience of this principle may be gained in a street car while it is rounding a curve.

In the diagram shown on the next page we have a view of the Northern Hemisphere. The direction of the rotation is indicated by the curved arrows outside the circle representing the equator. Suppose that a wind starts from the equator, moving along the meridian A directly toward the North Pole. It is clear that it cannot continue to move along the meridian, because the direction of the meridian with reference to space is continually changing, and the inertia of the wind compels it to move in a straight line without reference to the points of the compass. So when the meridian A has been moved to B by the rotation of the earth, the wind, although it maintains its original direction, no longer points toward the pole but to the right of the pole. Likewise, a wind starting from the pole toward the equator also turns to the right of the meridians and becomes a northeast wind as it approaches the equator. A wind moving east or west also turns to the right of the parallels for the same reason. So a wind starting out from the equator with the best possible intention of hitting the pole, and all the while continuing in the same straight line, will miss the pole by many miles, and always on the right side in the Northern and on the left side in the Southern Hemisphere. Thus, the oblique movement of both the trade winds and the prevailing westerlies is accounted for.

It now remains to consider the cause of the unexpected low pressure found at the poles, and the reason for the belts of

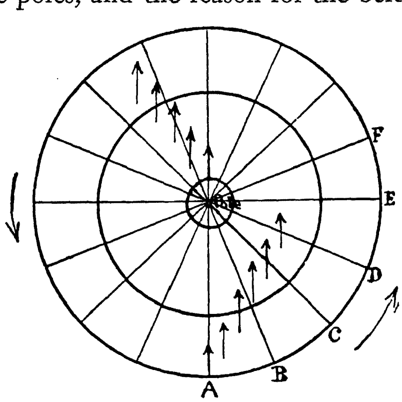
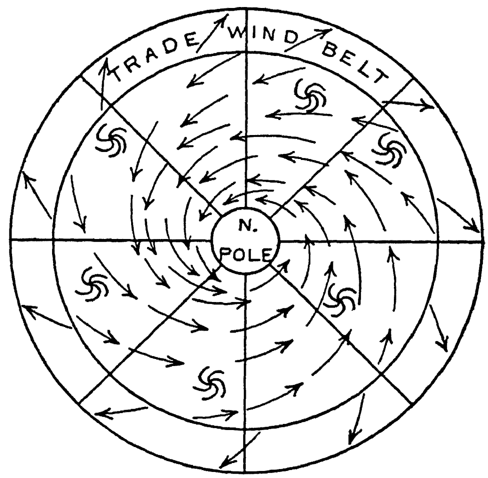


Diagram showing the effect of the earth's rotation on the atmosphere

high pressure at the tropics. If we refer to Fig. 2, page 794, we see that not all air that ascends at the equator descends at the tropics, else there would be an absence of air at the higher latitudes, which is manifestly not the case. On the other



The circumpolar whirl

hand, it is equally impossible that all the air ascending at the equator should move to the poles, because the space it could occupy decreases rapidly from a maximum at the equator to zero at the poles. Only a part of the air that ascends at the equator is, therefore, involved in the trade wind circulation and a part passes over the tropics, and moves on toward the low pressure at the poles. Furthermore, some of the air that descends at the tropics moves along the surface toward the poles, obeying the law that impels air to move from high pressure to low pressure. Now every particle of air that passes over the tropics, every particle that moves northward along the surface, turns to the right in the Northern and to the left in the Southern Hemisphere. All, therefore, miss the poles — on the right side in the Northern and on the left side in the Southern Hemisphere. The result is that two great whirlpools develop in the atmosphere; one whirling about the North and the other whirling about the South Pole. The outer margins of these whirlpools coincide with the tropical belts of high pressure.

As an example of a whirlpool we may take a basin having a vent at the center of the bottom. If the basin is filled with water, the plug withdrawn, and the water given a slight rotary motion, its velocity will increase as it approaches the center and the rapid whirling will develop sufficient centrifugal force to open an empty core. Those who have visited the great whirlpool at Niagara have undoubtedly noticed that the whirling waters are held away from the center and piled up around the margins by the centrifugal force developed. Let us suppose that air starting from the equator moves without friction or other resistances toward the pole. Its velocity must increase as its radius shortens, because the law of the conservation of areas requires that the radius must always sweep over equal areas in a given unit of time. (See law of conservation of areas.) At the equator, the air has an easterly motion equal to the eastward motion of the earth, which is 1,000 miles per hour. At latitude 60° the radius will have decreased one-half and the velocity, therefore, doubled; but at latitude 60° the eastward motion of the earth is only 500 miles per hour, so the air would be moving 1,500 miles per hour faster than the earth. At a distance of 40 miles from the pole the wind would attain an easterly velocity of 100,000 miles per hour, and moving on so short a radius would develop sufficient centrifugal force to hold all the air away from the pole and thus form a vacuum. That the supposed case of no friction is far from the truth is evidenced by the fact that the pressure at the North Pole is but little less than at the equator; but the centrifugal force developed by the gyration winds, in thus withdrawing the air from the poles and piling it up at the tropics, may be fairly taken as sufficient cause for the low pressure found at the poles and the belts of high pressure at the tropics.

The questions that remain to be considered are: (1) the low pressure at the South Pole as compared with the pressure at the North Pole, and (2) the unequal distance of the tropical belts of high pressure from the equator. These questions may be considered together.

It is to be remembered that the Southern Hemisphere is the water hemisphere, and that the prevailing westerlies, in gliding over the smooth water surface, are but little retarded by friction and, therefore, attain a higher velocity than the corresponding winds of the Northern Hemisphere, where the rougher surface materially retards their movement. As a consequence, the circumpolar whirl of the Southern Hemisphere is stronger, and develops a greater centrifugal force, thus holding a larger quantity of air away from the South Pole and reducing the pressure to a greater degree than is brought about by the weaker winds of the Northern Hemisphere.

Since the circumpolar whirl of the Southern Hemisphere is the stronger of the two, it withdraws the air to a greater distance from the pole than does its weaker counterpart of the Northern Hemisphere, and piles it up in the tropical belt of high pressure about five degrees nearer the equator than do the weaker forces that operate in the Northern Hemisphere.

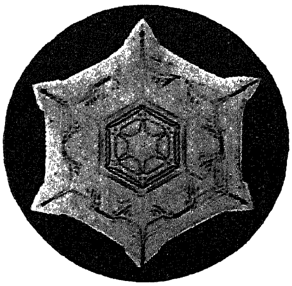
STORMS

Having gained a comprehensive view of the general planetary wind system, we may now undertake the study of local disturbances that arise within the general circulation and are known as "storms."

Storms are simply eddies in the atmosphere. They may be compared to the eddies that are often seen floating along with the current of a river or creek. In these eddies the water is seen to move rapidly around a central vertex, developing sufficient centrifugal force to hold some of the water away from the center, thus forming a well-marked depression, frequently of considerable depth. The whole circulation of the eddy is quite independent of the current of the stream which carries it along its course, and while its general direction and velocity of movement coincide with that of the current, there are times when it will be seen to move quickly from side to side and again when it will remain nearly stationary for a time or take on a rapid movement.

The eddies or storms in the atmosphere act in much the same way. They are carried along by the general currents of the river of air in which they exist. Their general direction coincides with the direction of the current in which they are floating, and their rate of movement conforms in a general way to its velocity; but, like the eddies in the river, they do not always move in straight lines or at a uniform rate of speed.

There is one important respect in which the eddies in the air differ from eddies in water. The water may revolve in either direction, depending upon the direction in which the initial force was applied, but the storm eddies in the atmosphere always revolve counterclockwise in the Northern Hemisphere, and clockwise in the Southern.



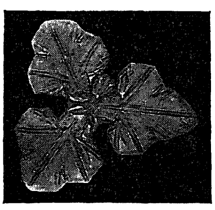
Photomicrograph by W. A. Bentley

Snow crystal

This is due to the deflecting force of the earth's rotation, which is fully explained on pages 796–98.

WEATHER MAPS

A weather map is a sort of flashlight photograph of a section of the bottom of one or more of these great rivers of air. It brings into view the whole meteorological situation over a large territory at a given instant of time; and, while a single map conveys no indication of the movements continually taking place in the atmosphere, a series of maps, like a moving picture, shows not only the whirling eddies, the hurrying clouds, and the fast-moving winds, but the ceaseless on-flow of the great river of air in which they float. Our present knowledge of the movements of the atmosphere has been gained chiefly from a study of weather maps; they form the basis of the modern system of weather forecasting, and their careful study is essential to any adequate understanding of the problems presented by the atmosphere. (See pp. 801–6.)



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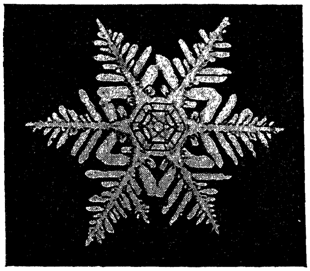
Snow crystal

The Principles of Weather Forecasting

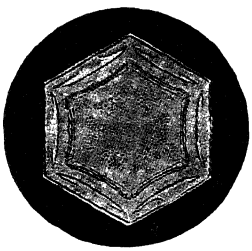
The forecasting of the weather has been made possible by the electric telegraph. It is based upon a perfectly simple, rational



Photomicrograph by W. A. Bentley

Snow crystal

process constantly employed in everyday affairs. We go to a railway station and ask the operator about a certain train. He tells us that it will arrive in an hour. We accept his statement without question, because we are confident that he knows the speed at which the train is approaching; a few clicks of his telegraph instrument have told him just where it is, and the time it will arrive, barring accidents, is



Photomicrograph by W. A. Bentley

Snow crystal

a simple calculation. Information of coming weather changes is obtained in a similar manner. Although storms do not run on steel rails like a train, nevertheless their movements may be foreseen with a reasonable degree of accuracy, depending chiefly upon the size of the territory from which telegraphic reports are received and the experience and skill of the forecaster. As a rule, the larger the territory brought under observation, especially in its longitudinal extent (the general currents carry storms of the middle latitudes eastward around the world and those of the tropics westward), the earlier advancing changes may be recognized and the more accurately their movements foreseen.

Forecasts Based on Weather Maps

The forecasts issued by the United States Weather Bureau are based on weather maps, prepared from observations taken at 7:30 A.M. and 7:30 P.M. Eastern Standard Time, throughout the country, at about 200 observatories. In addition to the reports received by telegraph by the Central Office at Washington, the several forecast centers, and other designated stations from observatories or stations in the United States, a system of interchange with Canada, Mexico, the West Indies, and other island outposts in the Atlantic and Pacific give to the forecaster two daily photographs of the weather conditions over a territory embracing nearly the whole of the inhabited part of the Western Hemisphere north of the equator. Any sort of disturbance within this vast region is photographed at once upon the weather map. If it be a West Indies hurricane or other destructive storm, its character is recognized instantly, its rate and direction determined, and information of the probable time of its arrival sent to those places that lie in its path. The method is perfectly simple. Anyone with a weather map and a little experience can forecast the weather with some degree of accuracy, or, at least, gain an intelligent understanding of the conditions upon which the forecasts that accompany the map are based.

Maps, Where Published and How Obtained

Weather maps are published in some daily papers, and in somewhat larger form, and more in detail, at Weather Bureau stations in some of the largest cities. They may usually be obtained for school use by applying to the Chief of the Weather Bureau at Washington, D. C.

The forecasts that accompany the maps are simply an expression on the part of the official forecaster as to the weather changes he expects to occur in various parts of the country within the time specified, usually within 36 to 48 hours. His opinion is based upon the conditions shown by the map. He has no secret source of information. You may accept his conclusions, or, if in your opinion they are not justified, you have all the information necessary to make a forecast for yourself. Weather maps are published so extensively with a view to thus stimulating an intelligent interest in the problem of weather forecasting, and also that one may see at a glance what the temperature, rainfall, wind, and weather are in any part of the country in which he may be interested. The friends of the weather service are those who best understand its work.

THE VALUE OF THE WEATHER SERVICE

No one knows so well as the forecaster that the changes that appear most certain to come sometimes fail, or come too late; but taking all in all, about 85 out of 100 forecasts are correct. Of those that fail, probably not more than three or four per cent fail because severe changes come unannounced. Most forecasters predict too much, and their forecasts fail because the expected changes come after the time specified or not at all. It is fortunate that this is so; for it is better to be prepared for the change though it be late in coming than to have it come without warning.

The value of the weather service to the agriculture and commerce of the United States cannot be questioned seriously. That the appropriations for its support have been increased year by year from \$1,500 in 1871 to nearly \$4,400,000 in 1929 is evidence of its value and efficiency. A conservative estimate places the value of property saved by the warnings issued by the Weather Bureau at many millions of dollars annually.

HOW TO READ WEATHER MAPS

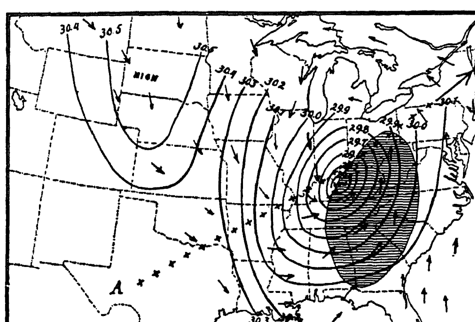
Weather maps may be obtained by writing to the Chief of the Weather Bureau, Washington, D. C., stating that you wish to post the maps in a public place. A supply of maps for three successive days for use in these lessons may be obtained at 20 cents per hundred. Sometimes they are sent free, if it is stated that they are to be used for school purposes.

The words *isobar* and *isotherm* have been bogies which have frightened many a teacher from undertaking to teach about weather maps, and yet how simple are the meanings of these two words. Isobar is made up of two Greek words, *isos* meaning equal and *baros* meaning weight. Therefore, as isobar means equal weight, and on a map one of these continuous lines means that, wherever it passes, the atmosphere there has equal weight, and the barometer stands at equal height. The isobar of 30 means that the mercury in the barometer stands 30 inches in height in all the regions where that line passes.

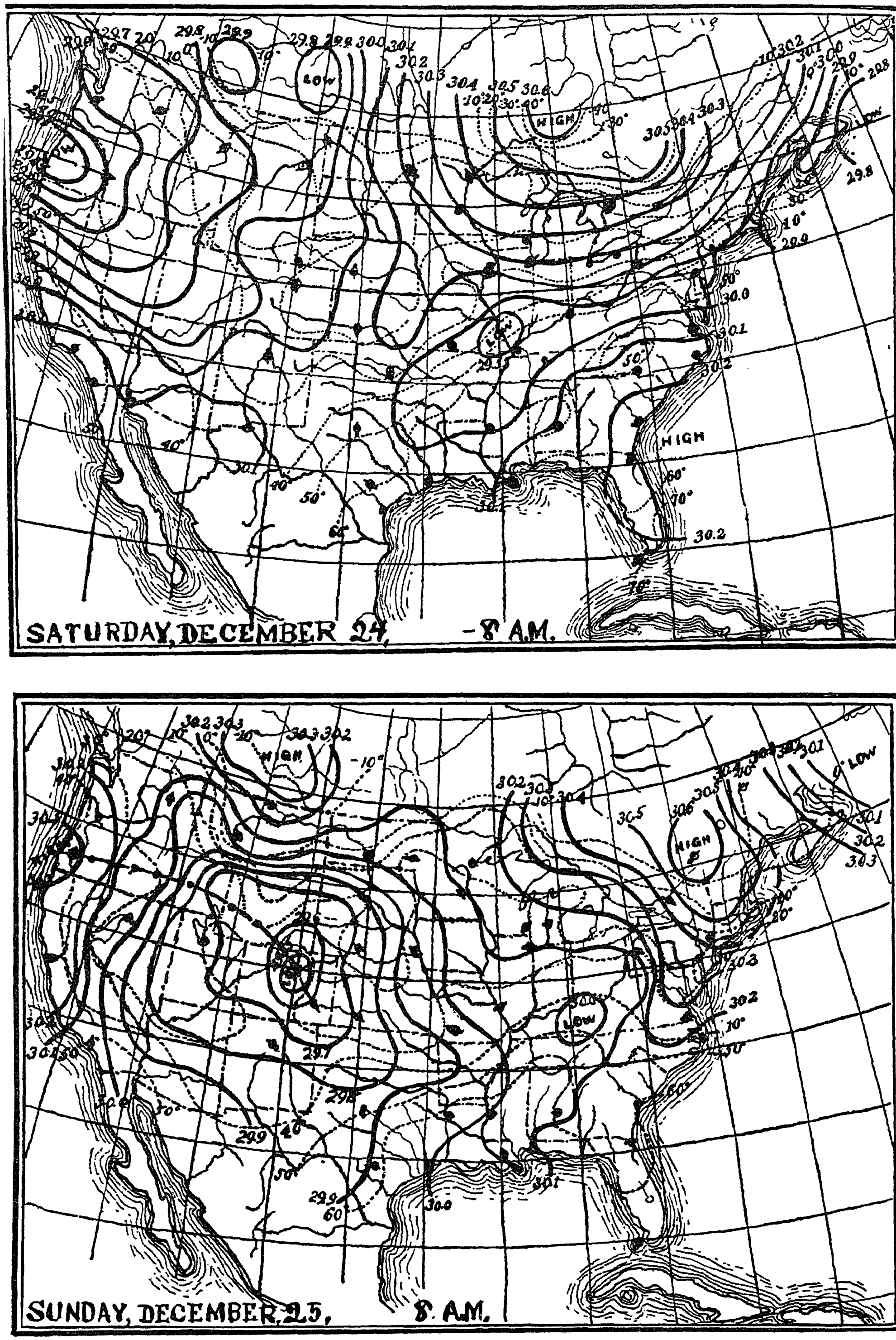
Isotherm comes from two Greek words, *isos* meaning equal and *therme* meaning heat. Therefore, on the map the dotted lines show the region where the temperature is the same. If at the end of the dotted line you find 60 it means that, wherever that line passes, the thermometer stands at 60 degrees.

HIGHS AND LOWS

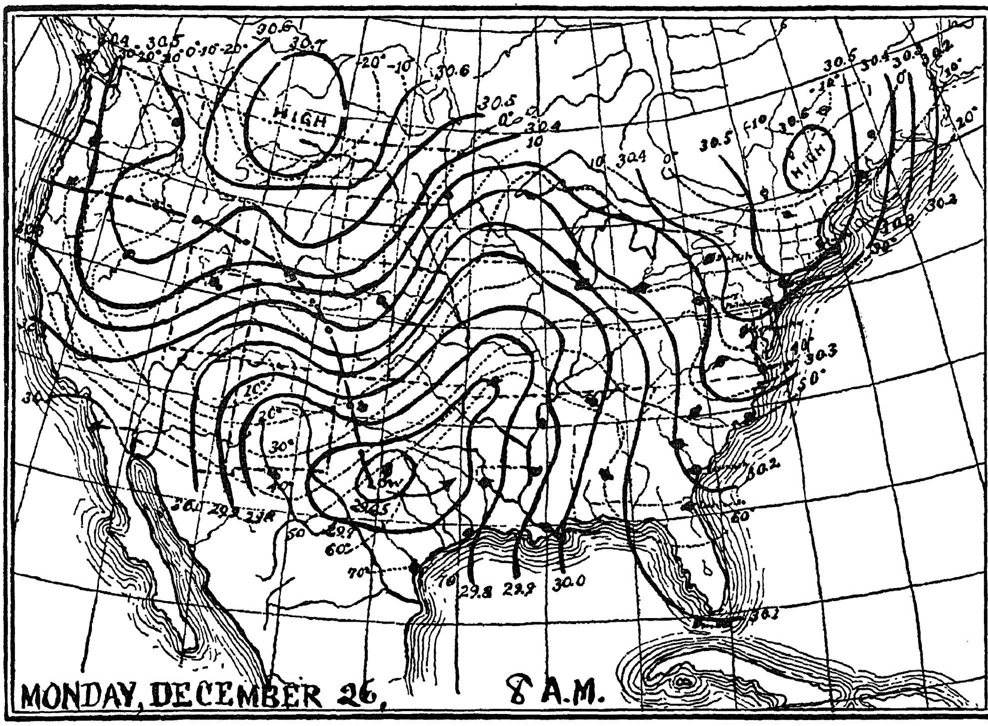
Many of the "highs" and "lows" enter the United States from the Pacific Ocean about the latitude of Washington State or southwest British Columbia; however, by far the greater number enter from the Canadian Northwest. They follow one another alternately, crossing the continent in the general direction of west to east in a path which curves somewhat to the north, and they leave the United States in the latitude of Maine or New Brunswick. If they enter by way of Lower California, they pass over to the Atlantic Ocean farther south. The time for the passage of a high or low across the continent averages about three and one-half days, sometimes a little more. These areas are usually more

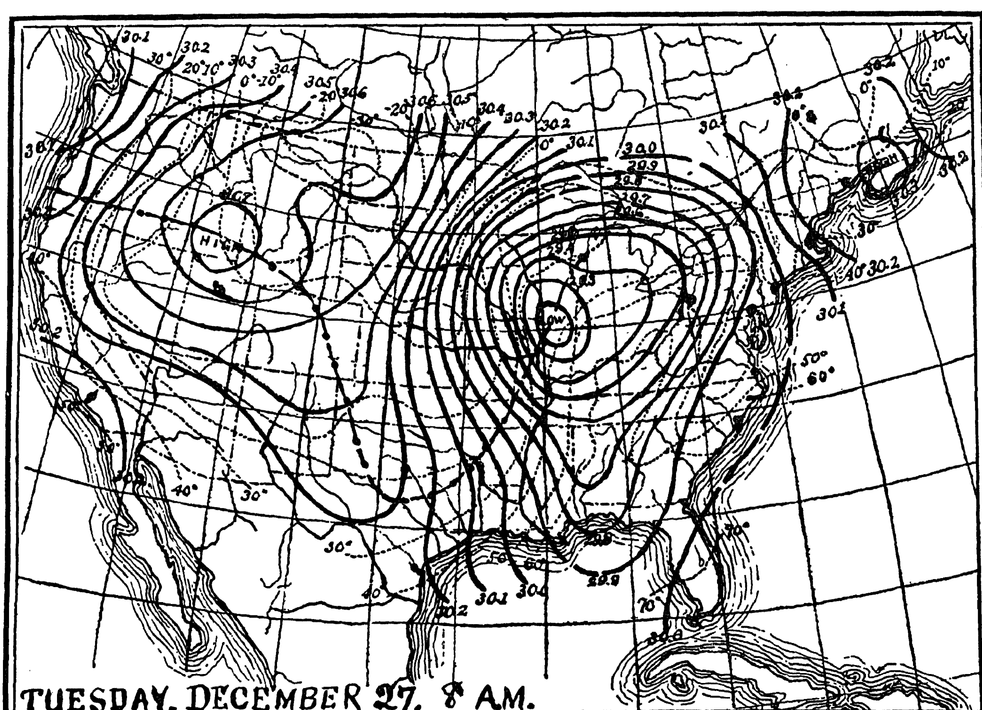


Map of a storm



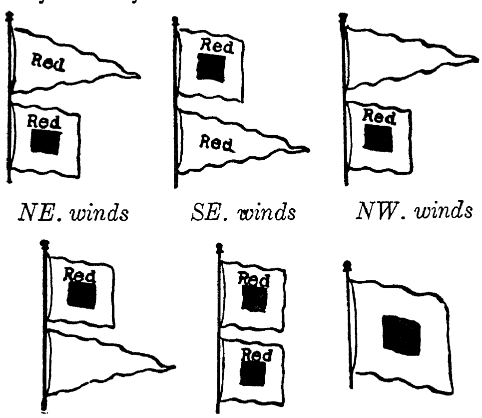
U. S. weather maps, showing the eastward progress of an area of low pressure for four
indicated by the line of dots





consecutive days. Note the course of the low that was on the Pacific coast Dec. 24; this is and dashes on the later maps marked in winter, and wind storms are more marked and more regular.

A low area is called a cyclone and a high area an anticyclone. The destructive winds, popularly called cyclones, which occur in certain regions, should be called tornadoes instead, although in fact they are simply small and violent cyclones. But a cyclone, when used in a meteorological sense, extends over thousands of square miles and is not violent; while a tornado may be only a few rods in diameter and may be very destructive. The little whirl-



NE. winds *SE. winds* *NW. winds*

SW. winds *Hurricane warning* *Cold wave*

Explanation of storm and hurricane signals

Storm warning — A red flag with a black center indicates that a storm of marked violence is expected.

The pennants displayed with the flags indicate the direction of the wind; red, easterly (from northeast to south); white, westerly (from southwest to north). The pennant above the flag indicates that the wind is expected to blow from the northerly quadrants; below from the southerly quadrants.

By night a red light indicates easterly winds and a white light below a red light westerly winds.

Hurricane warning — Two red flags with black centers displayed one above the other indicates the expected approach of a tropical hurricane or one of those extremely severe and dangerous storms which occasionally move across the Lakes and northern Atlantic coast.

No night hurricane warnings are displayed.

winds which lift the dust in the roads are rotary winds also, but merely the eddies of a gentle wind.

In a cyclone or "low," and also in a tornado, the air blows from *all* sides spirally inward *toward* the center where there is a column of *ascending* air.

In an anticyclone or "high" the air blows outward in every direction in curved lines *from* a column of *descending* air.

In the map (page 801), the curved lines are isobars; the line of crosses, A to B, indicates the course of the storm; the arrows indicate the direction of the wind — note that it is moving counterclockwise around the area of low pressure; the shaded area indicates the region where it is raining or snowing — note that this is the area where the warm, moist air from the Gulf and the ocean meets the colder air of the north.

The weather conditions during the passage of a cyclone are briefly as follows: Small, changing wisps of cirrus clouds appear about twenty-four hours before rain; these gradually become larger and cover the whole sky, making a nimbus cloud. The wind changes from northeast to east or southeast to south. The barometer falls, the thermometer rises; that is, air pressure is less to the square inch, and the temperature of the atmosphere is warmer. An accurate record of the temperature range can be had from the maximum and minimum thermometers (page 789). Rain begins and falls for a time, varying from an hour to a day or more. After the rain there appear breaks in the great nimbus clouds and finally the blue sky conquers until there are only a few or no clouds. The wind changes to southwest and west; the barometer rises, the temperature falls. The rain ceases, the sun shines out brightly. The low has passed and the high is approaching, to last about three days.

Formerly, the Weather Bureau used a series of flags, displayed in public places, to indicate approaching weather conditions; but that practice in general has been discontinued. Some local authorities still maintain the system at their own expense. The storm and hurricane warnings and the cold wave signal are still in use.

LESSON 222

How to Read Weather Maps

Leading Thought — Weather maps are made with great care by the Weather Bureau experts. Each map is the result of many telegraphic communications from all parts of the country. Every intelligent person should be able to understand the weather maps.

METHOD — Get several weather maps from a nearby Weather Bureau station. They should be maps for successive days, and there should be enough so that each pupil can have three maps, showing the weather conditions for three successive days.

OBSERVATIONS — 1. Take the map of the earliest date of the three. Where was your map used? What is its date? How many kinds of lines are there on your map? Are there explanatory notes on the lower left-hand corner of your map? Explain what the continuous lines mean. Find an isobar of 30; to what does this figure refer? Find all the towns on your map where the barometer stands at 30 inches. Is there more than one isobar on your map where the barometer stands at 30?

2. Where is the greatest air pressure on your map? How high does the barometer stand there? How are the isobars arranged with reference to this region? What word is printed in the center of this series of isobars?

3. What do the arrows indicate? What do the circles attached to the arrows indicate?

4. In general, what is the direction of the winds with reference to this high center?

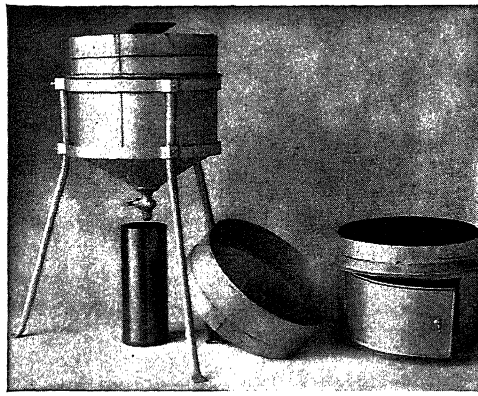
5. Is the air rising or sinking at the center of this area? If the wind is blowing in all directions from a center marked high, what sort of weather must the places just east of the high be having? Do the arrows with their circles indicate this?

6. Find a center marked low. How high does the barometer stand there? Does the air pressure increase or diminish away from the center marked low, as indicated by the isobars? Do the winds blow toward this center or away from it?

7. What must the weather in the region just east of the low be? Why? Do the arrows and circles indicate this?

8. Is there a shaded area on your map? If so, what does this show?

9. Compare the map of the next date with the one you have just studied. Are the highs and lows in just the same position that they were the day before? Where are the centers high and low now? In what directions have they moved?



Weather Bureau, U. S. D. A.

A rain gauge dismantled to show parts. By means of this instrument the amount of rainfall is measured by inches

10. Look at the third map and compare the three maps. Where do the high and low centers seem to have originated? How long does it take a high or low to cross the United States? How far north and south does a high or low, with all its isobars, extend?

11. What do the dotted lines on your map mean? Do they follow exactly the isobars?

12. What is the greatest isotherm on your map? Through or near what towns does it pass?

13. Do the regions of high air pressure have the highest temperature or the lowest? Do high temperatures accompany low pressures? Why?

14. What is the condition of the sky just east of a low center? What is its condition just west of low?

15. If the isobars are near together in a low, it means that the wind is moving rather fast and that there will be a well-marked storm. Look at the column giving wind velocity. Was the wind blowing toward the center of the low on the map? If so, does that mean it is coming fast or slow? How does this fact correspond with the indications shown by the distance between the isobars?

16. Describe the weather accompanying the approach and passage of a low in

the region where your town is situated. What sort of clouds would you have, what winds, what change of the barometer and thermometer?

Note: The amount of rainfall that has been recorded in representative areas will be indicated in a table printed below the map.

How to Find the General Direction and Average Rate of Motion of Highs and Lows

Observations — 1. On the first map of the series of three given, put an X in red pencil or crayon at the center of the high and a blue one at the center of the low; or if you do not have the colored pencils, use some other distinguishing marks for the two. If there are two highs and two lows, use a different mark for each one.

2. Mark the position of each center on this map for the following day with the same mark that you first used for that area. Do this for each of the highs and lows until it leaves the map or until your maps have been used. All the marks of one kind can be joined by a line, using a red line for the red marks and a blue line for the blue marks.

3. What do you find to be the general direction of the movement of the highs and lows?

4. Examine the scale marked statute miles at the bottom of the map. How many miles are represented by one inch on the scale?

5. With your ruler find out how many miles one area of high or low has moved in twenty-four hours; in three days. Divide the distance which the area has moved in three days by three and this will give the average velocity for one day.

6. In the same way find the average velocity of each of the areas on your map for three days and write down all your answers. From all your results find the average weekly velocity; that is, how many miles per hour and the general direction which has characterized the movement of the high and low areas.

How to Keep a Daily Weather Map

The pupils should keep a daily weather map record for at least six months. The observations should be made twice each day and always at the same hours. While it would be better if these records could be made at 7:30 o'clock in the morning and again at 7:30 o'clock in the evening, this is hardly practicable and they should, therefore, be made at 9 o'clock and at 4. The accompanying chart may be drawn enlarged. Sheets of manila paper are often used, so that one chart may cover the observations for a month.

Few schools are able to have a working barometer, but observations of temperature and sky should be made in every school. Almost any boy can make a weather vane, which should be placed on a high building or tree where the wind will not be deflected from its true direction when striking it. A thermometer should be placed on the north side of a post and on a level with the eyes; it should not be hung from a building, as the temperature of the building might affect it.

The direction of the wind and the cloudiness of the day may be indicated on the chart, as it is on the weather maps, by a circle attached to an arrow which points in the direction in which the wind is blowing. See weather maps for explanation of symbols.

Observations Concerning the Weather

It is an interesting hobby to really observe the weather. Of course, we all talk about the weather if rain or snow is falling; some people even remark about the wind. Let us make it a daily habit to give a thought to weather conditions: the wind directions; the presence or absence of dew during the hours of evening, night, or early morning; and the readings of the barometer, thermometer, and the weather maps if any are available.

There are many "weather signs" in common circulation; some have absolutely no foundation and others have scientific basis. The latter can usually be depended upon, and, in many instances, are quite interesting to study in an effort to find a reason why they are good signs. To make a collection of all the weather signs that one can learn from friends or find in various books is another interesting hobby; the next thing, for an inquiring mind, is to attempt to find out how many are merely sayings and how many are really good signs. Some of the books listed in the bibliography will be found quite useful in this field of inquiry.

Many Weather Proverbs Are Based on Scientific Facts

There follows a short list of weather proverbs or sayings that are based on scientific facts:

Evening red and morning gray,
Set the traveler on his way;
Evening gray and morning red,
Bring down rain upon his head.

Rainbow in the morning, sailors take warning,
Rainbow at night, sailor's delight.

Mackerel scales and mare's tails
Make lofty ships to carry low sails.

A mackerel sky,
Not twenty-four hours dry.

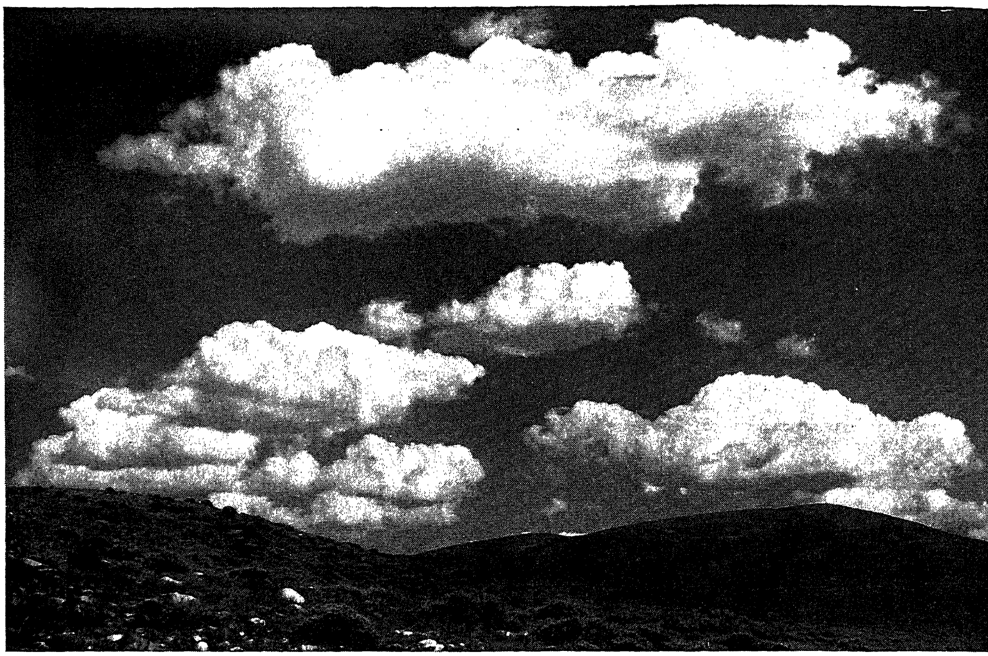
When walls are unusually damp, rain is to be expected.

Clouds flying against the wind indicate rain.

Chart for School Weather-Records

Date	Hour	Temp.	Barometer	Direction of Wind	Cloudiness. Fogs	Dew or Frost	Rain or Snow	Remarks
Weekly Summary								

WATER FORMS



Gayle Pickwell

Water in its various changing forms, liquid, gas, and solid, is an example of another overworked miracle — so common that we fail to see the miraculous in it. We cultivate the imagination of our children by tales of the prince who became invisible when he put on his cap of darkness, and who made far journeys through the air on his magic carpet. And yet no cap of darkness ever wrought more astonishing disappearances than occur when this most common of our earth's elements disappears from under our very eyes, dissolving into thin air. We cloak the miracle by saying "water evaporates," but think once of the travels of one of these drops of water in its invisible cap! It may be a drop caught and clogged in a towel hung on the line after washing, but as soon as it dons its magic cap, it flies off in the atmosphere invisible to our eyes; and the next time any of its parts are evident to our senses, they may occur as a portion of the white masses of cloud sailing across the blue sky, the cloud which Shelley personifies:

I am the daughter of Earth and Water,
And the nursling of the Sky;
I pass through the pores of the ocean and shores;
I change, but I cannot die.

We have, however, learned the mysterious key word which brings back the vapor spirit to our sight and touch. This word is "cold." For if our drop of water, in its cap of darkness, meets in its travels an object which is cold, straightway the cap falls off and it becomes visible. If it be a stratum of cold air that meets the invisible wanderer, it becomes visible as a cloud, or as mist, or as rain. If the cold object be an ice pitcher, then it appears as drops on its surface, captured from the air and chained as "flowing tears" upon its cold surface. And again, if it be the cooling surface of the earth at night that captures the wanderer, it appears as dew.

But the story of the water magic is only half told. The cold brings back the invisible water vapor, forming it into visible drops; but if it is cold enough to freeze, then we behold another miracle, for the drops are changed to crystals. The cool windowpane at evening may be dimmed with mist caught from the air of the room; if we examine the mist with a lens we find it composed of tiny drops of water. But

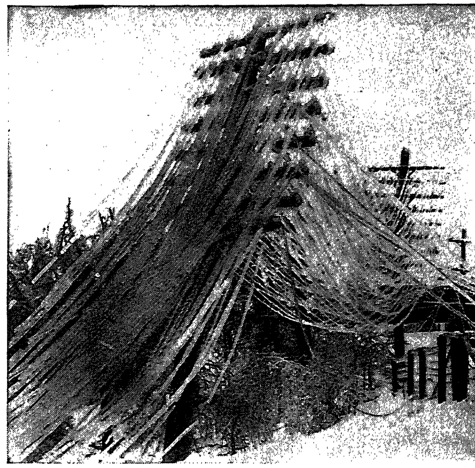
Weather Bureau, U. S. D. A.

"Hailstones as large as hens' eggs" is no figure of speech as applied to these stones that fell at Girard, Ill., in 1929. *Note the three eggs in front of the right-hand pile of hailstones*

if the night be very cold, we find next morning upon the windowpane exquisite ferns, or stars, or trees, all formed of the crystals grown from the mist which was there the night before. Moreover, the drops of mist have been drawn together by crystal magic, leaving portions of the glass dry and clear.

If we examine the grass during a cool evening of October we find it pearled with dew, wrung from the atmosphere by the permeating coolness of the surface of the ground. If the following night be freezing cold, the next morning we find the grass blades covered with the beautiful crystals of hoar frost.

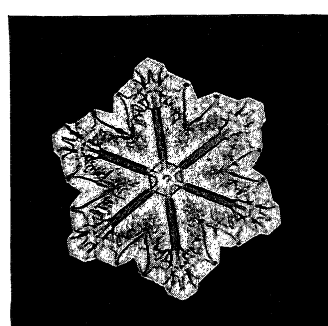
If a rain cloud encounters a stratum of air cold enough to freeze, then what would have been rain or mist comes down to us as sleet, hail, or snowflakes; and of all the forms of water crystals, that of snow in its perfection is the most beautiful; it is,



Weather Bureau, U. S. D. A.

After an ice storm. After this storm of Nov. 26, 1929, *at Worcester, Mass., the ice on the wires was three inches in diameter and weighed* 800 *pounds per wire from pole to pole*

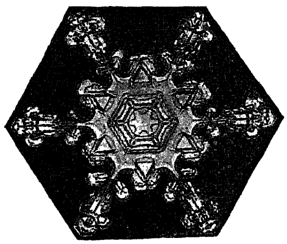
indeed, the most beautiful of all crystals that we know. Why should water freezing freely in the air so demonstrate geometry by forming, as it does, a star with six rays, each set to another, at an angle of 60 degrees? And as if to prove geometry divine beyond cavil, sometimes the rays are only three in number — a factor of six — and include angles of twice 60 degrees. More-



Photomicrograph by W. A. Bentley

Snow crystal formed in high clouds

over, the rays are decorated, making thousands of intricate and beautiful forms; but if one ray of the six is ornamented with additional crystals the other five are decorated likewise. Those snow crystals formed in the higher clouds and, therefore, in cooler regions may be more solid in form, the spaces in the angles being built out to the tips of the rays, and including air spaces set in symmetrical patterns; and some of the crystals may be columnar in



Photomicrograph by W. A. Bentley

Composite snow crystal; the center formed in a high cloud and the margins in a lower cloud

form, the column being six-sided. Those snow crystals formed in the lower currents of air, and therefore in warmer regions, on the other hand, show their six rays marvelously ornamented. The reason why the snow crystals are so much more beautiful and perfect than the crystals of hoar frost or ice, is that they are formed from water vapor, and grow freely in the regions of the upper air. Mr. W. A. Bentley, who spent many years photographing the snow crystals, found nearly 5,000 distinct designs.

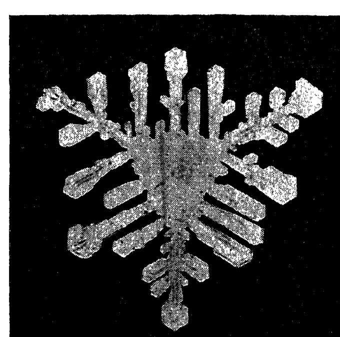
The high clouds are composed of ice crystals formed from the cloud mists; such ice clouds form a halo when veiling the sun or the moon.

When the water changes to vapor and is absorbed into the atmosphere, we call the process evaporation. The water left in an open saucer will evaporate more rapidly than that in a covered saucer, because it comes in contact with more air. The clothes which are hung on the line wet, dry more rapidly if the air is dry and not damp; for if the air is damp, it already has almost as much water in it as it can hold. The clothes will dry more rapidly when the air is hot, because hot air takes up moisture more readily and holds more of it than does cold air. The clothes will dry more rapidly on a windy day, because more air moves over them and comes in contact with them than on a still day.

If we observe a boiling teakettle, we can see a clear space of perhaps an inch or less in front of the spout. This space is filled with steam, which is hot air saturated with hot water vapor. But what we call " steam " from a kettle is this same water vapor condensed back into thin drops of water or mist by coming into contact with the cooler air of the room. When the atmosphere is dry, water will boil away much more rapidly than when the air is damp.

The breath of a horse, or our own breath, is invisible during a warm day; but during a cold day, it is condensed to mist as soon as it is expelled from the nostrils and comes in contact with the cold air. A person who wears spectacles finds them unclouded during warm days; but in winter the glasses become cold out-of-doors, and as soon as they are brought into contact with the warmer, damp atmosphere of a room, they are covered with a mist. In a like manner, the windowpane in winter, cooled by the outside temperature, condenses on its inner surface the mist from the damp air of the room.

The water vapor in the atmosphere is invisible, and it moves with the air currents until it is wrung out by coming into contact with the cold. The air thus filled



Photomicrograph by W. A. Bentley

Blizzard type of snow crystal formed in low cloud

with water vapor may be entirely clear near the surface of the earth; but, as it rises, it comes in contact with cooler air and discharges its vapor in the form of mist, which we call clouds; and if there is enough vapor in the air when it meets a cold current, it is discharged as rain and falls back to the earth. Thus, when it is very cloudy, we think it will rain, because clouds consist of mist or fog; and if they are subjected to a colder temperature, the mist is condensed to rain. Thus, often in mountainous regions, the fog may be seen streaming and boiling over a mountain peak, and yet always disappears at a certain distance below it. This is because the temperature around the peak is cold and condenses the water vapor as fast as the wind brings it along, but the mist passes over and soon meets a warm current below and, presto, it disappears! It is then taken back into the atmosphere. The level base of a cumulus cloud has a stratum of warmer air below it, and marks the level of condensation.

At the end of the day, the surface of the ground cools more quickly than the air above it. If it becomes sufficiently cold and the air is damp, then the water from it is condensed, and dew is formed during the night. However, all dew is not always condensed from the atmosphere, since some of it is moisture given off by the plants, which could not evaporate in the

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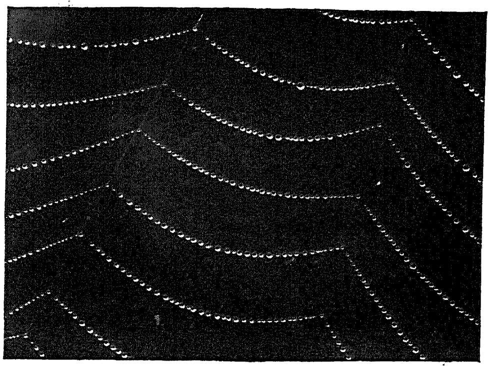
Cumulus clouds

cold night air. On windy nights, the stratum of air cooled by the surface of the earth is moved along and more air takes



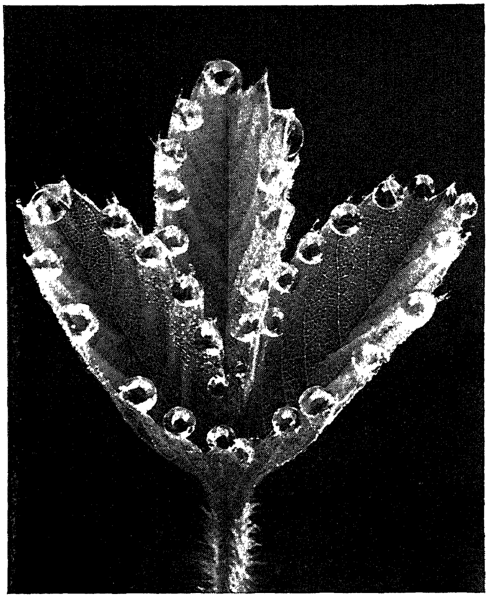
W. A. Bentley

Dew on a spider's web

its place, and it therefore does not become cold enough to be obliged to yield up its water vapor as dew. If the weather during a dewy night becomes very cold, the dew becomes crystallized into hoar frost. The crystals of hoar frost are often very beautiful and are well worth our study.

The ice on the surface of a still pond usually begins to form around the edges first, and fine, lancelike needles of ice are sent out across the surface. It is a very interesting experience to watch the ice crystals form on a shallow pond of water. This may easily be seen during cold winter weather. It is equally interesting to watch the formation of the ice crystals in a glass bottle or jar. Water, in crystallizing, expands, and requires more room than it does as a fluid; therefore, as the water changes to ice it must have more room, and often presses so hard against the sides of the bottle as to break it. The ice in the surface soil of the wheat fields expands and buckles, holding fast in its grip the leaves of the young wheat and tearing them loose from their roots; this "heaving" is one cause for the winter-killing of wheat. Sleet consists of rain crystallized in the form of sharp needles. Hail consists of ice and snow compacted together, making the hard, more or less globular hailstones.

SUGGESTED READING—*Fogs and Clouds*, by William J. Humphreys; *The Wonders of Water*, by Marian E. Baer; also, readings on page 781.



W. A. Bentley

In transpiring, plants give off moisture. "The magic of the cold" has held this moisture in the form of drops on a strawberry leaf

LESSON 223
Water Forms

Leading Thought — Water occurs as an invisible vapor in the air and also as mist and rain; and when subjected to freezing, it crystallizes into ice and frost and snow.

Method — The answers to the questions of this lesson should, as far as possible, be given in the form of a demonstration. All of the experiments suggested should be tried, and the pupils should think the matter out for themselves. In the study of the snow crystals a compound microscope is a great help, but a hand lens will do. This part of the work must be done out of doors. The most advantageous time for studying the perfect snow crystals is when the snow is falling in small, hard flakes; since, when the snow is soft, there are many crystals massed together into great fleecy flakes, and they have lost their original form. The lessons on frost or dew may be given best in the autumn or spring.

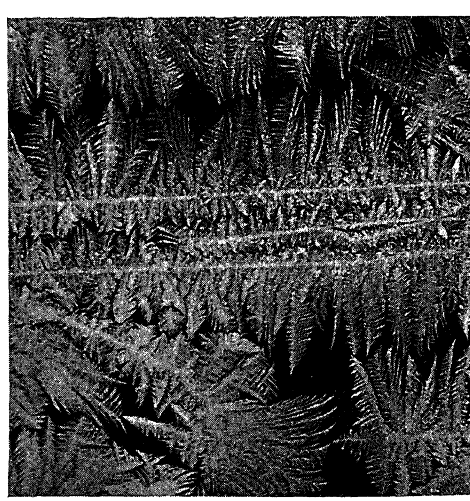
Observations — 1. Place a saucer filled with water near a stove or radiator; do not cover it or disturb it. Place another saucer filled with water near this but cover it with a tight box. From which saucer does the water evaporate more rapidly? Why?

2. We hang the clothes, after they are washed, out-of-doors to dry; what becomes of the water that was in them? Will they dry more rapidly during a clear or during a damp day? Why? Will they dry more rapidly during a still or during a windy day? Why? Will they dry more rapidly during hot or cold weather? Why?

3. Watch a teakettle of water as it is boiling. Notice that near its spout there is no mist, but what we call steam is formed beyond this. Why is this so? What is steam? Why does water boil away? Do kettles boil dry sooner on some days than on others? Why?

4. If the water disappears in the atmosphere where does it go? Why do we say "the weather is damp"? What force is it that wrings the water out of the atmosphere?

5. Why does the breath of a horse show as a mist on a cold day? Why do persons who wear spectacles find their glasses covered with mist as soon as they enter a warm room after having been out in the cold? Why do the windowpanes become covered with mist during cold weather? Is it the mist on the outside or on the



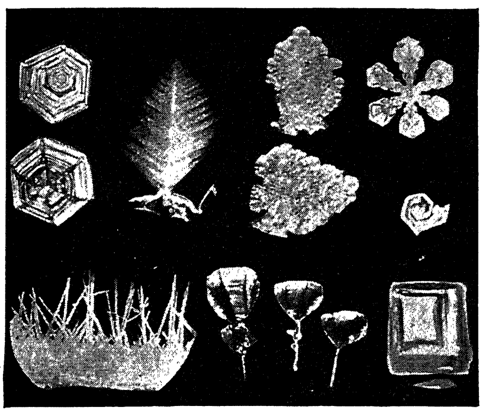
W. A. Bentley

Frost crystals on a windowpane

inside? Why does steam show as a white mist? Why does the ice pitcher, on a warm day, become covered on the outside with drops of water? Would this happen on a cold day? Why not?

6. Why, when the water is invisible in the atmosphere, does it become visible as clouds? What causes the lower edges of cumulus clouds to be so level? What is fog? Why do clouds occur on mountain peaks? What causes rain?

7. What causes dew to form? When the grass is covered with dew, are the leaves of the higher trees likewise covered? Why not? What kind of weather must we have in order to have dewy nights? What must



Photomicrograph by W. A. Bentley

Forms of hoar frost

be the atmosphere of the air in relation to that of the ground in order to condense the dew? Does dew form on windy nights? Why not? Does all dew come from the air, or does some of it come from the ground through the plants? Why is not this water, pumped up by the plants, evaporated?

8. What happens to the dew if the weather becomes freezing during the night? What is hoar frost? Why should water change form when it is frozen? How many forms of frost crystals can you find on the grass on a frosty morning?

9. When a pond begins freezing over, what part of it freezes first? Describe how the first layer of ice is formed over the surface.

10. Place a bottle of water out of doors

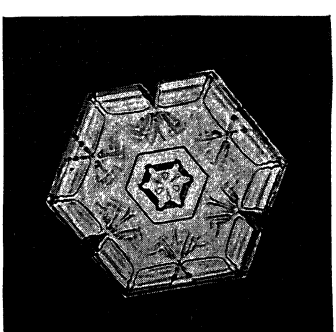
Marjorie Ruth Ross

Hoar frost on a tree

in freezing weather. How does the ice appear in it at first? What happens later? Why does the bottle break? How is it that water which has filled the crevices of rocks scales off pieces of the rock in cold weather? Why does winter wheat "winter-kill" on wet soil?

11. Why does frost form on a windowpane? How many different figures can you trace on a frosted pane? Are there any long, needle-like forms? Are there star forms? Can you find forms that resemble ferns and trees? Do you sometimes see, on boards or on the pavement, frost in forms like those on the windowpane?

12. When there is a fine, dry snow falling, take a piece of dark flannel and catch some flakes upon it. Examine them with a lens, being careful not to breathe upon them. How many forms of snow crystals can you find? How many rays are there in the star-shaped snow crystals? Do



Photomicrograph by W. A. Bentley

High cloud snow crystal

you find any solid crystals? Can you find any crystals that are triangular? When the snow is falling in large, feathery flakes, can you find the crystals? Why not?

13. What is the difference between a hailstone and a snow crystal? What is sleet?

When in the night we wake and hear the
rain
Which on the white bloom of the orchard
falls,
And on the young, green wheat-blades,
where thought recalls
How in the furrow stands the rusting plow,
Then fancy pictures what the day will
see —
The ducklings paddling in the puddled
lane,
Sheep grazing slowly up the emerald slope,
Clear bird-notes ringing, and the droning
bee
Among the lilac's bloom — enchanting
hope —
How fair the fading dreams we entertain,
When in the night we wake and hear the
rain! — ROBERT BURNS WILSON

The thin snow now driving from the north and lodging on my coat consists of those beautiful star crystals, not cottony and chubby spokes, but thin and partly transparent crystals. They are about a tenth of an inch in diameter, perfect little wheels with six spokes without a tire, or rather with six perfect little leaflets, fern-like, with a distinct straight and slender midrib, raying from the center. On each side of each midrib there is a transparent thin blade with a crenate edge. How full of creative genius is the air in which these are generated! I should hardly admire more if real stars fell and lodged on my coat. Nature is full of genius, full of divinity. Nothing is cheap and coarse, neither dewdrops nor snowflakes.

A divinity must have stirred within them before the crystals did thus shoot and set. Wheels of storm-chariots. The same law that shapes the earth-star shapes the snow-stars. As surely as the petals of a flower are fixed, each of these countless snow-stars comes whirling to earth, pronouncing thus, with emphasis, the number six. — THOREAU'S JOURNAL

THE SKIES

Revised by S. L. Boothroyd

Professor of Astronomy in Cornell University

Lick Observatory

Halley's Comet, May 7, 1910

THE STORY OF THE STARS

Why did not somebody teach me the constellations and make me at home in the starry heavens, which are always overhead, and which I don't half know to this day.

— Thomas Carlyle

For many reasons aside from the mere knowledge acquired, children should be taught to know something of the stars. It is an investment for future years; the stars are a constant reminder to us of the thousands of worlds outside our own, and looking at them intelligently lifts us out of ourselves in wonder and admiration for the infinity of the universe, and serves to make our own cares and trials seem trivial. The author has not a wide knowledge of the stars; a dozen constellations were taught to her as a little child by her mother, who loved the sky as well as the earth; but perhaps nothing she has ever learned has been to her such a constant source of satisfaction and pleasure as this ability to call a few stars by the names they have borne since the men of ancient times first mapped the heavens. It has given her a sense of friendliness with the night sky that can only be understood by those who have had a similar experience.

There are three ways by which the mysteries of the skies are made plain to us: first, by our own eyes; second, by the telescope; and third, by the spectroscope and other physical instruments. These instruments help us to interpret the messages brought by the light coming from the heavenly bodies. The spectroscope is an instrument which tells us, by analyzing the light of stars, not only the chemical elements which compose them, but something of the state in which the gases exist in the stars, planets, and nebulæ. It also makes possible the measurement of the rate at which a heavenly body is approaching or receding from us. Further still it gives information which assists in determining the temperature of stars as well as in measuring their sizes.

Thus, we have learned many things about the stars; we know that every shining star is a great blazing sun, and there is no reason to doubt that many of these suns have worlds like the earth spinning around them, although, of course, so far away as to be invisible to us; for our world could not be seen at all from even the nearest star.

The telescope early revealed to Galileo that the Milky Way or Galaxy is not a nebulous band of hazy light around the sky, as it appears to the unaided eye, but is composed of myriads of faint stars, too faint to be seen individually without telescopic aid.

We also know that many of the stars which seem single to us are really double — made up of two vast suns swinging around a common center; and although they may be millions of miles apart, they are so far away that they seem to us as one star. The telescope reveals many of these double stars and shows that they circle around their orbits in various periods of time, the most rapid making the circuit in five years, another in sixteen years, another in forty-six years; while there is at least one lazy pair which seems to require fully sixteen hundred years to complete one journey around their elongated, oval orbit. And the spectroscope has revealed to us that many of the stars which seem single through the largest telescope are really double, and some of these great suns race around each other in the period of a few days, at a rate of speed we could hardly imagine.

Astronomers have been able to measure the distance from us to many of the stars, but when this distance is expressed in miles it is too much for us to grasp. Consequently, they have come to express distance to heavenly bodies in terms of the time it takes light to reach us from them. Light travels 186,300 miles a second or about six trillion miles a year; this distance is called a light-year. Thus a star whose distance is such that it takes eight years for its light to reach us, is said to be removed from us eight light-years. Light reaches us from the sun in eight and one-third minutes; but it takes more than four years for a ray to reach us from the nearest star. It adds new interest to the Polestar to know that the light which reaches our eyes left that star almost half a century ago, and that the light we get from the Pleiades started on its journey before America was discovered. Most of the stars are so far away that we cannot measure the distance.

Although stars seem stationary, they are all moving through space just as our own sun is doing; but the stars are so far away that even if one moved a million miles a day, it would require years of observation to detect that it moved at all, except for that component of its motion which is directly toward or away from us. We know the stars are in motion — just as planets are in motion in our solar system. The problem of determining these motions belongs in the realm of advanced astronomical study, and is too difficult to consider here.

The spectroscope reveals the life cycle of stars; when young they are composed of thin gases shining red and are giant stars; when older and more condensed they shine yellow; when still more condensed they shine white and may shine blue. This condition marks the end of their infancy; then they decline through these colors in reverse order. When on the decline, they become yellowish, white stars; after this they change very little in size and shine with a constant light through millions upon millions of years; this stage constitutes the solar stage of their life and occupies the major part of their life history.

Scattered through the skies are objects which look like clouds; these are the so-called nebulæ. Some of these have already been found to consist of stars arranged in a globular system of suns. Others have been found to be whole Milky-Way systems — the so-called spiral nebulæ; others are found to be large volumes of glowing gas and yet others are immense areas of interstellar dust illumined by giant stars.

Only two nebulæ can be seen with the unaided eye. The telescope, by the aid of photography, reveals planetary nebulæ, and both bright and dark irregular nebulæ within our own Milky-Way system of stars and in the Magellanic clouds (those nearest external galaxies beyond the Milky-

Way system known to man). Photographs taken by the largest telescopes reveal millions of spiral nebulæ which are distant Milky-Way systems of stars, each containing all the types of stars, planetary nebulæ, and irregular nebulæ which are found in our own Milky-Way system.

The planetary nebulæ are so named because they have a fairly definite boundary and may appear like a luminous disc or luminous ring; they always have at their center a hot star, whose radiation is richest in the ultraviolet rays.

The number of stars that can be seen in the whole sky with the unaided eye is between six and seven thousand; since we see only half of the sky at once, and since the region near the horizon is obscured by a more or less dense haze, we can seldom see more than about two thousand stars at a given time. With the help of the telescope, about eight hundred thousand stars have been seen individually, classified, and catalogued, while photography of the skies reveals thousands of millions.

The Milky Way or Galaxy, that great white band across the heavens, is made up of stars which are so far away that we cannot see them individually, but see only their diffused light. It is well called a "river of stars" flowing in a circle around our whole sky; and during the early hours of night, except in the months of spring, one-half of it is seen directly above us while the other half is hidden below us. If one observes the skies at a late hour of the night in early spring, a portion of the Galaxy can be seen then; since it is not visible in early evening hours, most observers do not see it during the spring months. The place of the Milky Way in the heavens seems fixed and eternal; any star within its borders is always seen at the same point. When the Northern Cross lifts itself toward the zenith we are able to see that near that constellation the star river divides into three streams with long, blue islands between.

Suggested Reading — *Astronomy for the Layman*, by Frank Reh; *Boys' Book of Astronomy*, by Goodwin D. Swezey and J. Harris Gable; *Consider the Heavens*, by Forest R. Moulton; *Exploring the Heavens*, by G. Clyde Fisher; *Handbook of the Heavens*, by Hubert J. Bernhard, Dorothy A. Bennett, and Hugh S. Rice; *Let's Look at the Stars*, by Edwin B. Frost; *Our Wonderful Universe*, by Clarence A. Chant; *Pathways in Science*, by Gerald S. Craig and Co-authors, Book 2, *Out-of-Doors*, Book 3, *Our Wide, Wide World*, Book 5, *Learning About Our World*, and Book 6, *Our Earth and Its Story*; *The Stars for Children*, by Gaylord Johnson; *The Stars for Sam*, by W. Maxwell Reed; *Science Stories*, by Wilbur L. Beauchamp and Co-authors, Books 1 and 2; *Through Space and Time*, by Sir James H. Jeans; *Through the Telescope*, by Edward A. Fath; *When the Stars Come Out*, by Robert H. Baker; *Wonders of the Sky*, by Mary Proctor; *The Young Folk's Book of the Heavens*, by Mary Proctor; additional references are to be found in the bibliography in the back of this Handbook.

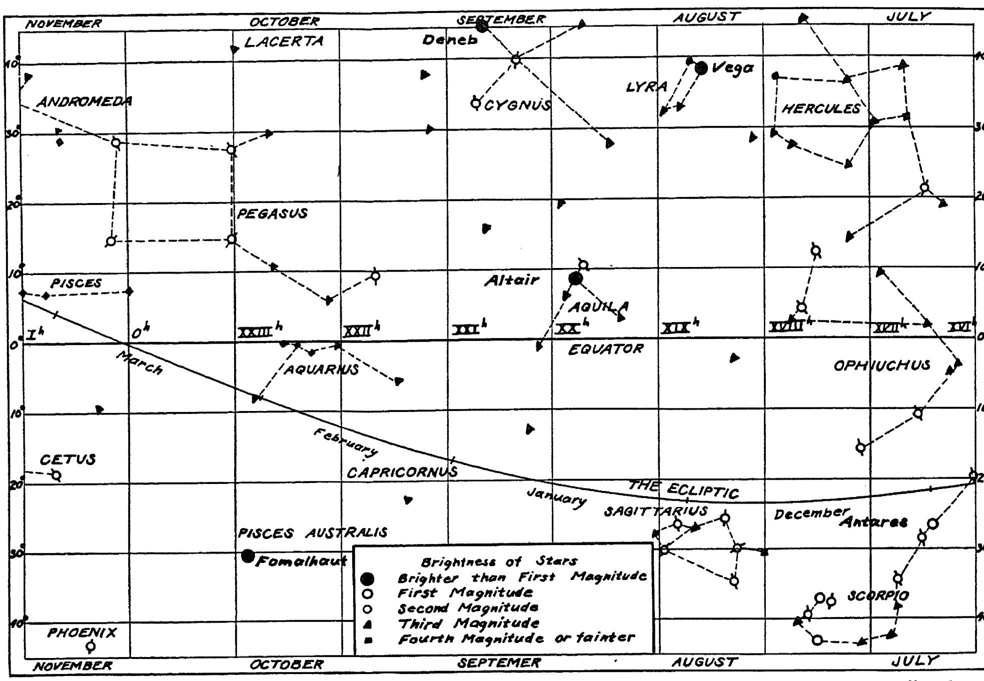
Books particularly useful in the study of stars:

Astronomy for Young Folks, by Isabel M. Lewis; *Astronomy from a Dipper*, by Eliot C. Clarke; *A Beginner's Star Book*, by Kelvin McKready (Edgar G. Murphy); *The Book of Stars for Young People*, by William T. Olcott; *Field Book of the Skies*, by William T. Olcott and Edmund W. Putnam; *The Friendly Stars*, by Martha E. Martin; *Introducing the Constellations*, by Robert H. Baker; *Our Stars Month by Month*, by Mary Proctor; additional references are to be found in the bibliography in the back of this Handbook.

HOW TO BEGIN STAR STUDY: THE CIRCUMPOLAR CONSTELLATIONS

THE POLESTAR AND THE DIPPERS

The way to begin star study is to learn to know the Big Dipper, and through its pointers to distinguish the Polestar; for whenever we try to find any star we have to find the Big Dipper and Polestar first, so as to have some fixed point to start from. There are four stars in the bowl of the Big Dipper and three in the curved handle. A line drawn through the outer two stars of the bowl, if extended, will touch the North Star, or Polestar. It is very important for us to know the Polestar, because the northern end of the earth's axis is directed toward it, and it is therefore situated in the heavens almost directly above our North Pole. For those of us who live in the Northern Hemisphere, the North Star never sets, but is always in our sky. Of course, the North Star has nothing to do with the axis of our earth any more than the figure on the blackboard has to do with the pointer; it simply happens to lie in the direction toward which the northern end of the earth's axis points. In the southern skies, there is no bright star which lies directly above the South Pole, so there is no South Polestar.



S. L. Boothroyd

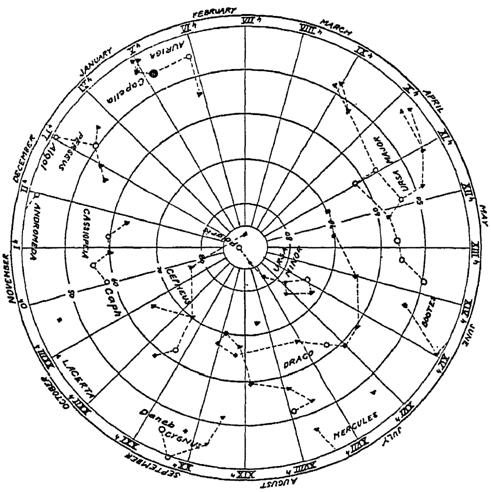
Stars of late summer and autumn

Key map to the sky as the observer in the Northern Hemisphere faces south. An observer in the Southern Hemisphere would need to face north and hold the map upside down.

On Sept. 1, 10 P.M., Sept. 15, 9 P.M., Oct. 1, 8 P.M., Oct. 15, 7 P.M., Nov. 1, 6 P.M., the regions shown in the center of the map are due south of an observer in the Northern Hemisphere and due north of an observer in the Southern Hemisphere. Use the map that represents the date nearest the time the observations are being made

The Polestar cannot be seen from the Southern Hemisphere; but if we should start from Florida, on a journey toward Baffin's Bay, we should discover that each night this star would seem higher in the sky. And if we should succeed in reaching the North Pole, we would find the Polestar directly over our heads, and what a wonderful sight the stars would be from this point! For none of the stars we could see would rise or set, but would move around us in circles parallel to the horizon.

The Big Dipper shows us the Polestar, and seems to revolve around it counterclockwise every twenty-three hours and fifty-six minutes; but of course this appearance is caused by the fact that we ourselves are revolving from west to east.



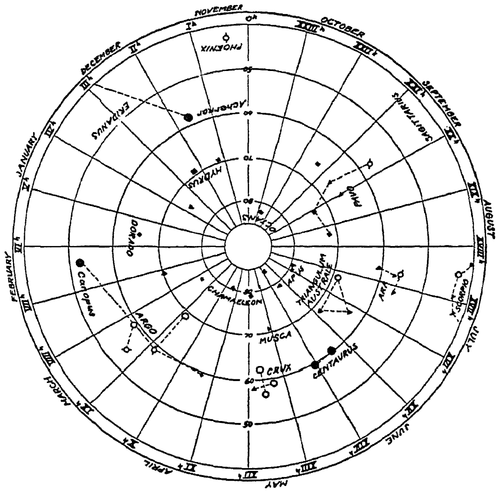
S. L. Boothroyd

North circumpolar chart. For observations about 9 P.M. Hold the map in such a way that the name of the month in which the observation is made is at the top of the map

Therefore, the stars seem to revolve counterclockwise about the Polestar as we face it. The fact that the sky makes one revolution in nearly four minutes less than twenty-four hours is due to the annual motion of the earth around the sun. The Big Dipper is seen east of the Polestar with handle down early in the evening in January, and it is seen west of the Polestar with handle up at the same time of evening in July; but the time of year that a certain star reaches a given point with reference to our horizon is so invariable that if we know star time, or sidereal time as it is called, we can tell just what hour of night it is when a star is at this point.

Thus, the Big Dipper and the other polar constellations are the night clock of the sailors of the Northern Hemisphere; for though this great polar clock has its hands moving around the wrong way, it gains time with such regularity that anyone who understands it is able to compute exact time by it.

The Little Dipper lies much nearer the Polestar than does the Big Dipper; in fact, the Polestar itself is the end of the handle of the Little Dipper. Besides the Polestar,



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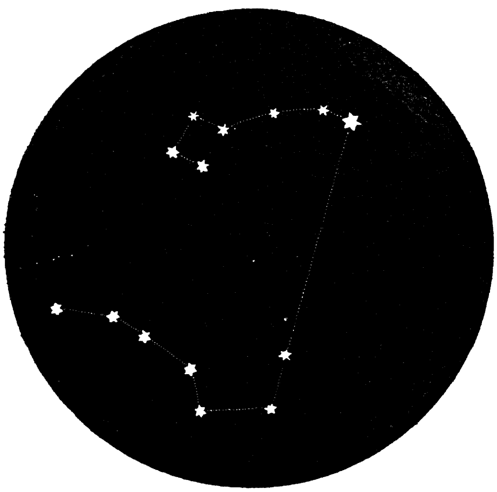
South circumpolar chart. For observations about 9 P.M. Hold the map in such a way that the month in which the observation is made occurs at the top of the map

there are two more stars in the handle of the Little Dipper, and of the four stars which make the bowl, the two that form the outer edge are much the brighter. The bowl of the Little Dipper is above or below the Polestar according to the hour of the evening and the night of the year, for it apparently revolves about the Polestar as does the Big Dipper. The two Dippers open toward each other, and as someone has said, "They pour into each other."

The Big Dipper is a part of a constellation called *Ursa Major*, the Great Bear; and the Little Dipper is the Little Bear, the handle of the dipper being the bear's tail.

There is an ancient myth telling the

story of the Big and Little Bears: A beautiful mother called Callisto had a little son whom she named Arcas. Callisto was so beautiful that she awakened the anger of Juno, who changed her to a bear; and when her son grew up he became a hunter, and one day would have killed his transformed mother; but Jupiter seeing the danger of this crime caught the two up into the heavens, and set them there as shining stars. But Juno was still vindictive,



The Polestar and the Big and Little Dippers

so she wrought a spell which never allowed these stars to rise and set like other stars, but kept them always moving around and around.

Suggested Reading — *Elementary Science by Grades*, by Ellis C. Persing and Elizabeth K. Peeples, Book 2; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 3, *Surprises; Star Myths from Many Lands*, by Dorothy Renick; also, readings on page 817.

LESSON 224

The Two Dippers

Leading Thought — The North Star or Polestar can always be found by the stars known as the pointers in the Big Dipper; the stars of the Big Dipper seem to revolve around the Polestar once in twenty-three hours and fifty-six minutes.

Method — The time to begin these observations is when the moon is in its last quarter, so that the moonlight will not pale the stars in early evening. Draw upon the blackboard, from the chart shown opposite, the Big Dipper and the Polestar, with a line extending through the pointers. Say to the pupils that this Big Dipper is above or below or at one side of the Polestar, and that you wish them to observe for themselves where it is and tell you about it the next day. After they surely know the Big Dipper, ask the following questions.

Observations — 1. Can you find the Big Dipper among the stars?

2. Is it in the north, south, east, or west?

3. Which stars are the "pointers" in the Dipper, and why are they so called?

4. Make a drawing showing how you can always find the Polestar, if you can see the Big Dipper.

5. How many stars make the bowl of the Dipper?

6. How many stars in the handle?

7. Is the handle straight or is it curved?

8. Does the Big Dipper open toward the Polestar, or away from it?

9. On the night of your observation was it above or below the Polestar at eight o'clock in the evening, or at the right or the left of it?

10. Does the Big Dipper remain in the same direction from the Polestar all night? Look at it at seven o'clock and again at nine o'clock and see whether it has changed position.

11. Do you think it moves around the Polestar approximately every twenty-four hours? In which direction? How could you tell the time of night by the Big Dipper and the Polestar?

12. Does the Big Dipper ever rise and set?

13. The Big Dipper is part of the Great Bear. Can you find the stars which make the bear's head and front legs?

After the pupils surely know the Big Dipper and Polestar, draw the complete diagram upon the board to show the Little Dipper and where it may be found, and call attention to the fact that the end of the Little Dipper's handle is the Polestar itself and that its bowl is not flaring, like that of the Big Dipper, and that the two pour into each other. Let the pupils find the Little Dipper in the sky for themselves and ask the following questions.

14. Is the Little Dipper nearer or farther from the Polestar than the Big Dipper?

15. How many stars in the handle of the Little Dipper?

16. How many stars make the bowl of the Little Dipper? Which of these stars are the brightest? Is the bowl of the Little Dipper above or below the Polestar?

17. Does the Little Dipper extend in the same direction in relation to the Polestar all night?

18. Make observations on the relation to each other of the two dippers at eight o'clock in the evenings of January, February, March, and April.

After the above lessons are well learned, give the following questions about Polaris (the North Star) and try to have the pupils think out the answers.

19. How many names has the Polestar? Can the Polestar be seen from the Southern Hemisphere? If not, why not?

20. If you should start from southern Florida and travel straight north, how would the Polestar seem to change position each succeeding night?

21. If you could stand at the North Pole, where would the Polestar seem to be?

22. If you were at the North Pole, would any of the stars rise and set? In what direction would the stars seem to move and why?

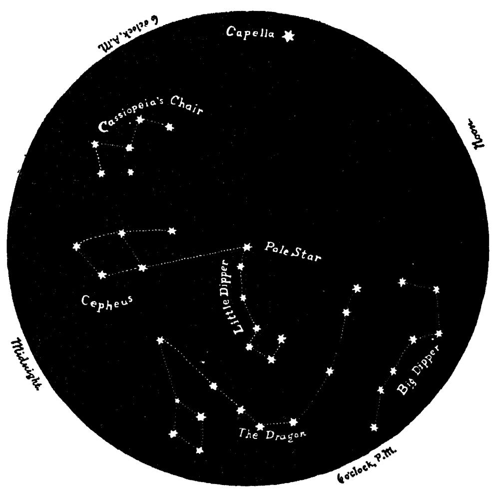
23. How does the North Star help the sailors to navigate the seas and why?

24. How do astronomers reckon distances between us and the stars? What is a light-year?

Topics for English Lesson — (a) What a star is. (b) What a constellation is. (c) How the stars and constellations received their names in ancient times. In ancient times the constellations which contain the Big and Little Dippers were named the Big and Little Bears, and those are their Latin names to this day. Write a story about what the ancient Greeks told about these Bears and how they came to be in the sky.

CASSIOPEIA'S CHAIR, CEPHEUS, AND THE DRAGON

There are other constellations besides the two Dippers which never rise and set in the latitude of central New York, because they are so near to the Polestar that, when revolving around it, they do not fall below the horizon. There is one very brilliant star, called Capella, which almost belongs to the polar constellations in this latitude but not quite, for it is far enough



The polar constellations as they appear at about 8 P.M. *on January* 20, *the Dragon being below the Polestar. By revolving this chart as indicated, the positions of the stars are shown for* 6 P.M., midnight, 6 A.M., *and* noon *of January* 20

away from Polaris to dip below the horizon for a few hours during each circuit around the Pole.

Queen Cassiopeia's Chair is on the opposite side of the Polestar from the Big Dipper and at about equal distance from it. It consists of five brilliant stars that form a W with the top toward Polaris, one-half of the W being wider than the other. There is a less brilliant sixth star which finishes out half of the W into a chair seat, making of the figure a very uneasy looking throne for a poor queen to sit upon.

King Cepheus is Queen Cassiopeia's husband, and he sits with one foot on the Polestar quite near to his royal spouse. His constellation is marked by five stars, four of which form a lozenge, and a line connecting the two stars on the side of the lozenge farthest from Cassiopeia, if extended, will reach the Polestar as surely as a line from the Big Dipper pointers. Cepheus is not such a shining light in the heavens as is his wife, for his stars are not so brilliant. Perhaps this is because he was only incidentally put in the skies. He was merely the consort of Queen Cassiopeia, who being a vain and jealous lady boasted that she and her daughter Andromeda were far more beautiful than any goddesses that ever were, and thus incurred the wrath of Juno and Jupiter who set the whole family "sky high" and quite out of the way, a punishment which has its compensations since they are where the world of men may look at and admire them for all ages.

Lying between the Big and Little Dippers and extending beyond the latter is a straggling line of stars, which, if connected by a line, make a very satisfactory dragon. Nine stars form his body and three his head, the two brighter ones being the eyes.

Suggested Reading — *Elementary Science by Grades*, by Ellis C. Persing and Elizabeth K. Peeples, Book 3; also, readings on page 817.

LESSON 225

Cassiopeia's Chair, Cepheus, and the Dragon

Leading Thought — To learn to know and to map the constellations which are so near the Polestar that they never rise or set in our latitude, but seem to swing around the North Star once in twenty-three hours and fifty-six minutes.

Method — Place on the blackboard the diagram given showing the Polestar, the Big and Little Dippers, and Cassiopeia's Chair, and ask for observations and sketches showing their position in the skies the following evening. After the pupils have observed the Chair and know it, add to your diagram first Cepheus and then the Dragon. After you are sure the pupils know these constellations, give the following lesson. The observations should be made early and late in the same evening and at different times of the month, so that pupils will in every case note the apparent movement of these stars around the Polestar.

Observations — 1. How many stars form Cassiopeia's Chair? Make a drawing showing them and their relation to the Polestar.

2. Is the Queen's Chair on the same side of the Polestar as the Big Dipper? Is the top or the bottom of the "W" which forms Cassiopeia's Chair turned toward the Polestar?

3. Does Cassiopeia's Chair move around the Polestar, like the Big Dipper?

4. How many stars mark the constellation of Cepheus?

5. Make a sketch of these stars and show the two which are pointers toward the North Star.

6. Does Cepheus also move around the Polestar, and in which direction?

7. Describe where the Dragon lies, and where his tail and his head are in relation to the two Dippers. Make a sketch of the Dragon.

8. Why do all the polar constellations seem to move around the Polestar every twenty-three hours and fifty-six minutes, and why do they seem to go in a direction opposite the movement of the hands of a clock? What do we mean by "polar constellations"?

Topics for English Themes — The Story of Queen Cassiopeia, King Cepheus, and their Daughter, Andromeda; The Story of the Dragon.

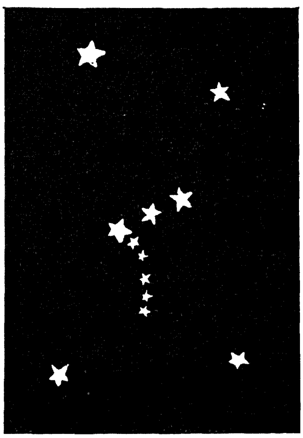
THE WINTER STARS

The natural time for beginning star study is in the autumn when the days are shortening and the early evenings give us opportunity for observation. After the polar constellations are learned, we are then ready for further study in the still earlier evenings of winter, when the clear atmosphere makes the stars seem more alive, more sparkling, and more beautiful than at any other period of the year. One of the first lessons should be to instruct the pupils how to draw an imaginary straight line from one star to another, and to perceive the angles which such lines make when they meet at a given star. A rule, or what is just as effective, a postal card or some other piece of stiff paper which shows right-angled corners, is very useful in this work. It should be held between the eyes and the stars which we wish to connect, and thus make us certain of a straight line and a right angle.

ORION (*o-ry'on*)

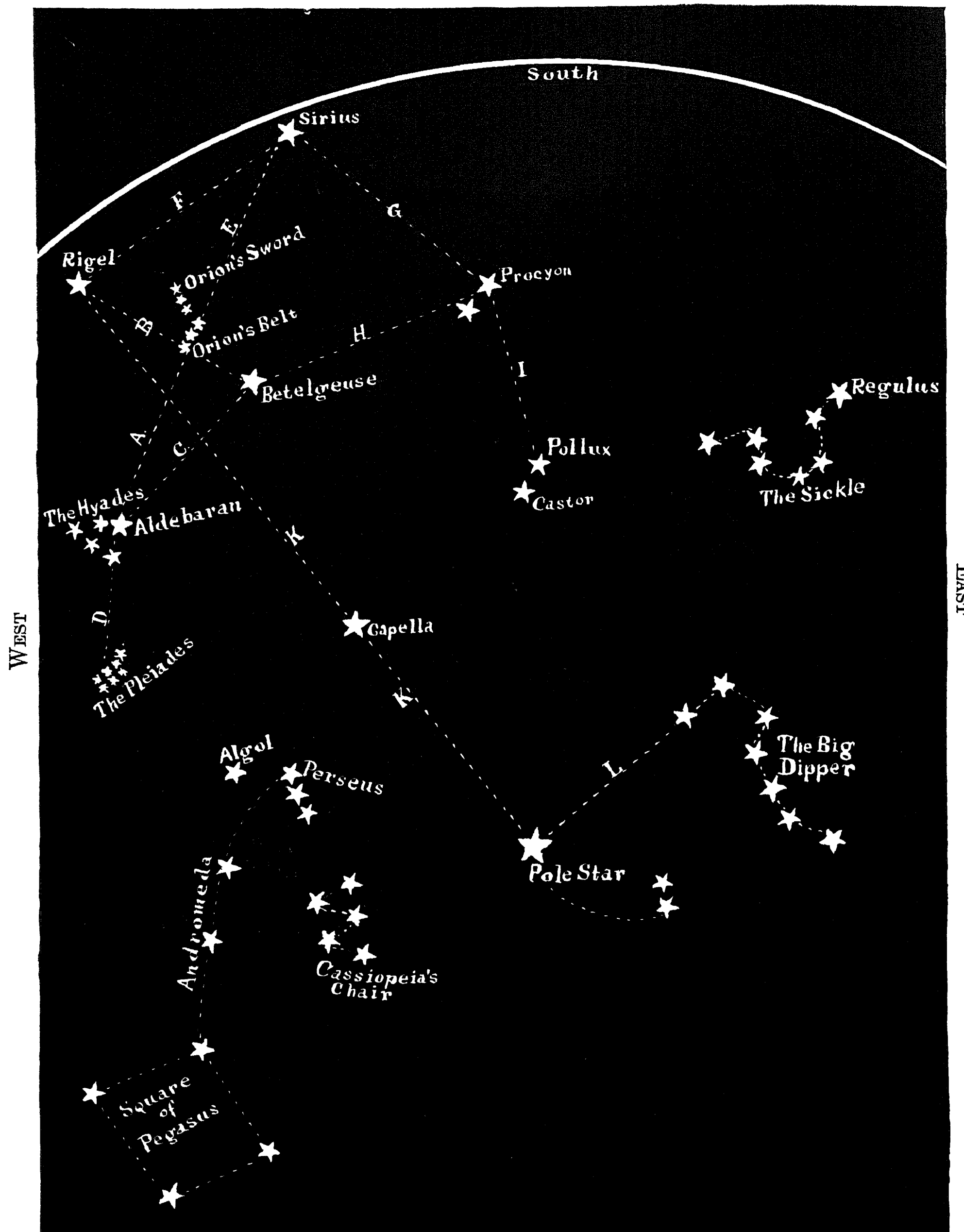
During the evenings of January, February, and March the splendid constellation of Orion takes possession of the southern half of the heavens; and so striking is it that we find other stars by referring to it instead of to the Polestar. Orion is a constellation which almost everyone knows; three stars in a row outline his belt, and a curving line of stars, set obliquely below the belt, outlines the sword. Above the belt as the constellation is seen in the evening sky of middle northern latitudes we can see the splendid red star Betelgeuse (*bet'el-jooz*), and below the belt, at about an equal distance, is the white star Rigel (*ry'jel*). West of the red star above, and east of the white star below, are two fainter stars, and if these four stars are connected by lines, an irregular four-sided figure results, which includes the belt and the sword. In this constellation the ancients saw Orion, the great hunter, with his belt and his sword; Betelgeuse was set like a glowing ruby on his shoulder, and the white star Rigel was set like a spur on his heel. Thus stood the great hunter in the sky, with his club raised to keep off the plunging bull whose eye is the red Aldebaran (*al-deb'a-ran*). And beyond him follows the Great Dog with the bright blue-white star Sirius (*sir'i-us*) in his mouth, and the Little Dog branded by the white star Procyon (*pro'si-on*). However, our New England ancestors did not see this grand figure in the sky; they called the constellation the Yard-ell or the Ell-yard.

The three beautiful stars which make Orion's belt are all double stars; the belt



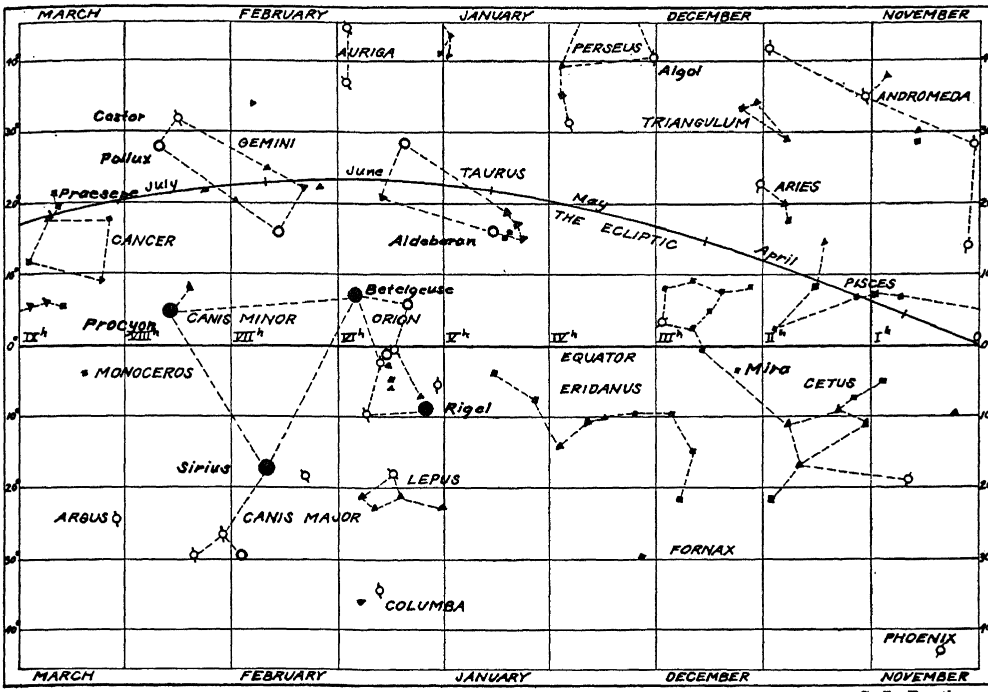
Orion, the three large stars in a line forming the belt, the curved line of smaller stars below forming the sword, Betelgeuse above to the left, Rigel below the belt, forming with Betelgeuse and the three stars of the belt a long narrow diamond in the sky

is just three degrees long and is a good unit for sky measurement. The sword is not merely the three stars which we ordinarily see, but is really a curved line of five stars; and what seems to be a hazy star, third from the tip of the sword is in fact a great nebula. Through the telescope this nebula seems a splash of light with six beautiful stars within it. Near latitude 40 degrees north, the first star in Orion to appear above the horizon is red



A diagram of the principal stars of winter as seen in early evening late in February

Betelgeuse, a blushing young giant just starting on its career as a star; it is composed of a gas much thinner than our air. Its diameter is 300,000,000 miles, which is more than one and one-half times that of the Earth's orbit. It is 200 light-years away from us. About fifteen minutes after Betelgeuse rises, and after the belt and sword are in sight, a white sparkling star appears 10 degrees to the south of the belt. This is Rigel, at a distance of 550 light-years. Seventeen thousand of our suns



S. L. Boothroyd

Stars of late autumn and winter

Key map to the sky as the observer in the Northern Hemisphere faces south. An observer in the Southern Hemisphere would need to face north and hold the map upside down

On Nov. 30, 12 P.M., Dec. 15, 11 P.M., Jan. 1, 10 P.M., Jan. 15, 9 P.M., Feb. 1, 8 P.M., Feb. 15, 7 P.M., March 1, 6 P.M., the regions shown in the center of the map are due south of an observer in the Northern Hemisphere and due north of an observer in the Southern Hemisphere. Use the map that represents the date nearest the time the observations are being made

would be required to send us the same amount of light if they were as far away as this lovely star.

Suggested Reading — *Elementary Science by Grades*, by Ellis C. Persing and Elizabeth K. Peeples, Book 3; also, readings on page 817.

LESSON 226

Orion

Leading Thought — Orion is one of the most beautiful constellations in the heavens. It is especially marked by the three stars which form Orion's belt, and the line of stars below the belt which form the sword.

Method — Place on the blackboard the outline of Orion as given in the diagram. Ask the pupils to make the following observations in the evening and give their report the next day.

Observations — 1. Where is Orion in relation to the Polestar?

2. How many stars in the belt of Orion? How many stars in the sword? Can you see plainly the third star from the bottom of the sword?

3. Notice above the belt, about three times its length, a bright star; this is Betelgeuse. What is the color of this star? What do we know about the age of a star if it is red?

4. Look below the belt and observe another bright star at about the same distance below that Betelgeuse is above. What is the color of this star? What does its color signify? The name of this is Rigel.

5. Note that west of the red star above and east of the white star below are two fainter stars. If we connect these four stars by lines we shall make an irregular four-sided figure, fencing in the belt and sword.

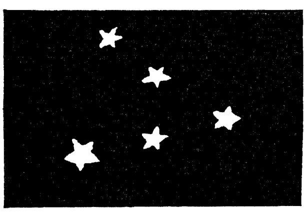
Sketch this figure with the belt and sword, and write on your diagram the name of the red star above and the white star below and also the name of the constellation.

6. Which star of the constellation rises first in the evening? Which last?

7. Write a story about Orion, the great hunter.

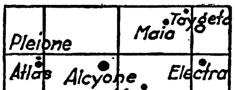
ALDEBARAN AND THE PLEIADES

Almost in a line with the belt of Orion, up in the skies northwest from it, is the rosy star Aldebaran. This star, which is also a ruddy young giant, marks the end of the lower arm of a V-shaped cluster



Aldebaran in the V-shaped cluster called the Hyades. This is a part of the constellation Taurus

composed of this and four other stars. This cluster is the Hyades (*hy'a-deez*). The Hyades is a part of the constellation called by the ancients Taurus, the bull, and is the head of the infuriated animal. Aldebaran is a comparatively near neighbor of ours, since it takes light only fifty-seven years to pass from it to us. It gives off about one hundred times as much light as does our sun; it lies in the path traversed by the moon as it crosses the sky, and is often thus hidden from our view when the moon occults the star.



The Pleiades, a well-known group of stars, with the visible stars named

Although we are attracted by many bright stars in the winter sky, yet there is a little misty group of stars, which has ever held the human attention enthralled, and of which the poets of all the ages have sung. These stars are called the Pleiades (*plee'ya-deez*); most eyes can count only six stars in the cluster. There are nine stars large enough to be seen through the field glass, and which have been given names; but sky photography has revealed to us that there are more than two thousand stars in this little group. Perhaps no stars in the heavens give us such a feeling of the infinity of the universe as do the Pleiades; for they form a great star system, known as an open cluster. These stars which look so close together to us are really so far apart that our own sun and all its planets could roll in between them and never be noticed. It would require several years for light to travel from one of these stars in the Pleiades to another. The Pleiades are so far from us that it takes light three hundred years to reach us from them. There is a mythical story that once the unaided eye could see seven instead of six stars in the Pleiades, and much poetic imagining has been developed to account for the "lost Pleiad." This myth is probably founded on fact.

LESSON 227

Aldebaran and the Pleiades

Leading Thought — The Pleiades seem to be a little misty group of six stars, but instead there are in it two thousand stars. Half way between the Pleiades and Orion's belt is Aldebaran, an adolescent ruddy star.

Method — Draw the diagram (p. 824) on the blackboard showing Orion, Aldebaran, and the Pleiades, and the lines B, C, D. Give an outline of the observations to be made by the pupils, and let them work out the answers when they have opportunity. Each pupil should prepare a chart of these constellations.

Observations — 1. Imagine a line drawn from Rigel to Betelgeuse and then another line just as long extending to the west of the latter at a little less than a right angle, and it will end in a bright, rosy star, not so red as Betelgeuse.

2. What is the name of this star? Write it on your chart.

3. Can you see the figure V formed by Aldebaran and four fainter stars? Sketch the V and show where in it Aldebaran belongs. This V-shaped cluster is called the Hyades.

4. Imagine a line drawn from Orion's belt to Aldebaran and extend it to not quite an equal length beyond it, and it will end near a "fuzzy little bunch" of stars which are called the Pleiades. Place the Pleiades on your chart.

5. How many stars can you see in the Pleiades?

6. Why are they called the seven sisters?

7. How many stars in the Pleiades are named, and how many does photography show that there really are in the group?

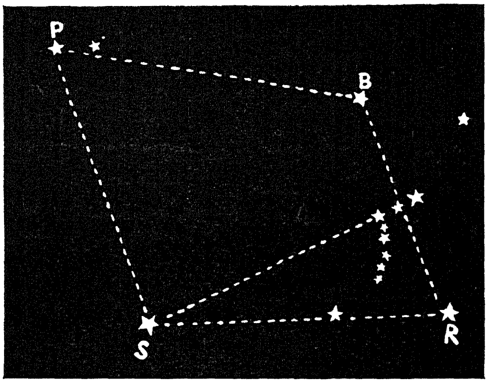
8. How far apart from each other are the nearest neighbors of the Pleiades?

THE TWO DOG STARS, SIRIUS AND PROCYON

If a line from Aldebaran is passed through the belt of Orion and is extended about as far on the other side, it will reach the Great Dog Star, following at Orion's heels. This is Sirius (*sir'i-us*) the most brilliant of all the stars in our skies, glinting with ever changing colors, sometimes blue, at others rosy or white. It must have been of this star that Browning wrote:

All that I know
Of a certain star
Is, it can throw
(Like the angled spar)
Now a dart of red,
Now a dart of blue.

Sirius has reached the blue white stage of star development. Although it is larger than our sun, and gives twenty-six times as much light as our sun, its superior brilliance is due to its nearness to us; it is only eight and three-fourths light-years away from us. It is the most celebrated star in literature. The ancients knew it, the Egyptians worshipped it, Homer sang of it, and it has had its place in the poetry of all ages.



Orion and the Dog Stars
B, Betelgeuse; R, Rigel; S, Sirius, the Great Dog Star; P, Procyon, the Little Dog Star

Procyon (*pro'si-on*) the Little Dog Star was so called perhaps because it trots up the eastern skies a little ahead of the magnificent Great Dog Star; it gives out five times as much light as our sun, and is only ten light-years away from us.

LESSON 228

The Two Dog Stars

Leading Thought — The Great Dog Star, Sirius, is the most famous of all stars in the literature of the ages. The two Dog Stars were supposed by the ancients to be following the great hunter, Orion.

Method — Draw upon the board from the chart shown on this page, the constellation of Orion with Sirius and Procyon. Ask the pupils to note that after Orion is well up in the sky a straight line drawn through Orion's belt and dropping down toward the eastern horizon ends in a beautiful blue white star, which is Sirius; and that if we draw a line from Betelgeuse to Rigel, from Rigel to Sirius, and then draw lines to complete a quadrangle, we shall find our lines meet at a bright star just a little too far away to make the figure a square, but making it somewhat kite-shaped instead. This is the Little Dog Star, Procyon, and it has a twin which can be seen near it. After giving these directions let the children make the following observations.

Observations — 1. How do you find Sirius? Which rises first, Orion or Sirius?

2. What color is Sirius? Judging from its color what stage of development do you think it is in?

3. Try to find out how large Sirius is compared with our sun and how near it is to us.

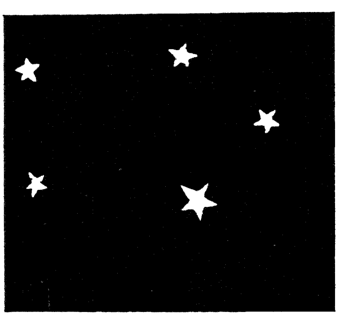
4. Why is Sirius called the Great Dog Star? Is the Little Dog Star nearer to the North Star than Sirius? Which is the brighter, the Great Dog Star or the Little Dog Star? Can you see any fainter star near Procyon? What direction is it from Procyon?

5. Why is Procyon called the Little Dog Star?

6. Make a chart showing Orion and the two Dog Stars.

CAPELLA AND THE HEAVENLY TWINS

Capella is nearer to the North Star than any other of the bright stars, and in the latitude of northern New York it is a circumpolar star. Its light very much resembles that of our sun, as does that of all

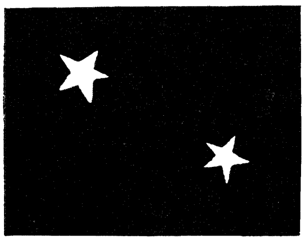


Capella in the constellation Auriga

the bright yellow white stars; but it is a much larger star. Capella is always a beautiful feature of the northern skies, being almost in the zenith during the evenings of January and February. It is in a brilliant shield-shaped constellation known as Auriga.

Capella is a double star; its two components give off 150 times as much light as our sun and it is forty-eight light-years away from us. If our sun were where Capella is, it would be barely visible to the unaided eye on a very clear night. These two components, which make up Capella as we know it, are removed from each other about the same distance as the earth and the sun. One revolves about the other in a period of 104 days. The attraction between these two massive suns is more powerful than the attraction between the earth and the sun; hence they race three and one-half times as fast in their orbits as does the earth.

During the winter evenings we see two stars set like glowing eyes almost in the zenith, and in a region of the sky where



Gemini, the heavenly twins: the larger one is Pollux, and the smaller, Castor

there are no other bright stars. These twin stars are set just a little closer together than are the pointers of the Big Dipper. To this brilliant pair the ancients gave the names of Castor and Pollux. Pollux is the brighter of the two and is the more southward in situation. Pollux and Castor were two beautiful twin boys who loved each other so much that, after they were dead, they were placed in the skies where they could always be near each other. Although Castor and Pollux seem so near together in the sky, they are separated by a distance of eleven light-years, Castor being that much farther away from us than Pollux.

The twin stars are supposed to exert a benign influence on oceans and seas and are, therefore, beloved by sailors. When a boy says " By Jimminy," he does not realize that he may be using an ancient expletive " By Gemini," which is the Latin name of these twin stars and was a favorite ancient oath, especially with sailors.

Castor is easily seen as a double star in a three-inch telescope. Each star of the pair is really two stars, as revealed by the spectroscope. There are also three other faint stars in the system, so Castor is really seven stars — a most remarkable system.

LESSON 229

Capella and the Heavenly Twins

Leading Thought — There are, during the evenings of January and February, three brilliant stars almost directly overhead. One of these is Capella; the other two are the Heavenly Twins.

Method — Place on the board the part of the chart (p. 824) showing the Big Dipper, Polestar, Capella, and the Twins. Draw a line, L, from the pointers of the Big Dipper, and extend it to the Polestar. Draw another line, K, from the Polestar at right angles to the line L, and on the side away from the Big Dipper's handle, and it will pass through a large, brilliant, yellow star which is Capella. Ask the pupils to imagine similar lines drawn across the sky when they are making their observations, and thus find these stars, and to place them on their charts, making the following observations.

Observations — 1. Is Capella as near to the Polestar as the Big Dipper? Is it near enough so that it never sets where you live?

2. Can you see the shieldlike constellation of which Capella is a part? Do you know the name of this constellation?

3. How do you find the Heavenly Twins after you have found Capella?

4. Why are these stars called the Heavenly Twins? What is their Latin name? What are the names of the two stars?

5. How can you tell the Heavenly Twins from the Little Dog Star and its companion?

6. Read in the books all that you can find about the Heavenly Twins. Try to find whether they are the same age, whether they are as near together as they seem, and whether they are going in the same direction. What sort of influence did the ancient sailors attribute to these twin stars?

THE STARS OF SUMMER

To us, who dwell in a world of change, the stars give the comfort of abidingness; they remain ever the same to our eyes and the teacher should make much of this. When we once come to know a star, we know exactly where to find it in the heavens, wherever we may be. A star which a person knows during childhood will, in later life and in other lands, seem a staunch friend and a bond, drawing him back to his early home and associations.

The summer is an inviting season for making the acquaintance of eight of the fifteen brightest stars visible in northern latitudes. Few midsummer entertainments rival that of lying on one's back on the grass of some open space which commands a wide view of the heavens. There with a planisphere and an intermittently lighted flashlight with which to consult it, learn by sight, by name, and by heart those brilliant stars which will ever after meet our uplifted eyes with friendly greeting. To teach the children in a true informing way about the stars, the teacher should know them, and nowhere in Nature's realm is there a more thought-awakening lesson.

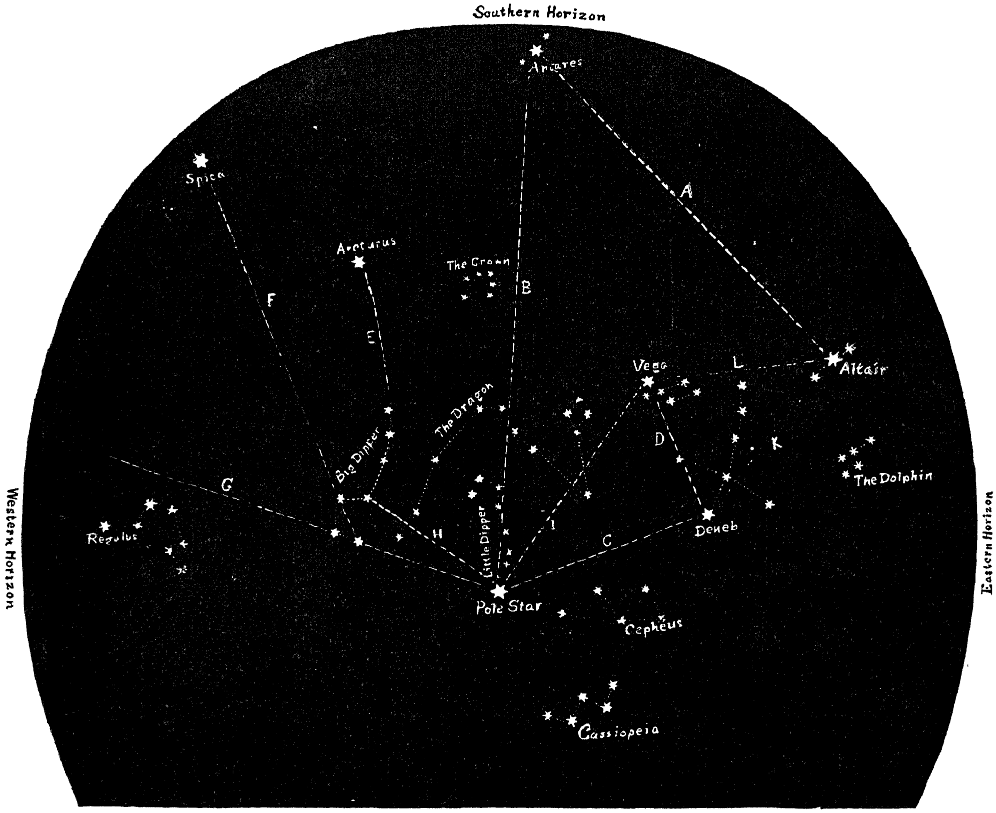
LESSON 230

The Bright Stars of Summer

Leading Thought — The stars we see shining during summer evenings are not the same ones that we see during the winter evenings, except those in the circumpolar constellations. There are eight of the brilliant summer stars which we should be able to distinguish and call by name.

Method — Begin by the middle of May when the Big Dipper is well above the Polestar in the early evening, and when, therefore, Regulus, Spica, Arcturus, and the Crown are high in the sky. The others may be learned in June, although July is the best month for observing them. In teaching the pupils how to find the stars, again instruct them how to draw an imaginary straight line from one star to another and to observe the angles made by such lines connecting three or four stars.

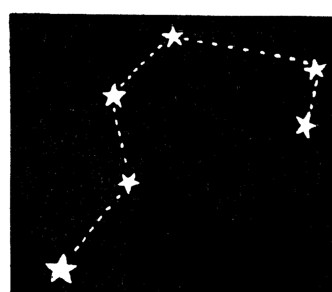
Place upon the blackboard the figures from the chart below, as indicated, leaving each one there until the pupils have observed and learned it. Then erase it and put on another figure. In each case try to get the pupils interested in what we know about each star, a brief summary of which is given. Note that the observations given in the lessons are for early in the evenings of the last of May, of June, and of early July.



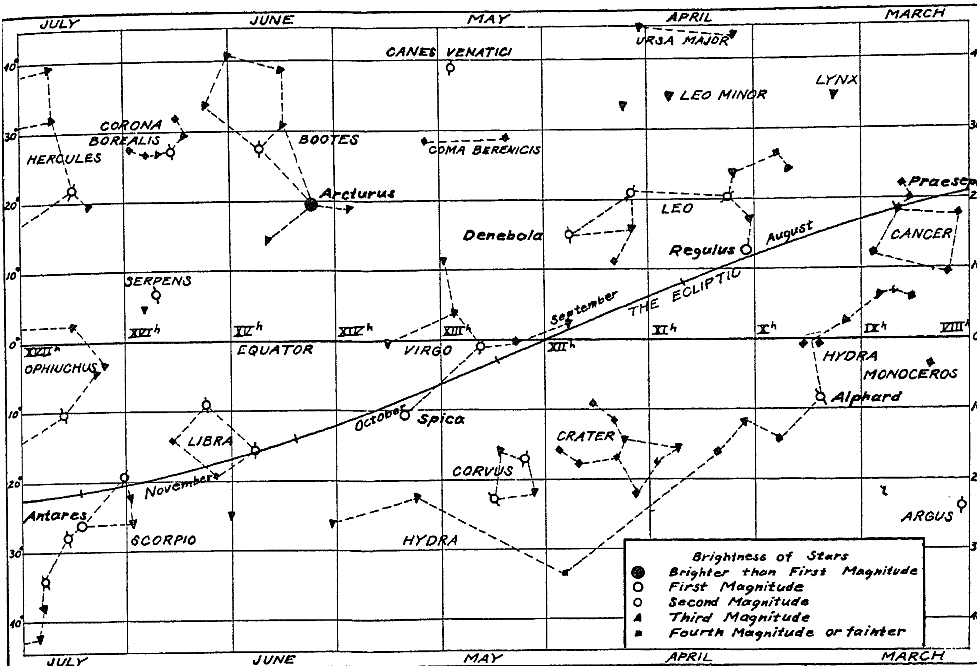
A chart of the brightest stars of summer, showing their positions in early evenings of June

Regulus (reg′yu-lus)

Draw upon the blackboard from the above chart the Polestar, the Big Dipper, the line G, and the Sickle, shown just below the outer end of the line. Extend the line that passes through the pointers of the Big Dipper to the North Star backward into the western skies; just west of this line lies a group of stars called the Sickle, and the stars that form it outline this implement. The Sickle has a jewel at the end of the handle, which is a white and diamond-glittering star called Regulus. It is a great sun giving out seventy times as much light as our own sun, and this light reaches us in about fifty-seven years. The Sickle is part of a constellation



Regulus, the large star in the handle of the sickle



S. L. Boothroyd

Stars of spring and summer

Key map to the sky as the observer in the Northern Hemisphere faces south. An observer in the Southern Hemisphere would need to face north and hold the map upside down

On April 1, 12 P.M., April 15, 11 P.M., May 1, 10 P.M., May 15, 9 P.M., June 1, 8 P.M., the regions shown in the center of the map are due south of an observer in the Northern Hemisphere and due north of an observer in the Southern Hemisphere. Use the map that represents the date nearest the time the observations are being made

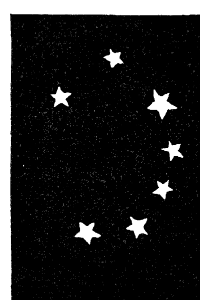
called the Lion, from which comes the shower of meteors which we see on the evenings from November 11 — 15. Regulus is seen best in the evening skies of spring.

Arcturus (ark-tu'rus)

Place on the blackboard the Big Dipper, the Polestar and the line E, Arcturus, and the Crown. Extend the handle of the Big

Arcturus and the Big Dipper

Dipper following its own curve for about its own length and it will end in a beautiful, orange star, the only very bright one in that region. It is one hundred times as bright as our own sun, but its light does not reach us for thirty-eight years after it is given off. Arcturus is a giant sun, having



The Northern Crown

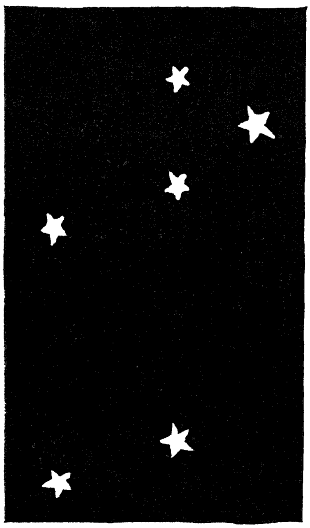
a diameter of nineteen million miles. During the latter part of June and July it is almost overhead in the early evening.

The Crown

Between Arcturus and Vega, but much nearer the former, is a circle of smaller stars that is called the Northern Crown, which because of its form is quite noticeable.

Spica (*spy′ka*)

Place on the blackboard the Big Dipper, Polestar, line F (Fig. p. 830), and Spica. To find Spica draw a line through the star on the outer edge of the top of the bowl of



Vega and her train of five stars

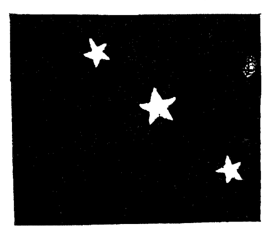
the Big Dipper, through the star at the bottom of the bowl next the handle, and extend this line far over to the southwest, during the evenings of June and July. (See p. 830.) Spica is a white star, and is the only bright one in that part of the sky. It is over two hundred light-years distant; 1,500 of our suns would be required to equal its brilliance at that distance. Spica is in the constellation called the Virgin.

Vega (*vee′ga*)

Place on the blackboard the Polestar, the Big Dipper, the lines H and I (Fig. p. 830), and Vega with her five attendant stars, as shown in the chart. Teach that these stars are the chief ones in the constellation called the Lyre. To find Vega, draw a line from the Polestar to the star in the Big Dipper which joins the bowl to the handle. Then draw a line at right angles to this (see chart lines H, I) and extend the line I a little farther from the North Star than is the end star of the Dipper handle; this line will reach a bright star, bluish in color, which can always be identified by four smaller attendant stars that lie near it and outline a parallelogram with slanting ends. Vega is the most brilliant summer star that we see in the Northern Hemisphere. It is a very large sun, giving out fifty times as much light as our sun; it is so far away that it requires twenty-six years for a ray of light to reach us from it. Vega's chief interest for us, aside from its beauty, is that toward it our sun and all its planets, including our earth, are moving at the rate of thirteen miles per second.

Antares (*an-ta′rees*)

Add to the last diagram on the blackboard the line E (Fig. p. 830), to Arcturus, the line B, and Antares. To find this star, draw a line half way between Arcturus and Vega from the Polestar straight across the sky to the south, and just above the southern horizon it will point to the glowing star, Antares, in the constellation of the Scorpion. Also a line drawn at right angles to the line connecting Altair with its companions and extending toward the south will reach Antares. Late June and July



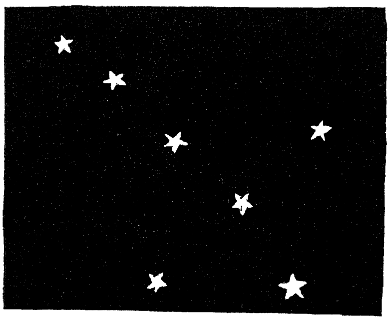
Antares, a brilliant star in the southern skies

about ten o'clock in the evening is the best for viewing this beautiful star. An interesting thing about Antares is that it is the greatest of the young giant stars yet measured; it has a diameter of 400,000,000 miles.

Deneb or Arided (*den′eb; a′ri-ded*)

Erase from the last diagram Antares and the line B. Add to it the lines C and D making a right angle at Deneb, and the

Cross — the head of which is Deneb, the foot ending near the letter on line L. This star is at the head of the Northern Cross, which is a very shaky looking cross and appears in the eastern skies during the evenings of June and July, with its upright arm nearly horizontal as seen in a middle northern latitude. Deneb is white in color

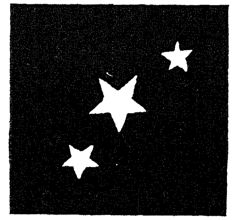


The Northern Cross, in the constellation of the Swan

and is a very large sun, because it seems to us a bright star although it is so far away from us that the distance has never been surely measured; but it has been estimated that a ray of light would need at least six hundred years to reach us from Deneb. It and the cross are a part of the constellation of Cygnus, or the Swan.

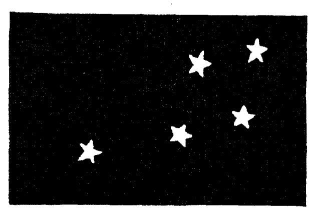
ALTAIR (al′ta-ir)

Add to the last diagram on the board the lines L, K, Altair and its two attendant stars, and the Dolphin. Emphasize the fact that Altair marks the constellation of Aquila, or the Eagle. This beautiful star is easily distinguished because of the small star on either side, all three being in a line. The three belong to a constellation called the Eagle, and may be seen in early evening from June to December. Altair,



Altair in the constellation of the Eagle

Deneb, and Vega form a triangle with the most acute angle at Altair. (See diagr. L, K.) Just northeast of Altair is a little diamond-shaped cluster of stars called the Dolphin, which is a good name for it, since it looks like a Dolphin, the fifth star forming the tail. It is also called Job's Coffin, but the reason for this is uncertain, unless Job's trials extended to a coffin which could not possibly fit him. If the line C on the chart drawn from the Polestar to



The Dolphin or Job's Coffin

Deneb be extended, it will touch the Dolphin. Altair is always low in the sky; it is a great sun giving off nearly ten times as much light as our own sun; light reaches us from it in fifteen years.

THE SUN

If, only once in a century, there came to us from our great sun light and heat bringing the power to awaken dormant life, to lift the plant from the seed and clothe the earth with verdure, then it would indeed be a miracle. But the sun by shining every day cheapens its miracles in the eyes of the thoughtless. While it hardly comes within the province of the nature-study teacher to make a careful study of the sun, yet she may surely stimulate in her pupils a desire to know something of this great luminous center of our system.

Our sun is a great shining globe about one hundred and ten times as thick through as the earth, and more than a million times as large. If we look at the sun in a clear sky, it is so brilliant that it hurts our eyes. Thus, it is better to look at it through a smoked glass, or when the atmosphere is very hazy. If we should see the sun through a telescope, we should find that its surface is not one great glare of light but is mottled, looking like a plate of rice soup, and at times there are dark spots to be seen upon its surface. Some of these spots are so large that during very "smoky weather" we can see them with the naked eye. In September, 1908, a sunspot was plainly visible; it was fifty thousand miles across, and our whole world could have been dropped into it with twelve thousand miles to spare all around it. We do not know the cause of these sunspots, but we know they appear in greater numbers in certain regions of the sun, above and below the equator. And since each sunspot retains its place on the surface of the sun, just as a hole dug in the surface of our earth would retain its place, we have been able to tell by the apparent movement of these spots how rapidly and in which direction the sun is turning on its axis; it revolves once in about twenty-six days and, since the sun is so much larger than our earth, a spot on the equator travels at a rate of more than a mile a second. There is a queer thing about the outside surface of the sun — the equator rotates more rapidly that the parts lying nearer the poles; this shows that the sun is a gaseous or liquid body, for if it were solid, like our earth, all its parts would have to rotate at the same rate. At periods of eleven years the greatest number of spots appear upon the sun.

Another interesting feature of the sun is the tremendous explosions of hydrogen gas mixed with the vapors of calcium and magnesium, which shoot out flames from twenty-five thousand to three hundred thousand miles high, at a rate of speed two hundred times as swift as a rifle bullet travels. Think what fireworks one might see from the sun's surface all the time! These great, explosive flames can be seen by the telescope when the moon eclipses the sun, and may be seen with the aid of a spectroscope at any time. Besides these magnificent explosions, there is surrounding the sun a glow which is brighter near the sun's surface and paler at the edges; it is a magnificent solar halo, some of its streamers being millions of miles long. This halo is called the Corona, and is visible only during total eclipses. By means of the spectroscope we know that there are about seventy chemical elements in the sun, which are the same as those we find upon our earth. The element helium which gets its name from Helios, the sun, was discovered in the sun by means of the spectroscope before it was isolated on the earth.

The sun weighs 330,000 times as much as the earth; the force of gravity upon its surface is twenty-seven and two-thirds times as much as it is here. A letter which weighs an ounce here would weigh almost a pound and three-quarters on the sun; and a man of ordinary size in this world would weigh more than two tons there, and would be crushed to death by his own weight. Find how much your watch, your book, your pencil, your baseball, and your football would weigh on the sun.

Suggested Reading — *Elementary Science by Grades*, by Ellis C. Persing and John A. Hollinger, Book 6; *Nature and Science Readers*, by Edith M. Patch and Harrison E. Howe, Book 6, *The Work of Scientists*, and Book 3, *Surprises*; *Romance of the Sun*, by Mary Proctor; *The Sun*, by Charles G. Abbot; also, readings on page 817.

Our Sun and Its Family — The Solar System

First of all we shall have to acknowledge that our great, blazing sun is simply a medium-sized star, not nearly so large as Vega nor even so large as the Polestar; but it happens to be our own particular star and so is of the greatest importance to us. The sun has several other worlds, more or less like our own, called planets; these planets revolve around the sun on almost the same level or plane in which our world revolves, but some of these worlds are much nearer the sun and others are much farther away than ours. See the diagram showing the orbits of planets, below, and page 836.

One peculiar thing about all the planets of the sun's family and all their moons is that they shine by reflecting the light of the sun, and none of them is hot enough to give off light independently; but these sister worlds of ours are so near us that they often seem larger and brighter than the stars which are true suns and give off much more light than our own sun. After a little experience the young astronomer learns to distinguish the planets from the true stars: the planets always closely follow the path of the sun and the moon through the sky; they often seem larger and brighter than the true stars and do not twinkle so much. The so-called morning and evening stars are planets of our sun's family and are not stars at all.

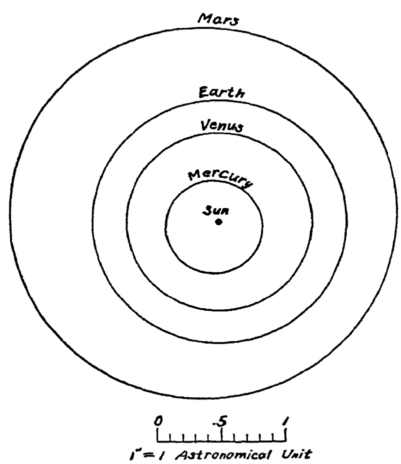
To determine which planets are morning or evening stars at a given time consult an almanac for the current year, or such a publication as *The Monthly Evening Sky Map*.

The planets in order of their relative distance from the sun are *Mercury*, *Venus*, *Earth*, *Mars*, *Jupiter*, *Saturn*, *Uranus*, *Neptune*, and *Pluto*.

The planet nearest the sun is *Mercury*; it was so named by the ancients because it travels very rapidly about the sun, and the god Mercury was very fleet-footed because of his winged slippers. It makes a circle about the sun in eighty-eight days; that means its year is eighty-eight days long. The amount of heat it receives is four and three-fifths to ten and one-fourth times greater than the amount received per unit area outside of the earth's atmosphere. Because Mercury follows the sun so closely, it is very difficult to observe; but it is possible to see it sometimes, quite near the horizon, as a morning or evening star.

Venus is the next planet in order of distance from the sun, and is called the twin sister of the earth; it is a little smaller than the earth, but has about the same amount of atmosphere, of a different composition. Venus is, to earth dwellers, the most brilliant object in the sky, with the exception of the sun and moon. It receives about twice as much heat and light from the sun as does the earth. The silvery light from Venus is so strong that on moonless nights it often casts shadows. Sirius, the brightest star in the sky, is only about one-twelfth as bright as Venus is at its brightest. This planet makes a circuit about the sun in a period of 225 days.

Our *earth*, with its year of 365¼ days, comes next. If we could view Earth from some other nearby planet, it too would shine by reflected light from the sun. If the earth and moon could be seen from Venus, when Venus and the earth are nearest each other, the moon would appear as bright as Venus at its best, and



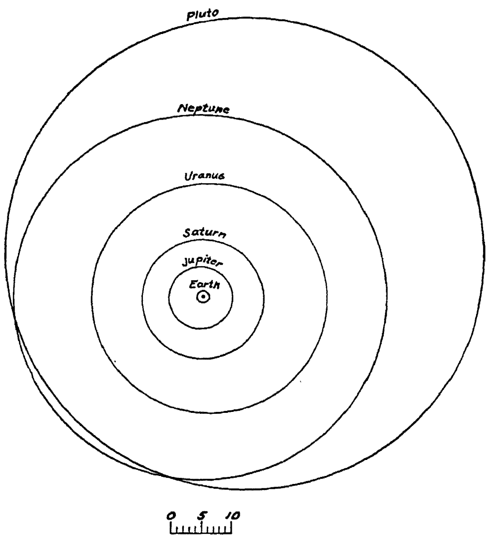
S. L. Boothroyd

The orbits of the Inner Planets. Note that each planet has an orbit which is not circular but is very nearly so

earth would be about eighty times as brilliant.

Mars is next in relative distance from the sun, but is so much farther from the sun that it receives only about one-half as much heat and light as does the earth, per unit of area outside of the earth's atmosphere. Polar caps may be seen on Mars, similar to those around our North and South Poles. A year on Mars is equal to 687 of our days or 669⅗ of its own. While Mercury and Venus have no satellites and the earth has only one, Mars has two; these satellites are named Phobos and Deimos. They are quite small; Phobos has a diameter of seven miles, and goes around Mars every seven hours, while Deimos has a diameter of sixteen miles and circles Mars every thirty hours. The diameter of our moon is 2163 miles, and it circles the earth every twenty-seven and one-third days. If you were on Mars, you would see Phobos rise in the west and set in the east, while Deimos would rise in the east and set in the west.

Mercury, Venus, Earth, and Mars as a group are relatively near the sun. Since



S. L. Boothroyd

The Outer Planets and their orbits. The orbits of these planets also are not circular but are nearly so

they are nearer the sun than other planets, they are called the Inner Planets. Because they are not greatly different in size from the earth and have earthlike surfaces they are also called Terrestrial Planets.

The remaining planets are larger than the ones just discussed, and as a group they are called the Major Planets. They are much farther from the sun and for that reason they are often called the Outer Planets. In contrast to the Terrestrial Planets, all except Pluto have immensely deep, cloudy atmospheres, and so we see only the outer layer of clouds, hundreds of miles deep, which completely hide their surfaces.

Beyond the Terrestrial Planets, there is a tremendous space in our solar system; in this space are to be found several hundred smaller bodies, called planetoids or asteroids. The next planet is *Jupiter*, found at a great distance from Mars. Jupiter is the largest of all the planets; its diameter is eleven times and its volume thirteen hundred times those of the earth. In reality, it is larger in mass and volume than all the other eight planets put together. About twelve years are required for the journey of Jupiter around the sun. The atmosphere of Jupiter seems very dense with vapors of ammonia and methane. Jupiter has eleven satellites, and three of them go around the planet in the opposite direction from the other eight satellites, which go around him from west to east as does our moon about the earth.

Saturn is located at a point nine and one-half times the earth's distance from the sun, and requires about twenty-nine and one-half years to go around the sun. This is the last planet that can be easily seen with the naked eye, and it appears about as bright as Arcturus; it has a definite orange tinge. This planet is surrounded by nine satellites and by multitudes of tiny particles which revolve in circular orbits, and are so numerous that seen from the earth they appear like flat rings encircling the planet. With even a small telescope the rings are quite evident, except when presented edgewise or nearly so.

Soon after *Uranus* had been discovered, the astronomers calculated its orbit and thereby found where it should be from day to day; but the planet did not behave as they thought it should. The astronomers decided there was a far-distant body pulling the planet Uranus from its computed orbit; they undertook to calculate the position of the body that must be causing the disturbance, and in 1846 two different men, working independently, discovered a new planet, *Neptune*, in the position calculated. Neptune requires nearly 165 years to complete a journey around the sun. One satellite, similar in size to our moon, accompanies Neptune on its long journey.

Even after Neptune had been discovered, Uranus still failed to follow the new orbit computed for it. A long series of computations followed, and in 1930 a new planet was located near the position predicted from the remaining discrepancies in Uranus' orbit. The name *Pluto*, suggested by a child in England, has been given to this planet. Its trip around the sun has been calculated to require about 248 years; it is about forty times as far from the sun as is the earth, and is quite likely one of several planets that may exist in the remote portions of the solar system. Careful photographic search, among the millions of faint stars, may reveal more distant planets in the future. Powerful spectrographs, aided by the light grasp of some of the great reflectors now or soon to be available, may reveal new and interesting wonders about the sun and his attendant planets.

Dr. Simon Newcomb in his delightful book, *Astronomy for Everybody*, gives the best illustration to make us understand the place of our sun and its planets and its relation to the stars in space. He explains that if here in the Atlantic States we should make a model of our solar system by putting an apple of four and one-half inches diameter down in a field to represent the sun, our earth could be represented by a mustard seed forty feet away revolving around the apple; and Neptune could be represented as a small pea circling around the apple at the distance of a quarter of a mile. Now that a planet more distant than Neptune has been discovered, the size of our solar system has been definitely increased and we shall need to consider Pluto in constructing our model. Pluto is forty times farther away from the sun than is the earth; so we shall need to represent Pluto by an object placed at a point 1600 feet from the apple which we have used to represent the sun. But to find the star nearest to our earth, the star that is only four and one-half light-years away from us, we should have to travel from this field across the whole of North America to California, and then take steamer and go out into the Pacific Ocean before we should reach our nearest star neighbor, which would be another sun like our own represented by a pair of apples.

A HAPPY FAMILY

The Sun, a great father, is hanging in space
With his children all playing around,
And each child is careful to play as it should,
Without commotion or sound.

Little Mercury stays near his father's side
And hangs on his every smile,
While he kicks up his tiny impertinent heels
And speeds over mile after mile.

Next to Mercury the beauteous one,
Venus, her father's delight,
Unrivaled reigns, without sceptre or crown,
The glorious queen of the night.

And Venus's twin, our own Mother Earth,
Though not considered so fair,
Must be great to observe on a clear night in June,
With the moonbeams astream through her hair.

Then next to the Earth comes little red Mars
With Deimos and Phobos at hand,
They swing into place and scamper around
Within the Zodiac band.

After Mars comes Jupiter, largest of all;
His father looks at him with pride;
And with the big giant his ten satellites
Come tripping in side by side.

Then Saturn rolls in his three pretty rings
While around him nine moons swarm;
He's next to his brother Jupiter in size
And his sister Venus in charm.

And out beyond Saturn are still other twins,
Uranus and Neptune, so far
That to either of them, astronomers say
Their father looks like a big star.

And Pluto finally comes out into view,
After aeons of hiding away;
Although he is quiet, secretive, and shy,
He merrily joins in the play.

But the Sun and his family will all stay in place
Right on to the end of time;
Nor does it disturb them one tittle or jot
This spinning them into a rhyme.

"MONTHLY EVENING SKY MAP,"
NANCY L. MOOREFIELD
(April 1937)

COMETS AND METEORS

COMETS

Besides planets and stars there are in space other bodies moving around our great star, the sun, and following paths shaped quite differently from those followed by our earth and its sister planets. We move around the sun nearly in a circle with the sun at the center, but these other heavenly bodies move in narrow oval orbits, the sun being near one end of the ellipse and the other end being much farther out in space, in some cases beyond our farthest planet. These bodies do not revolve around the sun in the same plane as our world and the other planets; indeed they often move in quite the opposite direction. The most noticeable of these bodies whose race-track around the sun is long instead of circular are the comets, and we know that some of these almost brush the sun when turning at the sunward end of their course. The astronomers have been able to measure the length of the race-tracks of some of the comets and thus tell when they will come back. Encke's comet, named after the German astronomer, makes its course in three and one-half years and this is the shortest period of any we know. When nearest the sun, it is just within the orbit of Mercury, and when farthest, it is about one hundred and ten million miles nearer the sun than Jupiter.

Lick Observatory

Halley's Comet, May 6, 1910. This photograph was taken in Chile

There are about five hundred comets whose courses have been thus determined; the longest accurately known period belongs to Halley's comet, which makes such a long trip that it comes back only once in seventy-six years; but there are other comets which travel such long routes that they come back only once in hundreds or even thousands of years. About twelve hundred comets have been discovered, many of them so small that they can only be seen with the aid of the telescope; and it has been found that in one instance, at least, three comets are racing around the sun on the same track.

A comet is a beautiful object, usually having a head which is a point of brilliant light and a long, flaring tail of fainter light, which always extends out from it on the side opposite the sun. The head of a comet must be nearly twice as thick through as the earth in order to be large enough for our telescopes to discover it. Some of the comet heads have been measured; one was thirty-one times, and another one hundred and fifty times as wide as our earth. If the heads are this large, imagine how long the tails must be! Some of them are far longer than the distance from our earth to the sun. The comet head decreases as it approaches the sun. The head of a comet is supposed to be a swarm of meteors with some gas, glowing by the reflected light of the sun. When in the end of the orbit near the sun, the gas which the comet contains absorbs the energy of the ultraviolet radiation of the sun and re-emits it as visible light; thus at such times the comet appears to be partly self-luminous. In fact, this gas has so little weight that light can push it; one would never believe that light could push anything, because we cannot feel it strike against us; but the physicists have found that it does push, and by pushing against the particles of the gas of comets it sends them streaming away from the sun, just as the heat appears to push out a flaring cloud of steam from the spout of a teakettle.

Comets have played an important part in history; they were formerly considered signs of the approval or wrath of God. The return of Halley's Comet appearing in 1066 struck terror to the Saxons and presaged the Norman conquest of England. The comet of 1811 was thought to warn us of the war of 1812 and Napoleon of his coming defeat. This was a wonderful comet illuminating our skies for a year and a half; its rosy head was veiled in a gaseous sphere, which with the head was larger than the sun. Some comets, which have failed to appear when expected, have their orbits marked by swarms of meteors.

Suggested Reading — *Romance of the Comets*, by Mary Proctor; also, readings on page 817.

Shooting Stars

When we look up during an evening walk and see a star falling through space, sometimes leaving a track of light behind it, we wonder which of the beautiful stars of heaven has fallen. But astronomers tell us that these so-called shooting stars are small pieces of solid material which are traveling around the sun in an orbit that intersects the orbit of the earth. Arriving at the point of intersection of the orbits, when the earth is there, they hit the upper atmosphere and become luminous. The flash of light, which we call the *shooting star*, is due to the heat resulting from the impact, just as a bullet melts when it hits a big rock. The difference between the small dust particle, which in reality is a meteor, and the bullet striking a big rock, is that the meteor strikes a lot of air molecules; one after another, the molecules become luminous by the impacts. The molecules of air become luminous along the path traveled by the meteor through a distance of some thirty to sixty miles through the rare upper atmosphere of the earth. For some time after the bright flash of light has vanished, one sees the numerous particles of the meteor left behind, and also the glowing air molecules which cause the luminous train as they persist in the path of a bright shooting star.

Meteorites sometimes weigh hundreds of pounds; one in the Yale Museum weighs 1,635 pounds. If it were not for the air, which wraps our globe like a great kindly blanket, and by its friction heats the meteors and reduces them to microscopic dust particles, no one could live on this earth; the meteors would pelt us to death. It is reliably estimated that during every twenty-four hours our world meets hundreds of millions of these meteors; some of them are no larger than fine shot and others weigh a few ounces. Occasionally meteorites which weigh from a few pounds to many tons do reach the earth. The origin of these is not certainly known; but some may be the larger particles which make up the nucleus of small comets. Others almost certainly come to earth from interstellar space.

The Relation between Comets and Meteors

Before we see the meteor as a shooting star, it is traveling around the sun in an orbit which intersected the orbit of the earth. It is very interesting to know that many meteors travel in swarms made up of a scattered assemblage of particles of matter; this matter once formed part of the head of a comet. Whenever the orbit of a comet intersects or comes very near the orbit of the earth, we get a shower of meteors if we are in that part of our orbit which is near the orbit of the comet. For instance, on May sixth the earth passes near the orbit of Halleys comet; we always get many meteors near that date whose paths seem to radiate from a point near the star Eta Aquarii. These meteors are known as Eta Aquarids.

In the same way the orbit of Tuttle's comet of 1862 intersects the orbit of the earth near the point where our planet is on about August 10. Since much of the original material of this comet is widely dispersed around its orbit, we get meteors of this swarm from about July 12 to September 1 of each year. As the paths of these shooting stars seem to radiate from a point in the constellation Perseus, they are called Perseid Meteors. The orbits of these meteors lie in a plane nearly at right angles to the earth's orbit plane. It is a very elongated orbit; at its farthest point from the sun it reaches nearly to the orbit of Pluto. Tuttle's comet and its associated meteors take 123 years to complete one circuit of the orbit. This is an unusually good meteor shower to observe, because the meteors are fairly abundant every year; many of them are bright enough to be seen even in the presence of the full moon, and besides this the August nights are comfortable nights for outdoor observations.

The most notable meteor shower is undoubtedly the Leonid shower; the paths of these meteors seem to come from a point near the curve of the Sickle, in the constellation Leo. These meteors are associated with Temple's comet of 1866; its orbit crosses the orbit of the earth at the place where we are about November 14. As the main meteor swarm is very compact, some spectacular meteor showers often occur when the earth encounters the main swarm, every thirty-three years. Some Leonid meteors are seen every year, near the middle of November. Some spectacular showers of Leonids occurred in 1799, 1833, and 1866, when meteors were counted by several observers, each watching small areas of the sky, at rates as high as 300,000 per hour. Historical records of spectacular showers of these meteors can be traced in Chinese annals, almost to New Testament times.

We are now nearly certain that all meteors whose paths as shooting stars seem to radiate from a small area on the sky were traveling in elliptical orbits about the sun, and hence were members of the solar system even before becoming a part of the earth. Such meteor showers take their names from the star or constellation in the area from which they seem to radiate.

There are, however, many meteors appearing all the time whose paths have no radiant, or central point of origin; recent observations indicate that all of these come to us from interstellar space. They are continually streaming through the solar system along hyperbolic orbits; those whose orbits intersect the orbit of the earth and arrive at the point of intersection when the earth is there, produce the flash of light we see as a shooting star. They thereby lose their identity as independent bodies and become a part of the earth. Judging by the number of meteors that strike the earth yearly, the number streaming through the solar system must run into millions of millions daily.

We thus learn from observation and the study of meteors that interstellar space is far from being completely devoid of matter. Occasionally one of these pieces of matter is so large that it is not completely disintegrated in its passage through our atmosphere, and solid pieces of it fall on the surface of the earth. Such an event is called a fall of meteorites and the pieces which fall are called meteorites.

THE RELATION BETWEEN THE TROPIC OF CANCER AND THE PLANTING OF THE GARDEN

By John W. Spencer

In years gone by, many farmers had a favorite phase of the moon when they planted certain crops, usually spoken of as the "dark" or the "light" of the moon. I once knew a woman who picked her geese by the "sign of the moon." Hogs were butchered in the "light" of the moon, and then the pork would not "fry away" so much in the skillet. It is true some pork from some hogs wastes faster than that of others, but the difference is due to the kind of food given the hogs. Many farmers hold to those old superstitions yet, but the number is much less now than twenty-five years ago. I wish I might impress on you young agriculturists that the moon has no influence on plant life, or pork, or geese, but the position of the sun most decidedly has. We have some plants that had best be planted when the sun's rays strike the State of New York slantingly, which means in early spring or late fall. We have other plants that should not be put in the open ground until the rays of the sun strike the state more direct blows, which means the hotter weather of summer. If I were in close touch with you pupils, I should be glad to tell some things that happen to three young friends of mine, hoping that thereby my statement might give the boys and girls an interest in three geographical lines concerning the tropics, and lead them to find their location on the map, particularly when later they learn what happens to my three young friends. There is one in Quito, Ecuador, of whom we will speak as Equator Shem; the one on the Island of Cuba is named Tropic of Cancer Ham; and the other in São Paulo, Brazil, answers to the name of Tropic of Capricorn Japhet.

What happens to these three boys, Shem, Ham, and Japhet, is this. At certain times of the year they have no shadow when they go home for dinner at noon. This state of affairs is no fault of theirs. It is not because they are too thin to make shadows. It is due to the position of the sun. If the boys should look for that luminary at noon, they would find it as directly over their heads as a plumb line. It is a case of direct or straight blows from rays of the sun, and, oh, how hot — hotter than any Fourth of July the oldest inhabitant can remember! These three boys are not hit squarely on the head on one and the same day. Each is hit three months after the other. The first boy to be hit this year in the above manner will be Equator Shem. The time will be during the last half of March. Can any of my young friends in this grade tell me the exact day of March that Equator Shem has no shadow? If no one of you can answer that question at this time, you had best talk it over with your friends, and bring your answers tomorrow. It happens at a time when our days and nights are of about equal length.

Another thing about this particular day is that our almanacs call it the first day of spring. All because no boy or anything else has a shadow on the equator at noon time. People and bluebirds and robins in the State of New York will see squalls of snow about that time, and there will be some freezing nights. But after the first day of spring the cold storms do not last so long as during December, January, and early February, when the sun's rays hit us with very glancing blows. Watch to see how much faster the sun melts the snow on the last days of March than it did at Christmas time. The light is also stronger and brighter, and plants in greenhouses and our homes have more life, and are not so shiftless, so to speak. Even the hens feel the influence, for they begin to lay more eggs and cackle, and down goes the price of eggs. Do not forget to learn what day in March spring begins, when the Equator boy finds it so hot that he would like to take off his flesh, and sit in his bones. After a few days, Equator Shem will find he again has a shadow at noon — a short one it is true, but it will get longer and longer each day. Now his shadow will be on the south side of him. Is this a queer thing to happen? On which side of you is your noontime shadow? I will give every one of you a red apple that finds it anywhere but on the north side of him at twelve o'clock. Every time the sun shines at noon, watch to find your old uncle in the wrong, and thereby get the apple. Each day that the shadow of Equator Shem becomes longer and longer, the noonday shadow of Tropic of Cancer Ham, living on the Island of Cuba, will be getting shorter and shorter, until at last there comes a day during the last of June when he, too, will have no shadow, and the almanac says that that day is the beginning of summer.

Now it will be the turn of the Tropic of Cancer Ham, on the Island of Cuba, to say the weather is hotter than two Fourths of July beat into one, and he too will wish that he could take off his flesh, and sit in his bones. Everybody in the State of New York will say that the first summer day is the longest day of the year. It is on this day that Equator Shem will have as long a shadow as *he* ever had in his life. No United States boy will ever be without a shadow at noon so long as he remains in his own country. When the eight o'clock curfew bell says it is time for boys and girls to go to bed, it will yet be light enough to read the papers. The sun not only sets late on that first summer day, but it appears early next morning. What a beautiful spectacle a sunrise in June is! Men of wealth will pay thousands of dollars for pictures showing its glory, yet I suppose that not one boy in five hundred ever saw the beauty of the birth of a new day in the sixth month of the year, and with no price of admission at that.

For only one day do the sun's rays fall directly on top of the head of Tropic of Cancer Ham, who lives on the Island of Cuba — just for one day, after which the up and down rays travel back towards the Equator Shem. On the twenty-third of September Shem again has no shadow at noon, and the almanac makers say that is the last day of summer, and tomorrow will be the first day of autumn. Again it is very hot where Shem lives, but the alligators and monkeys and the parrots do not seem to mind it. Where do the up and down rays of the sun go next? They keep going south, hunting for the boy named Tropic of Capricorn Japhet, to warm *him* up, as was the case with the boys in Cuba and at the Equator. The up and down rays do not find the top of the head of the lad in the City of São Paulo, Brazil, until the last part of December, just three days before Christmas, and then the almanac says this is the beginning of winter, and the shorter days of the year, when we in the State of New York light the lamp at five o'clock in the afternoon. Now, my boys and girls, do you understand why we have a change of seasons? Do you understand that the sun changes his manner of pitching his rays at us? That in winter, when he is over the head of the Tropic of Capricorn Japhet in São Paulo, and making summer on that part of the earth, to us people in the north, in the State of New York, he pitches only slanting rays that do not hit us hard, and have but little power? Thus you will see that the rays of the sun that strike the earth direct blows, swing back and forth like a pendulum, year after year, and century after century, coming north as far as Tropic of Cancer Shem, but no farther, and then swinging south as far as the boy named Tropic of Capricorn Japhet, and no farther, just stopping and swinging back again towards the north.

THE ECLIPTIC AND THE ZODIAC

By S. L. Boothroyd

Long before man began to write history, he noticed that the sun appeared to move all the way around the sky in a year. He noticed also that the yearly path among the stars was always the same. If the moon happened to be on the sun's path at the time of new moon, there was always an eclipse of the sun; and if the moon was on the same line at full moon there was always an eclipse of the moon. What was more natural than to call this line the Ecliptic? Since it was found by observation that the moon and the wandering stars which we now call planets, were always quite near this same line, it was perfectly natural that this band of the sky traversed by the sun, moon, and planets should seem especially important to early man. This region of the sky, a band 16° wide, 8° on either side of the Ecliptic, is called the Zodiac and the stars in it were, long ago, divided into twelve groups called constellations.

These constellations, in order, around the Ecliptic are: *Aries*, the Ram; *Taurus*, the Bull; *Gemini*, the Twins; *Cancer*, the Crab; *Leo*, the Lion; *Virgo*, the Virgin; *Libra*, the Scales; *Scorpio*, the Scorpion; *Sagittarius*, the Archer; *Capricornus*, the Sea Goat; *Aquarius*, the Water Bearer; and *Pisces*, the Fishes. What a collection of zoological specimens this is!

If one were to go from California to New York across the United States, he would pass through many states; as he left one state he would pass into the state to the east of the one he had just left. In the same way the sun in its annual eastward journey around the sky as he leaves one zodiacal constellation enters another.

A little more than two thousand years ago, when these zodiacal constellations were adopted, substantially as they are known to us, the sun just as it crosses the Equator, going north on about March 21, was entering Aries. We still call this point the first of Aries, and Aries the first sign of the Zodiac; but due to an effect we call "precession of the equinoxes" this point is now in the constellation Pisces.

At present, the sun is in the same constellation about a month later than it was when the zodiacal constellations were adopted; and furthermore, owing to slight changes in the boundaries of the constellations as we know them, the dates are not the same as given in the almanac.

Referring to star maps, pages 818, 825, and 831, the line marked Ecliptic is the sun's apparent annual path around the sky. On the maps the approximate time when the sun is in each of the constellations along the Ecliptic is given. If desired, more accurate dates may be found in the following table.

At present, the sun is in the given constellations during approximately the times indicated:

1. Aries	April 18	to	May 14
2. Taurus	May 14	"	June 21
3. Gemini	June 21	"	July 20
4. Cancer	July 20	"	Aug. 10
5. Leo	Aug. 10	"	Sept. 16
6. Virgo	Sept. 16	"	Oct. 31
7. Libra	Oct. 31	"	Nov. 23
8. Scorpio and Ophiuchus	Nov. 23	"	Dec. 18
9. Sagittarius	Dec. 18	"	Jan. 19
10. Capricornus	Jan. 19	"	Feb. 16
11. Aquarius	Feb. 16	"	Mar. 12
12. Pisces	Mar. 12	"	Apr. 18

It may be difficult for the pupils to learn to know all these constellations, as some of them are not very well marked; however, if they wish to learn them they can do so by the use of the planisphere. Some of the constellations of the Zodiac are marked by brilliant stars which have already been learned. Regulus is the heart of Leo, the Lion; Spica which means "ear" is the ear of wheat which the Virgin is holding in the constellation Virgo. Red Antares lies in the Scorpion; and the Milk Dipper, which is shaped like the Big Dipper, but smaller, marks Sagittarius. Red Aldebaran is the fiery eye of Taurus, the Bull, while Gemini, or the Twins, are the most conspicuous of the stars high overhead in the evening skies of February and March.

In almanacs one may see a table indicating the signs of the Zodiac; for a certain stated period the sun is said to be in a definite sign which corresponded to the region traversed by the sun at the time these Zodiacal constellations were adopted. Each of the twelve Zodiacal constellations constitutes a sign. The times given in these signs are those that were used by the ancients.

The following lines will aid one in becoming familiar with the relative positions of the zodiac:

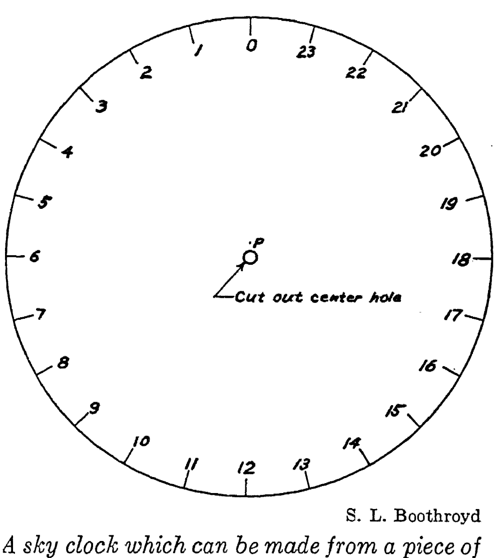
The Ram, the Bull, the Heavenly Twins
And next the Crab, the Lion shines,
The Virgin and the Scales.
The Scorpion, the Archer and He-goat,
The Man that holds the Watering-pot,
The Fish with glittering tails.

THE SKY CLOCK

By S. L. Boothroyd

Since the sky, to a northern observer, appears as a vast sphere which turns at a uniform rate about the line joining the observer's eye to Polaris it is evident that the turning of the sky may be used to measure the passage of time. Of course, the stars appear as fixed points upon this sphere.

Everywhere on the earth, north of 33° north latitude, the five bright stars of Cassiopeia and all the stars of the Big Dipper, except the two farthest from Polaris, are always above the observer's horizon.



S. L. Boothroyd

A sky clock which can be made from a piece of heavy firm paper

All the stars on the sky appear to move as though they were bright points on the surface of an immense sphere. To a person facing Polaris the sky seems to be rotating counterclockwise about the line joining his eye to Polaris. It rotates at such a rate that the line joining Polaris to any star appears to revolve through 360 degrees in 23 hours 56 minutes and 4 seconds. This is the rate of rotation of the earth on its axis. Since this apparent rotation of the sky about the line joining the observer's eye to Polaris takes place at a perfectly uniform rate, we may regard the sky about the North Star as the face of a great sky clock.

It is most convenient to consider the hour hand of this sky clock as the line joining Polaris to the star Caph (*caf*) in Cassiopeia. See the north circumpolar star map. The dial of this sky clock must be considered as a circle drawn around Polaris as a center, and the figures on the clock face go around the dial in the opposite direction from those on an ordinary clock. Also the clock has 24 divisions or hours on its face instead of 12. The 0 or 24 hour division is straight above Polaris and the 12 hour division is straight below the same star. The left half of the dial is then numbered from 0 (or 24) at the top to 12 at the lowest point straight below Polaris, and the right half of the dial is numbered from 12 at the lowest point to 24 (or 0) at the top.

One then imagines this dial printed on the sky, and to get the star time simply notes where the line from Polaris to Caph crosses the face of the dial. As an aid to observing the star time with fair accuracy, make a dial on a piece of stiff white bristol board, cut in a circle one foot across. Make a hole one-half inch in diameter at the center of the dial. Divide the circumference into 24 equal spaces and number the divisions, with black waterproof ink, from 0 to 23. Fasten a piece of black string 8 inches long on a line from the center of the dial to a point about one inch above the center and fasten to the other end a bullet or a washer so the string will hang plumb when the dial is held up to the observer as he faces the Polestar. Hold the dial up so that Polaris can be seen through the hole in the center; then turn the dial around the line leading from the eye to Polaris until the plumb line falls directly over the line from the center to the 12 hour mark on the dial. At this moment, note where the line from Polaris to Caph crosses the dial; the reading of the dial at this point is *star time*, called *sidereal time* by the astronomer. This time is used also by sailors and others who often need to calculate time without the use of the customary timepieces.

Suppose that on an August evening one has found (with the aid of the dial just described) the time to be 19 hours. The observer will now locate the line marked XIX on the equator of the Equatorial Star Map and the line marked XIX extending from the center to the boundary of the Circumpolar Star Chart. These lines indicate the line on the sky which at that moment passes from Polaris directly overhead to the south part of the horizon. Again, if the star time read on the dial is 20 hours, then the line from Polaris to XX on the boundary of the Circumpolar Star Chart, and the line marked XX on the equator of the Equatorial Star Chart, are at that moment the line on the sky which passes from Polaris through the zenith to the south part of the horizon. It makes no difference what the day of the year happens to be; a person can, by using his dial, observe the star time and tell just what part of the sky as shown on the star map is on his celestial meridian, as the line from Polaris through his zenith to the south part of the horizon is called. The ability to get star time thus enables one to use his star maps more effectively as aids in learning to know the constellations and stars.

We must bear in mind that the time we use is standard time. This time is the local mean time for a given meridian, usually a meridian that is a multiple of 15 degrees from Greenwich, England. The Eastern standard time is the mean time for the 75° meridian west of Greenwich. It is therefore 5 hours slower than Greenwich time. If a standard meridian were 75 degrees east of Greenwich its time would be 5 hours faster than that of Greenwich.

Unless one lives exactly on the meridian that is the basis for the time that is used in his particular time belt, he is not using the *exact* time indicated by the position of the sun. He is using *standard time* and the time indicated by the mean sun is known as *local mean solar time*. It is easy to find the *local mean solar time* for any location after one has determined, by means of the sky clock, the star time. The following rule is used:

Subtract from the star time observed, a number of hours which is twice the number of months since March 23 and the remainder will be the number of hours since the observer's preceding local mean noon. If the observed star time is less than twice the number of months since March 23, add 24 hours to the observed time before subtracting.

Following are examples to illustrate the use of the sky clock:

1. Suppose that on the night of August 18, at Ithaca, New York, the sky clock was read. The part of the sky between the

lines marked XIX and XX on the star maps was on the celestial meridian and the star time was observed to be 19 hours and 40 minutes.

August 18 is 4 months and 25 days after March 23, or 4 25/30 months. This number of months multiplied by 2 equals 9 2/3.

This number expressed as hours and minutes equals 9 hours and 40 minutes and when this number is subtracted from the observed star time, 19 hours and 40 minutes, the remainder is 10. This figure represents the number of hours since the observer's local mean noon, or 10 P.M. by local mean solar time.

2. Suppose on the night of January 27 at Boston, Massachusetts, the sky clock was read, and the part of the sky between the lines marked VII and VIII on the sky maps was on the celestial meridian. The star time was observed to be 7 hours and 20 minutes.

January 27 is 10 months and 4 days after March 23 or 10 4/30 months after March 23. This number of months multiplied by 2 equals 20 4/15. This number expressed as hours and minutes equals 20 hours and 16 minutes. Since 20 hours and 16 minutes is larger than the observed star time, 7 hours and 20 minutes, 24 hours must be added to 7 hours and 20 minutes making 31 hours and 20 minutes; 31 hours and 20 minutes minus 20 hours and 16 minutes equals 11 hours and 4 minutes. Hence the observation was made 4 minutes after 11 on the night of January 27, local mean solar time.

If the observer wishes to express this "local mean solar time" in the "standard time" for the belt in which he lives, one more step must be taken. It is necessary to determine the longitude of the place where the observations are being made. The longitude is expressed in degrees; it can be easily determined by use of a map. By consulting a map which shows the standard time belts, determine what meridian is used as the standard meridian of the time belt in which the observations are being made; next determine how far east or west of the standard meridian the observer is located. For each degree there will be a difference of 4 minutes of time; that is, if the observer is 1 degree east of the standard meridian, his local mean solar time will be 4 minutes faster than standard time. If he is 1 degree west of the standard meridian, his local mean solar time will be 4 minutes slower than standard time. Therefore, if local mean solar time has been found, the standard time can be easily found provided one knows the longitude of the place where the observations were made. Four minutes will be added to the standard time for each degree the observer is located east of the standard meridian; 4 minutes will be subtracted from standard time for each degree the observer is located west of the standard meridian. Thus, it will be seen that the local mean solar time will be faster than standard time if east of a standard meridian and slower than standard time if west of a standard meridian.

Let us refer to the examples given on this and the preceding page; note that the reading of the sky clock in Example 1 was taken at Ithaca, New York. This town has a longitude of 1½ degrees west of the 75th meridian; it is in the Eastern standard time belt, whose standard meridian is 75 degrees. Therefore, since Ithaca is 1½ degrees west of the standard meridian, its local mean solar time would be 6 minutes slower than standard time. Boston, at which point the sky clock was read in Example 2, is at a point 4 degrees east of the 75th meridian; therefore its local mean solar time would be 16 minutes faster than standard time.

THE EQUATORIAL STAR FINDER

By S. L. Boothroyd

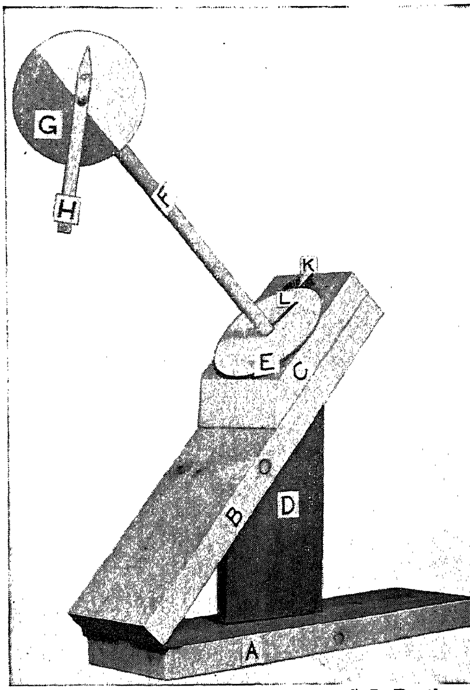
The line marked Equator on the star maps is the line in which the plane of the earth's equator extended outward meets the sky. By means of a very simple homemade device, which we call an equatorial star finder we can locate visible stars and the equator of the sky, or the Celestial Equator as it is called.

Directions for Making and Operating the Equatorial Star Finder

Cut pieces *A*, *B*, and *C* from a piece of plank 2 by 8 inches which has been planed and smoothed off on all sides; it should then be about 7½ inches wide and 1⅞ inches thick. Pieces *A* and *B* are each about 2 feet long with the ends accurately squared. Piece *C* is cut square on one end and on a bevel on the other end, the face in contact with *B* being about 11 inches long and the upper face being about 9½ inches long. Pieces *A* and *B* are hinged together at one end so that their inner faces will be everywhere in contact when the hinges are closed. Block *C* is nailed or screwed to piece *B*, as shown in the illustration. A ⅞ inch hole is bored into C at right angles to its upper surface and extending to within ¼ inch of the lower surface of piece *B*. The center of this hole must be 6 inches from the upper edge of the upper face of *C* and at the center of the face. The use of a press drill will insure the hole being at right angles to the face of *C* and will also prevent the hole being bored entirely through *B*.

Into this hole is inserted the polar axis, *F*, of the star finder. This can be made from a piece of broom handle which is very straight, and can be filed or sandpapered to accurately fit the hole in *C*, so that it will not wobble when pushed to the bottom of the hole and yet will be free to turn on its axis without undue effort.

Disc *E* is a circular piece of masonite, 7⅛ inches in diameter, in the center of which is bored a hole, ⅞ inch in diameter. The polar axis will just go through this hole and allow the disc to be turned on this axis, and yet be tight enough not to turn of its own accord. On the top face of disc *E* is glued a specially graduated protractor on which are printed the positions of 40 bright stars as projected on the equator plane of the celestial sphere. This protractor sheet[1] is shown in the first illustration on page 848. When this protractor sheet is glued to the disc above mentioned, we shall call disc *E* the "hour disc" of the star finder.



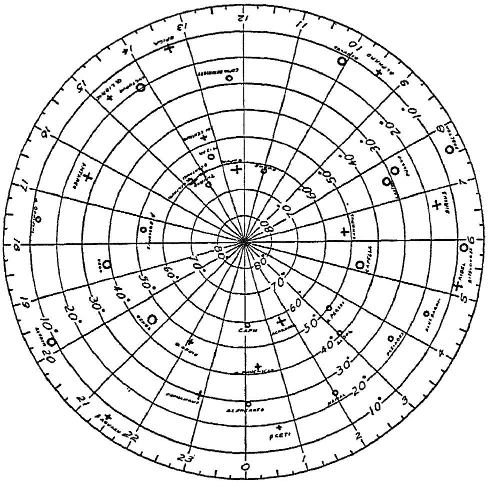
S. L. Boothroyd

The equatorial star finder. See pp. 847–50 for instructions for making and using it

Flatten the upper 6 inches of one side of the polar axis, *F*, cutting a maximum

[1] The protractor and hour disc may be obtained from the Comstock Publishing Company, Inc., Ithaca, New York for 10¢.

depth of ⅛ inch from the round stick. G is another disc of masonite of the same size as disc *E*, 7⅛ inches in diameter. G is nailed to the polar axis so that a diameter of the disc lies accurately along



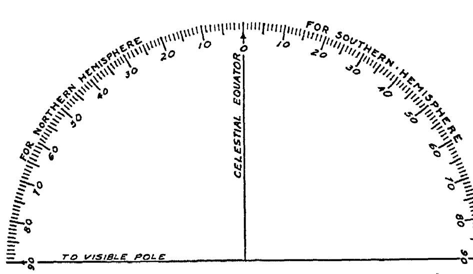
S. L. Boothroyd

Hour disc, E

the flattened face of the upper end of the polar axis, *F*. Now bore a ¼ inch hole through the center of disc G and through the axis of the polar axis, *F*, and at right angles thereto. Glue to disc G the declination protractor shown in the illustration opposite. Be sure to glue this to disc G so that the arrow marked *to visible pole* points upward when the polar axis, *F*, is vertical. This disc, *G*, with its declination protractor glued to it will be called the " declination disc."

Next, prepare the star pointer, *H*. Use a piece of wood ⅝ inch wide, ⅛ inch thick and 10 inches long; symmetrically point one end and bore a ⅛ inch hole three inches from the point and in the center of the piece. A ⅛ inch bolt through this and through the ⅛ inch hole bored through the declination disc, G, and the polar axis, *F*, will pivot this pointer, *H*, to the upper end of the polar axis, *F*, as shown in the illustration. Put washers under the head of the bolt, under the nut, and between the star pointer, *H*, and the declination disc, G. Screw the nut tight enough so that the star pointer, *H*, will remain in any position, and so that it is not too hard to turn. It is well to put a lock washer on to prevent the nut coming unscrewed. Insert screw eyes on the center line of this pointer, near its ends, and the pointer, *F*, is complete.

Next, rotate the star pointer, *H*, on its axis until it points at 0 degrees on the declination disc, G. Then rotate the polar axis, *F*, until the star pointer is parallel to the long side of piece *B*, and is pointing away from the hinges. Now hold the polar axis, *F*, so that it will not turn on its axis and rotate the hour disc, *E*, until the 0-hour-to-12 hour line is parallel to the star pointer, *H*, with the 0 hour point under the point of the star pointer, *H*. Cut an arrow point, *K*, from a piece of durable paper and glue it to a small piece of masonite to bring it on a level with the graduated face of the hour disc, *E*. Place the arrow point at the outer edge of the hour disc, *E*, with the point of the arrow at the end of the 0 hour line and pointing to the center of the hour disc, *E*. Next bore a hole in the polar axis, *F*, radially in from where the 0 hour line of the hour disc, *E*, meets the polar axis when all has been adjusted as has been explained. This hole should be a little smaller than a six-



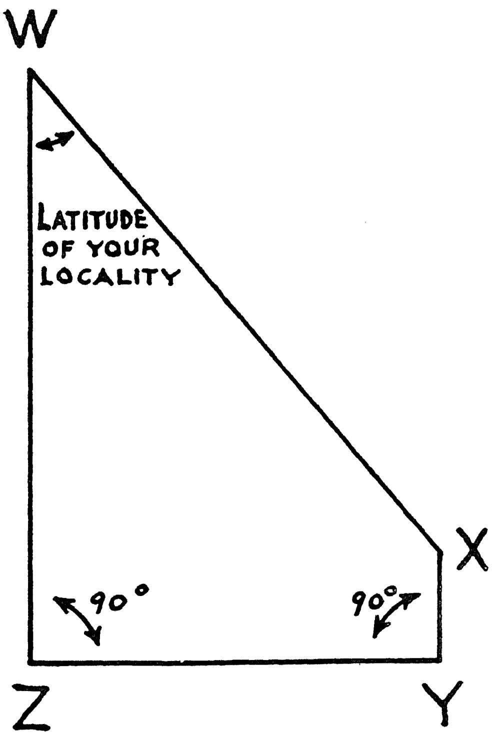
S. L. Boothroyd

Declination disc, G

penny finishing nail and should be about ⅜ inch deep. A nail when inserted in this hole, with the instrument adjusted as directed, will be over the 0 hour line of the hour disc, *E*. It will be well to file off the head of the nail to a blunt point, after the nail has been snugly driven into the hole which was bored to receive it. We shall call the nail the *right ascension pointer, L.*

Lastly, prepare a piece of ⅞ inch thick board for piece *D*, in illustration page 847. The preparation of this is best explained by showing a side view of it with all the necessary dimensions and angles given on the diagram below.

The degrees in angle W should be equal to the latitude of the locality where the instrument is to be used. Angles Y and Z



The equatorial star finder, piece D

are always 90°. Angle X is equal to 180° minus latitude of the locality where the instrument is to be used. Line ZY is always 8 inches. Line XY may be made about 4 inches; then the other lines are fully determined if the angles are laid out as specified.

With piece A on a horizontal surface, rotate *B* about the hinges until *D* can be placed with side ZY in contact with the upper face of piece A and side WX in contact with the lower face of piece *B*. Piece *D*, when accurately constructed for latitudes between 30° and 90°, will stay in place without anything but friction between the surfaces to hold it in place. For latitudes below 30°, piece *D* will need to be nailed or screwed into place. Piece *D* will be called *the latitude board.*

The equatorial star finder is now ready to be put in the place where it is to be used for observation. It must be set on a level surface, at least 2½ feet long and about 1 foot wide, with its long dimension north and south. The surface should be about as high as a table or perhaps a little higher.

With a compass, if you know the compass variation, or by means of the shadow of a vertical stick at apparent noon, mark a north and south line on the top of your table or slab. The line must be exactly north and south and the top of the table must be level if your star finder is to point accurately to the stars you wish to locate.

Having everything ready, go out with the star finder and place the long side of piece A of the star finder on the north and south line of the level surface, and with the polar axis, *F*, pointing towards the visible pole of the heavens. For an observer in the Northern Hemisphere, it will point at Polaris very nearly. You are now ready to use your star finder. Some star which you already know can be used as a helper to aid you in finding an unknown star. It is best, however, to select a helper that is located some distance from Polaris. Suppose you know the star Vega and wish to find the star Capella. Turn the polar axis, *F*, about its axis, and the star pointer, *H*, about its pivot until you can see Vega through the sight line determined by the center line of the two screw eyes in the star pointer, *H*. Now hold the polar axis, *F*, from turning and rotate the hour disc, *E*, until the star Vega shown on it is under the right ascension pointer, *L*. Now hold the hour disc, *E*, from turning and rotate the polar axis, *F*, until the right ascension pointer is over the star, Capella. Note, on the hour disc, *E*, the declination of Capella, which is its angular distance from the celestial equator. Now move the point of the star pointer, *H*, over the protractor on disc *G* until it is on the degree mark corresponding to the declination of Capella, as read off the hour disc, *E*, and the star pointer, *H*, will now be pointing at Capella, providing you have performed these operations promptly.

By following the above procedure, one can point the star finder at any of the forty stars shown on the hour disc, *E*, of the instrument, whether the star is above or below the horizon. Of course, you can see only those stars which are above your horizon. *Do not expect to find all the stars by one pointing on* Vega, as in the example illustrated; but set on Vega, or some other known star each time, and adjust the hour disc, *E*, as explained above, before setting on the star to be found.

Another way to find an unknown star is to find the star time using the sky clock explained on page 844. Immediately after you have obtained the star time, rotate the hour disc, *E*, of the star finder until the reading on the hour disc which is under the time arrow, *K*, is the same as the star time. Now hold the hour disc, *E*, until the right ascension pointer, *L*, is over the star to be found. Read its declination from the hour disc, *E*, adjust the star pointer, *H*, to this reading on its protractor, G, and the star pointer will point at the star in question.

It should, from the above, be seen that one can use the star finder to obtain the star time. For example, suppose one knows where to find the star Vega. Rotate the polar axis and adjust the star pointer until Vega is seen along the star pointer. Now hold the polar axis and rotate the hour disc, *E*, until Vega is under the right ascension pointer, *L*. The star time is the reading on the hour disc opposite the time arrow, *K*. To find other stars than those shown on the hour disc, consult the star maps on pages 818, 825, and 831 and find the right ascension and declination of each star. Then after adjusting the hour disc, *E*, by one of the methods already explained, hold the hour disc, *E*, and rotate the polar axis, *F*, until the right ascension pointer, *L*, points to the right ascension of the star to be found. Then adjust the star pointer, *H*, until its pointer is over the declination of said star, and the star pointer will be pointed at the star to be identified.

An ingenious boy will use the works of an old alarm clock to cause the hour disc to turn around at the proper rate, so that when once set with the time arrow at star time, it will continue to be so as long as the clock runs. One can then point at one star after another without first readjusting the hour disc. The clock keeps the hour disc, *E*, adjusted, when once set. People who are more deeply interested in the subject will make the whole apparatus a little heavier than indicated in the instructions given here. A small telescope can then be mounted on the star pointer; this makes possible the observation of many objects that are not easily visible to the naked eye.

To find planets, obtain, from some reliable source, the right ascension and declination of the planet and follow the instructions for pointing at stars of known right ascension and declination.

The hour disc, *E*, shown here is for use in the Northern Hemisphere. This disc, and also one that can be used in the Southern Hemisphere, may be secured from Comstock Publishing Company Inc., Ithaca, New York.

The outer edge of the hour disc, *E*, represents the Celestial Equator. The figures appearing near the outer edge of the disc indicate right ascension. For example, to find the right ascension of Vega, imagine a line drawn from the center of the disc through Vega until it intersects the graduated outer edge of the disc. The reading at this point in hours and minutes is the *right ascension* of Vega. It is about 18 hours and 30 minutes.

The concentric circles on the disc represent the parallels of declination which are similar to parallels of latitude on the earth. To find the *declination* of Vega note that it lies between the parallels of declination of 30° and 40°. The declination being about 38½°. Stars which are represented by circles (O) have north declination and those represented by crosses (+) have south declination.

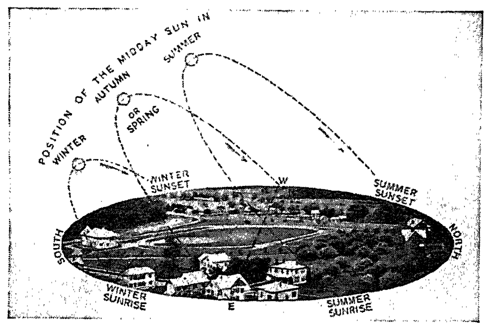
THE RELATIONS OF THE SUN TO THE EARTH

Whether we look or whether we listen,
We hear life murmur or see it glisten.
— LOWELL

All this murmuring and glistening life on our earth planet has its source in the great sun which swings through our skies daily, sending to us his messages of light and warmth — messages that kindle life in the seed and perfect the existence of every living organism, whether it be the weed in the field or the king on his throne.

At sunrise this heat which the sun sends out equally at all times of day and night is tempered when it reaches us, because it passes obliquely through our atmosphere-blanket, and thus traverses a greater distance in the cooling air. The same is true at sunset; but at noon, when the sun is most directly over our heads, its rays pass through the least possible distance of the atmosphere-blanket and therefore lose less heat on the way. It is true that often about three o'clock in the afternoon is the hottest period of the day, but this is because the air-blanket has become thoroughly heated; it is still true that we receive the most heat directly from the sun at noon.

The variations in the time of the rising and the setting of the sun may be made a most interesting investigation on the part of the pupils. They should keep a record for a month in the winter, and with this as a basis use the almanac to complete the lesson. Thus each one may learn for himself which is the shortest and which the longest day of the year. There is a slight variation in different years; for a person in latitude 45° north the shortest day of the year when this lesson was written, as computed from a current almanac, was December 22; the day was eight hours and forty-six minutes long. The longest day of the year was June 22, and it was fifteen hours and thirty-seven minutes in duration. On the longest day of the year the sun reaches its farthest point north and is, therefore, most nearly above us at midday. On the shortest day of the year, the sun reaches its farthest point south and is, therefore, farther from the point directly above us at midday than during any other day of the year.



Adapted from *Todd's New Astronomy*

Path of the sun across the sky of an observer in about latitude 40 *degrees north, on June* 22, *on March* 21 *or September* 23, *and on December* 22

The movement of the sun north and south is an interesting subject for personal investigation, as suggested in the lesson. Through quite involuntary observation, I have become so accustomed to the arc traversed by the points of sunrise as seen from my home, that I can tell what month of the year it is by simply noting the place where the sun rises. When it first peeps at us over a certain pine tree far to the south, it is December; when it rises over the reservoir it is February or October; and when it rises over Beebe Lake it is July. Only at the equinox of spring and fall does it rise exactly in the east and set directly in the west. Equinox means equal nights, that is, the length of the night is equal to that of the day.

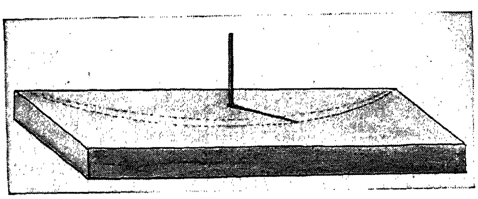
Because of the vast weight of the sun,

the force of gravity upon its surface is so great that even if it were not for the white-hot fireworks so constantly active there, we could not live upon it, for our own weight would crush us to death. But this multiplying the weight of common objects by twenty-seven and two-thirds to find how much they would weigh on the sun is an interesting diversion for the pupils, and incidentally teaches them how to weigh objects, and something about that mysterious force called gravity; and it is also an excellent lesson in fractions.

LESSON 231

The Relation of the Sun to the Earth

Leading Thought — The sun, which is the source of all our light and heat and therefore of all life on our globe, travels a path that is higher across the sky in June



A shadow stick

than the path which it follows in December, and hence we experience changes of seasons. The lesson should be given to the pupils of the upper grades and should be correlated with reading and arithmetic.

Observations — 1. What does the sun do for us?

2. At what time of the day after the sun rises do we get the least heat from it? At what hour of the day do we get the most heat from it?

3. Is the sun equally hot all day? Why does it seem hotter to us at one time of the day than at another?

4. At what hour does the sun rise and set on the first of the following months: February, March, April, May, and June?

5. Which is the shortest day of the year, and how long is it?

6. Which is the longest day of the year, and how many hours and minutes are there in it?

7. On what day of the year is the sun nearest a point directly over our heads at midday?

8. On which day of the year is the sun at midday farthest from the point directly above our heads? Explain why this is so.

9. Standing in a certain place, mark by some building, tree, or other object just where the sun rises in the east and sets in the west on the first of February. Observe the rising and setting of the sun from the same place on the first day of March and again on the first of April. Does it rise and set in the same place always or does its place of rising and setting move northward or southward?

10. Is the sun farthest south on the shortest day of the year? If so, is it farthest north on the longest day of the year?

11. At what time of the year does the sun rise due east and set due west?

12. The sun is so much more massive than the earth that, in spite of its greater size, its force of gravity is twenty-seven and two-thirds times that of the earth. How much would your watch weigh if you were living on the sun? How much would you yourself weigh if you were there?

13. Experiment. A Shadow Stick — Place a peg two or three inches high upright in a level board and place the board lengthwise on a sill of a south window or where it will be in the sunlight, at least from 9 A.M. to 3 P.M. Mark the shadow cast by the peg at half-hour intervals during a sunny day and draw a line with pencil or chalk outlining the tip of the shadow of the stick. Make a similar outline a month later, and again a month later and note whether the shadow traces the same line during each of these days of observation. Note especially the length of the shadow at noon, on March 21, June 22, September 23, and December 22, or as near these dates as possible.

A measurement that is even more exact than the one just described can be obtained by means of a *gnomon pin* placed in a board. (See List of Helpful Materials at the end of this Handbook.)

Another excellent observation lesson for teaching the fact that the sun travels farther south in the winter, is to measure the shadow of a tree on the school grounds at noonday once a month during the school year. The length of the tree shadow can be measured from the base of the tree trunk, a memorandum being made of it.

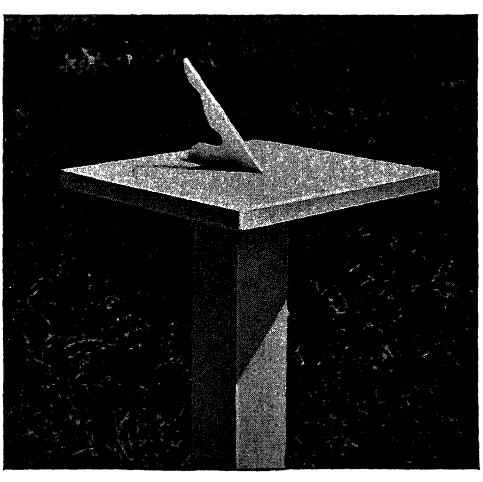
14. When does the stick or tree cast its longest shadow at noon — in December or February? February or April? April or June? Why?

TOPICS FOR ENGLISH THEMES — The Size and Distance of the Sun. The Heat of the Sun and Its Effect upon the Earth. What We Know about the Sun Spots. Our Path around the Sun.

HOW TO MAKE A SUNDIAL

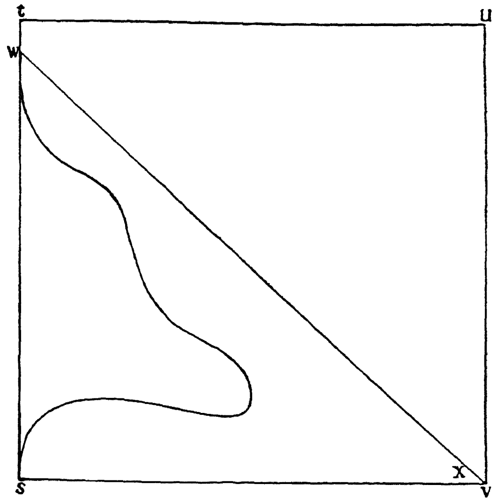
METHOD — The diagram for the dial is a lesson in mechanical drawing. Each pupil should construct a gnomon (no′mon) of cardboard, and should make a drawing of the face of the dial upon paper. Then the sundial may be constructed by the help of the more skillful in the class. It should be made and set up by the pupils. A sundial in the school grounds may be made a center of interest and an object of beauty as well.

MATERIALS — For the gnomon a piece of board a half inch thick and six inches square is required. It should be given several coats of white paint so that it will not



A sundial made by pupils

warp. For the dial, take a board about 14 inches square and an inch or more thick. The lower edge may be bevelled if de-

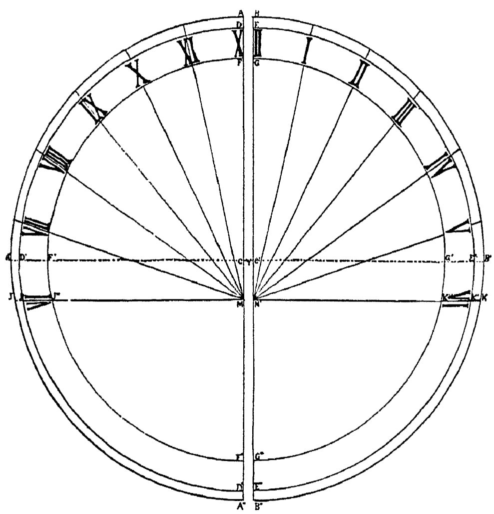


The gnomon

sired. This should be given three coats of white paint, so that it will not warp and check.

TO MAKE THE GNOMON — The word gnomon is a Greek word meaning " one that knows." It is the hand of the sundial, which throws its shadow on the face of the dial, indicating the hour. Take a piece of board six inches square, and be sure its angles are right angles. Let s, t, u, v represent the four angles; draw on it a quarter of a circle from s to u with a radius equal to the line vs. Then with a cardboard protractor, costing fifteen cents, or by working it out without any help except knowing that a right angle is 90°, draw the line vw making the angle at x the same as the degree of latitude where the sundial is to be placed. At Ithaca the latitude is 42°, 27′ and the angle at x measures 42°, 27′. Then the board should be cut off at the line vw, and later the edge sw may be cut in some ornamental pattern.

TO MAKE THE DIAL — Take the painted board 14 inches square and find its exact center, y. Draw on it with a pencil the line AA″ a foot long and one-fourth inch at the left of the center. Then draw the line BB″ exactly parallel to the line AA″ and a half inch to the right of it. These lines should be one-half inch apart — which is just the thickness of the gnomon. If the gnomon were only one-fourth inch thick, then these lines should be one-fourth inch apart, etc.

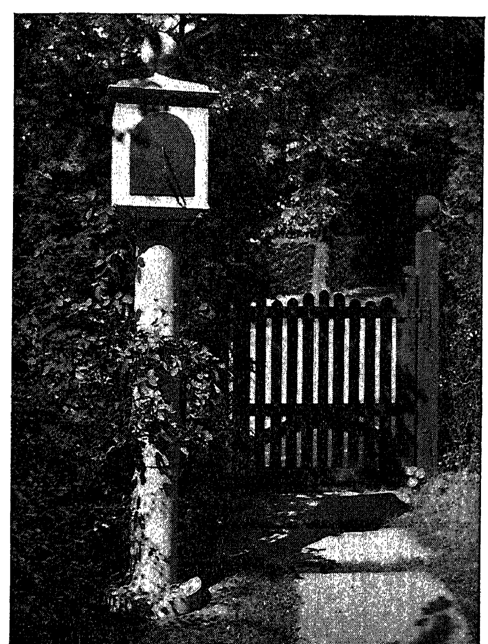


The face of the sundial

With a compass, or a pencil fastened to a string, draw the half-circle AA′A″ with a radius of six inches, with the point c for its center. Draw a similar half-circle BB′B″ opposite, with c′ for its center. Then draw the half-circle from DD′D″, from c with a radius of five and three-quarter inches. Then draw similarly from c′ the half-circle EE′E″. Then draw from c the half-circle FF′F″ with a radius of five inches, and a similar half-circle GG′G″ from c′ as a center.

Find the points M, M′ just six inches from the points F, G; draw the line JK through M, M′ exactly at right angles to the line AA″. This will mark the six o'clock points; so the figures VI may be placed on it in the space between the two inner circles. The noon mark XII should be placed as indicated (the " X " at D, F, the " II " at E, G). With black paint outline all the semicircles and figures.

To Set Up the Sundial — Fasten the base of the gnomon by screws or brads to the dial with the point s of the gnomon at F, G, and the point v of the gnomon at M, M′, so that the point W is up in the air. Set the dial on some perfectly level standard with the line AA″ extending exactly north and south. If no compass is available, wait until noon by the sun and set the dial so that the shadow from W will fall exactly between the points A, B, and this will mean that the dial is set exactly right. Then with a good watch note the points on the arc EK′, on which the shadow falls at one, two, three, four, and five o'clock by sun time; and in the morning the points on the arc J′D on which the shadow falls at seven, eight, nine, ten, and eleven o'clock by sun time. Draw lines from M to these points, and lines from M′ to the point on the arc EK′. Then place the figures on the dial as indicated in the spaces between the two inner circles. The space between the two outer circles may be marked with lines indicating the half and quarter hours. The figures should be outlined in pencil and then painted with black paint, or carved in the wood and then painted.



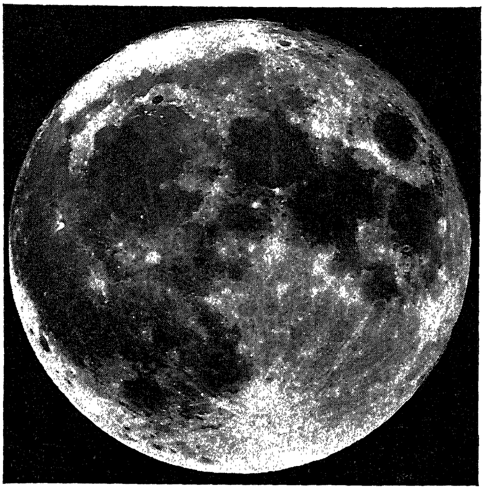
Sundial on the author's lawn

THE MOON

The moon is in more senses than one an illuminating object for both the earth and the skies. As a beginning for earth study it is an object lesson, illustrating what air and water do for our world and incidentally for us; while as the beginning of the study of astronomy, it appears as the largest and brightest object seen in the sky at night; and since it lies nearest us, it is the first natural step from our world to outer space.

The moon is a little dead world that circles around our earth with one face always toward us, just as a hat-pin thrust into an apple would keep the same side of its head always toward the apple no matter how rapidly the apple was twirled. As we study the face of the moon, thus always turned toward us, we see that it is dark in some places and shining in others, and some uninformed people have thought that the dark places are oceans and the light places, land. But the dark portions are simply areas of darker rocks, while the lighter portions are yellowish or whitish rocks. The dark portions are of such a form that people have imagined them to represent the eyes, nose, and mouth of a man's face; but a far prettier picture is that of a woman's uplifted face in profile. The author has a personal feeling on this point, for as a child she saw the man's face always and thought it very ugly, and, moreover, concluded that he chewed tobacco; but after she had been taught to find the face of the lady, the moon was always a beautiful object to her.

The moon is a member of our sun's family, his granddaughter we might call her if the earth be his daughter; and since the moon has no fires or light of its own, it shines by light reflected from the sun and therefore one-half of it is always in shadow. When we see the whole surface of the lighted half we say the moon is full; but when we see only half of the lighted side turned toward us, we say the moon is in its quarter, because all we can see is one-half of one-half, which is one-quarter; and when the lighted side is almost entirely turned away from us we say it is a crescent moon; and when the lighted side is entirely turned away from us we say there is no moon, although it is always there



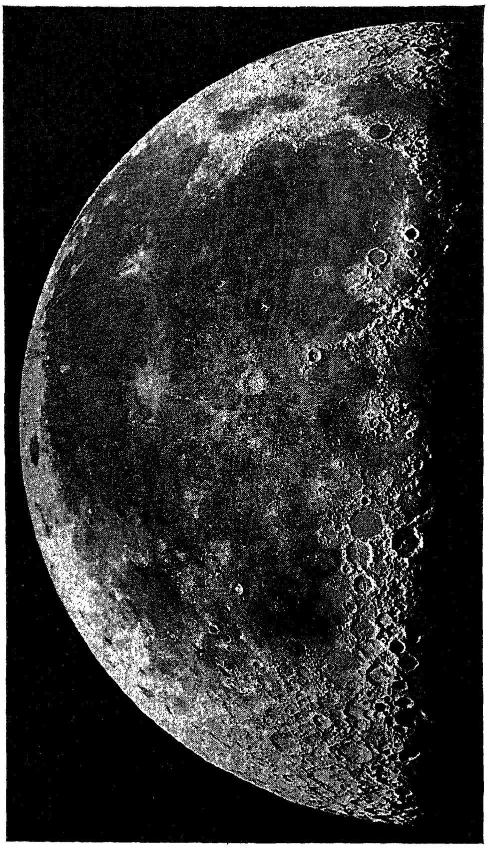
Lick Observatory

The Moon, age 14.9 days. This and the following photograph were made with the 36-inch refractor of the Lick Observatory

just the same. Thus, although we can never see the other side of the moon, we can understand that the sun shines on all sides of it.

Our earth, like the moon, shines always by reflected light and is almost four times as wide as the moon. When we see the old moon in the new moon's arms, the dark outline of the moon within the bright crescent is visible because of the earthshine which illumines it, part of which is reflected from the moon back again to us. Sometimes pupils confuse this appearance of the moon with a partial eclipse; but the former is the old moon, which is one edge of the moon shining in the sunlight, the remainder faintly illumined by earth light, while an eclipse must always occur at the full of the moon when the earth passes between the sun and the moon, almost completely hiding the latter in its shadow.

It is approximately a month from one new moon to the next, since it takes twenty-nine and one-half days for the moon to complete its cycle around the earth with respect to the sun, and thus turn once around in the sunshine. Therefore, each moon day is fourteen and three-



Lick Observatory

The moon, age 22.06 *days*

quarter days long and the night is the same length. The moon always rises in the eastern sky and sets in the western sky. The full moon rises at sunset and sets at sunrise, but owing to the movement of the earth around the sun the moon rises about fifty minutes later each evening; however, this time varies with the different phases of the moon and at different times of the year. This difference in the time of rising is so shortened at full moon in August and September, that we have several nights when the full moon lengthens the day; and it is called the "harvest moon," because in northern Europe in earlier times it was customary to work and sing in the harvest fields until late at night.

A Visit to the Moon

If we could be shot out from a Jules Verne cannon and make a visit to the moon, it would be a strange experience. First, we should find on this little world, which is only as thick through as the distance from Boston to Salt Lake City, mountains rising from its surface more than thirty thousand feet high, which is twice as high as Mt. Blanc and a thousand feet higher than the tallest peak of the Himalayas; and these moon mountains are so steep that no one could climb them. Besides ranges of these tremendous mountains, there are great craters or circular spaces enclosed with steep rock walls many thousand feet high. Sometimes at the center of the crater there is a peak lifting itself up thousands of feet, and sometimes the space within the crater circle is relatively level. Thirty-three thousand of these craters have been discovered. And, too, on the moon, there are great plains and chasms; and all these features of the moon have been photographed, measured, and mapped by people on our earth. For a boy studying geometry, the measuring of the height of the mountains of the moon is an interesting story.

But we could never in our present bodies visit the moon, because of one terrible fact — the moon has no air surrounding it. No air! What does that mean to a world? First of all, as we know life, no living thing — animal or plant — could exist there, for living beings must have air. Neither is there water on the moon; for if there were water there would have to be air. And without water no green thing can be grown, and the surface of the moon is simply naked, barren rock. If we were on the moon, we could not turn our eyes toward the sun, for with no air to veil it, its fierce light would blind us; and the sky is as black at midday as at midnight, since there is no atmospheric dust to scatter the blue rays of light, leaving the beautiful blue in the sky; nor is there a glow at sunset because there is no air prism to separate the rays of light and no clouds to reflect or refract them. The stars could be seen in the black skies of midday as well as in the black skies of night and they would be simply points of light and could not twinkle, since there is no air to diffuse the sun's light and thus curtain the stars by day and cause them to twinkle at night. The shadows on the moon are, for the same reason, as black as midnight and as sharply defined; and if we should step into the shadow of a rock at midday we should be hidden, although some light reflected from the rocks around us might reach us. Hiding in such a shadow would be like putting on the invisible cloak of fairy lore. And because there would be no layers of air to make an aërial perspective, a mountain a hundred miles away would seem as close to us as one a mile away.

Since there is no atmosphere on the moon to act as a blanket to prevent radiation of heat to outer space and to shield from the direct radiation of the sun, the temperature of the moon reaches above boiling point at noon and near absolute zero at midnight. This great change of temperature between sunlight and darkness is the only force on the moon to change the shape of its rocks, for the expansion under heat and contraction under cold must break and crumble even the firmest rock. Our rocks are broken by the freezing of water that creeps into every crevice, but there is no water to act on the moon's mountains in this fashion or to wear them away by dashing over their surface. However, the rocks and mountains of the moon may be changed in shape by the battering of meteorites, which pelt into the moon by the million, since the moon has no air to set them afire and make them into harmless shooting stars, burning up before they strike. But though a meteorite weighing thousands of tons should crash into a moon mountain and shatter it to atoms there would be no sound, since sound is carried only by the atmosphere.

Imagine this barren, dead world, chained to our earth by links forged from unbreakable gravity, with never a breath of air, a drop of rain or flake of snow, with no streams, or seas; graced by not a green thing — not even a blade of grass or a tree, or by the presence of any living creature! Out there in space it whirls its dreary round, with its stupendous mountains cutting the black skies with their jagged peaks above, and casting their inky shadows below; heated to a terrific temperature, by the sun's rays, then suddenly immersed into cold that would freeze our air solid, its only companion the terrific rain of meteoric stones driven against it with a force far beyond that of cannon balls, and yet with never a sound as loud as a whisper to break the terrible stillness which envelops it.

Suggested Reading — *Elementary Science by Grades*, by Ellis C. Persing and John A. Hollinger, Book 6; *Romance of the Moon*, by Mary Proctor; also, readings on page 817.

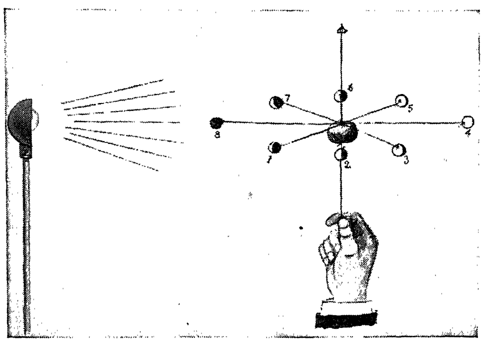
LESSON 232

The Moon

Leading Thought — The moon always has the same side turned toward us, so we do not know what is on the other side. The moon shines by reflected light from the sun, and is always half in light and half in shadow. The moon has neither air nor water on its surface, and what we call the moon phases depend on how much of the lighted surface we see.

Method — Have the pupils observe the moon as often as possible for a month, beginning with the full moon. After the suggested experiment, the questions which follow may be given a few at a time.

Experiment — Darken the room as much as possible; use a lighted lamp or electric light for the sun, which is, of course, stationary. Take a large apple to represent the earth and a small one to represent the moon. Thrust a piece of stiff wire, at least one foot long, through the big apple to represent the axis of the earth and also the axis about which the moon revolves. Tie a string about a foot long to the stem of the moon apple and make fast the other end to the piece of wire just above the earth apple. Hold the



Experiment for illustrating the phases of the moon

wire in one hand and revolve the apple representing the moon slowly with the other hand, letting the children see that if they were living on the earth apple the following things would be true:

1. Moving from right to left when it is between the earth and the sun the moon reflects no light.
2. Moving a little to the left a crescent appears.
3. Moving a quarter around shows the first quarter.
4. When just opposite the lamp, it shows its whole face lighted and turned toward the earth.
5. Another quarter around shows a half disc, which is the third quarter.
6. When almost between the sun and the earth the crescent of the old moon appears.
7. The moon always keeps one face toward the earth.
8. Note that the new moon crescent is the lighted edge of one side of the moon, while the old moon crescent is the lighted edge of the opposite side.
9. Make an eclipse of the moon by letting the shadow of the earth fall upon it, and an eclipse of the sun by revolving the moon apple between the sun and the earth. The earth's orbit and the moon's orbit are such that this relative position of the two bodies occurs but seldom.

Observations — 1. Describe how the moon looks when it is full.

2. What do you think you see in the moon?
3. Describe the difference in appearance between the new moon and the full moon, and explain this difference.
4. Where does the new moon rise and where does it set?
5. When does it rise and when does it set?
6. Where and when does the full moon rise and where and when does it set?
7. How does the old moon look?
8. Could the crescent moon which is seen in early evening be the old moon instead of the new; and, if not, why not?
9. When and where do we ordinarily see the old moon when it is crescent-shaped?
10. Does the moon rise earlier or later on succeeding nights? What is approximately the difference in time of moonrise on two successive nights?
11. Do you think we always look at the same side of the moon? If so, why?
12. Is more than one side of the moon lighted by the sun? Why?
13. How many days from one new moon until the next?
14. How long is the day on the moon and how long the night?
15. How many times does the moon go around the earth in a year?
16. What is the difference between the disappearance of the old moon and an eclipse of the moon?

The Physical Geography of the Moon

Questions for the Pupils to Think About and Answer if They Can —

17. Since it has been found that there is no air or water on the moon, could there be any life there?
18. Supposing you could do without air or water and should be able to visit the

moon what would you find to be the color of the sky there?

19. Would there be a red glow before sunrise or beautiful colors at sunset?

20. Would the sun appear to have rays? Could you look at the sun without being blinded?

21. Would the stars appear to twinkle? Could you see the stars in the daytime?

22. How would the shadows look? If you could step into the shadow of a rock at midday, could you be seen?

23. Could you tell by looking at it whether a mountain was far or near?

24. Why is it so much hotter and colder on the moon than upon the earth?

25. If you could shout on the moon, how would it sound? If one hundred cannons should be fired at once on the moon, how would it sound?

26. Is there any rain or snow on the moon? Are there any clouds there? If there is no air or water on the moon, would the intense heat and the powerful cold affect the soils or rocks, as freezing and thawing affect our rocks?

27. The moon is so small that the force of gravity on its surface is one-sixth that on the earth's surface. If a man can carry seventy-five pounds on his back here, how many pounds could he carry on the moon?

BIBLIOGRAPHY

By Eva L. Gordon
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NOTE

This list of books is by no means complete. The books included have been chosen from those the writer has used or examined, and many of them have already been mentioned in connection with the topics discussed in the preceding pages of this Handbook. An attempt has been made to suggest material for readers of many ages, appropriate for use over a wide area. Books for recreational reading have been included, as well as those for informational use or reference. Preference has been given to well-written, well-illustrated books, with the hope that many readers will find in these pages pleasant help in their nature studies.

NATURE STUDY IN GENERAL

GENERAL INFORMATION AND STORIES

ALONG THE BROOK. By Raymond T. Fuller. Reynal & Hitchcock, New York. 1931. 89 pages. $1.25. A small book discussing fifty denizens of brooks of northeastern United States, and describing a few plants. *Grades 5 to 7.*

ALONG NATURE'S TRAILS. By Lillian C. Athey. American Book Co., New York. 1936. 351 pages. $1.20. A brief general survey of plant and animal life of eastern North America. *Grades 5 to 8.*

ALONG THE SHORE. By Eva L. Butler. Reynal & Hitchcock, New York. 1930. 103 pages. $1.25. Short, simply told accounts of some common sea animals and plants. *Grades 5 to 8.*

AMERICAN CONSERVATION; IN PICTURE AND IN STORY. Compiled by Ovid M. Butler. American Forestry Association, Washington, D. C. 1935. 144 pages. $2.50. Photographs, with explanatory text. *Adult.*

AN AQUARIUM BOOK FOR BOYS AND GIRLS. By Alfred P. Morgan. Charles Scribner's Sons, New York. 1936. 191 pages. $2.00. An excellent guide for maintaining aquaria, including, also, much information about aquarium inhabitants. *Grades 5 to 8.*

BEACHCOMBER BOBBIE. By Florence Bourgeois. Doubleday, Doran & Co., Garden City, N. Y. 1935. 32 pages. $.50. A colorfully illustrated story of a small boy's adventures with seashore animals. *Grades 1 to 3.*

THE BURGESS SEASHORE BOOK FOR CHILDREN. By Thornton W. Burgess. Little, Brown & Co., Boston. 1929. 350 pages. $3.00. Well-illustrated accounts of many animals and of some of the commoner plants of the seashore, told in story form. *Grades 4 to 6.*

THE COMPLETE AQUARIUM BOOK. By William T. Innes. Blue Ribbon Books, Inc., New York. 1936. 317 pages. $.98. A new edition of a helpful reference, chiefly on the care and breeding of goldfish and tropical fishes. *Adult.*

THE CONQUEST OF LIFE. By Theodore Koppanyi. D. Appleton-Century Co., Inc., New York. 1930. 263 pages. $2.00. Valuable popular treatment of biology, one of *The Appleton New World of Science Series. Adult.*

CONSERVATION IN THE UNITED STATES. By A. F. Gustafson, H. Ries, W. J. Hamilton, Jr., and C. H. Guise. Comstock Publishing Co., Inc., Ithaca, N. Y. 1939. 430 pages. $3.00. A well-illustrated survey, the four parts of which consider soils, forests, animal life, and mineral resources. *Adult.*

CONSERVATION OF OUR NATURAL RESOURCES. By Loomis Havemeyer and others. The Macmillan Co., New York. 1930. 551 pages. $4.00. A new edition, based on Van Hise's *The Conservation of Natural Resources in the United States. Adult.*

DESERT NEIGHBORS. By Edith M. Patch and C. L. Fenton. The Macmillan Co., New York. 1937. 176 pages. $1.75. Fourteen accurate, well-presented stories of living things of the southwestern deserts of the United States. *Grades 3 to 5.*

DO YOU BELIEVE IT? By Otis W. Caldwell and Gerhard E. Lundeen. Garden City Publishing Co., Garden City, N. Y. 1934. 317 pages. $1.00. The history of many common superstitions, showing their influence and their actual fallacy. *Adult.*

EVOLUTION YESTERDAY AND TODAY. By Horatio H. Newman. Williams & Wilkins Co., Baltimore, Md. 1932. 181

pages. $1.00. One of the Century of Progress Series of carefully prepared discussions of various phases of science. *Adult.*

EXPLORING THE EARTH AND ITS LIFE IN A NATURAL HISTORY MUSEUM. By James L. McCreery. F. A. Stokes Co., New York. 1933. 269 pages. $2.00. A unique book, based on the collections in the American Museum of Natural History in New York. *Grades 6 to 8.*

FIELDBOOK OF NATURE STUDY. By E. Laurence Palmer. McGraw-Hill Book Co., Inc., New York. In preparation, to be published probably in 1942. About 700 pages. $3.50. This well-known sourcebook of information and help in field identification of more than 1500 kinds of things is completely rewritten and newly illustrated. Useful over most of the United States, in *grade 6 and above.*

FIELD BOOK OF PONDS AND STREAMS. By Ann H. Morgan. G. P. Putnam's Sons, New York. 1930. 464 pages. $3.50. A most satisfactory handbook for the study of plants and animals found in and near water. Abundant and excellent illustrations. *Grade 6 and above.*

FIELDS AND FENCEROWS. By W. P. Porter and E. A. Hansen. American Book Co., New York. 1937. 280 pages. $.84. Abundantly illustrated, compact information about many plants and animals, emphasizing those of the countryside of eastern North America. *Grades 4 to 7.*

FOREST NEIGHBORS. By Edith M. Patch and C. L. Fenton. The Macmillan Co., New York. 1938. 198 pages. $1.50. Eighteen authentic stories of big and little animals of the "North Woods." *Grades 3 to 5.*

HOLIDAY HILL. By Edith M. Patch. The Macmillan Co., New York. 1931. 135 pages. $1.50 or $1.00. Accounts of a hill in eastern America, containing the story of an old boulder, and of plants and animals through the year. *Grades 3 to 5.*

HOLIDAY MEADOW. By Edith M. Patch. The Macmillan Co., New York. 1930. 165 pages. $1.50 or $1.00. Two children's explorations among the plants and animals in a farm meadow. *Grades 3 to 5.*

HOLIDAY POND. By Edith M. Patch. The Macmillan Co., New York. 1929. 147 pages. $1.50 or $1.00. An invitation to visit an eastern American pond and meet some of the plants and animals to be found there. *Grades 3 to 5.*

HOLIDAY SHORE. By Edith M. Patch and C. L. Fenton. The Macmillan Co., New York. 1935. 150 pages. $2.00. Accurate introduction to marine life, particularly of the Atlantic Coast. *Grades 3 to 5.*

INTERESTING NEIGHBORS. By Oliver P. Jenkins. P. Blakiston's Son & Co., Inc., Philadelphia. 1922. 248 pages. $1.12. Excellently written, accurate narratives about many common plants and animals, usable over a wide area. *Grades 4 to 6.*

THE LIFE OF INLAND WATERS. By James G. Needham and J. T. Lloyd. Comstock Publishing Co., Inc., Ithaca, N. Y. Third edition, 1937. 438 pages. $3.00. Abundantly illustrated and delightfully written information. *Adult. A Guide to the Study of Fresh-Water Biology,* by James G. Needham and Paul R. Needham, Comstock Publishing Co., Inc., Ithaca, N. Y., 1938, 88 pages, $1.00, a well-illustrated help in identification, is useful in connection with the book mentioned.

THE LIVING WORLD. By Samuel H. Williams. The Macmillan Co., New York. 1937. 704 pages. $3.60. A college book, designed for a cultural course in biology, and useful to the average reader who is interested in the out-of-doors. *Adult.*

MOUNTAIN NEIGHBORS. By Edith M. Patch and C. L. Fenton. The Macmillan Co., New York. 1936. 156 pages. $1.75. Fourteen well-told, illustrated stories of wild life in the western mountains of America. *Grades 3 to 5.*

THE NATURAL HISTORY OF THE FARM. By James G. Needham. Comstock Publishing Co., Inc., Ithaca, N. Y. 1914.

348 pages. $1.50. Simple descriptions of common plants and animals on farms of northeastern United States, with suggestions for their study. *Grade 7 and above.*

NATURE PHOTOGRAPHY AROUND THE YEAR. By Percy A. Morris. D. Appleton-Century Co., Inc., New York. 1938. 269 pages. $4.00. A profusely illustrated book which combines month-by-month lists of nature objects with instructions and suggestions for the nature photographer. *Adult.*

NATURE TRAILS. By Dietrich Lange. D. Appleton-Century Co., Inc., New York. 1927. 261 pages. $1.20; student's edition, $.64. Short, interesting sketches about many living things. *Grade 6 and above.*

NATURE'S SECRETS. Edited by G. Clyde Fisher. Blue Ribbon Books, Inc., New York. 1927. 951 pages. $1.89. Material by different authors on plants and animals of several groups, useful for general information. *Grade 7 and above.*

ONE THOUSAND AND ONE QUESTIONS ANSWERED ABOUT YOUR AQUARIUM. By Ida M. Mellen and Robert J. Lanier. Dodd, Mead & Co., New York. 1935. 463 pages. $3.00. Comprehensive reference. *Adult.*

OUR NATURAL RESOURCES AND THEIR CONSERVATION. By A. E. Parkins and J. R. Whitaker. John Wiley and Sons, Inc., New York. 1936. 650 pages. $4.00. A balanced, concrete view of the resources and conservation problems of the United States, composed of contributions of twenty authors, each a specialist in his particular field. *Adult.*

OUR PLANT AND ANIMAL NEIGHBORS. By Frank B. Younger. C. C. Nelson Publishing Co., Appleton, Wis. 1929. 242 pages. $1.00. One of the few textbooks on plant and animal life written from the point of view of conservation. *Grades 7 and above.*

OUT-OF-DOORS; A GUIDE TO NATURE. By Paul B. Mann and George T. Hastings. Henry Holt & Co., Inc., New York. 1932. 458 pages. $2.00 or $1.68. A condensed, general survey of plant life, of animal life, and of earth and sky, containing suggestions for activities and for further reading. *Grades 5 to 9.*

THE OUTLINE OF SCIENCE. Edited by Sir J. Arthur Thomson. G. P. Putnam's Sons, New York. One-volume edition, 1937. 1220 pages. $3.95. An older book, but still valuable for its simple discussions of many subjects and for its abundant, excellent illustrations. The author's *The Outline of Natural History*, one-volume edition, 1932, 700 pages, $5.00, is also valuable. *Grade 6 and above.*

THE POND BOOK. By W. P. Porter and E. A. Hansen. American Book Co., New York. 1936. 216 pages. $.84. Simple, well-illustrated, accurate information about pond life, including plants and animals found in the water and along the shores. Usable over much of the United States. *Grades 4 to 7.*

SEA-BEACH AT EBB-TIDE. By Augusta F. Arnold. D. Appleton-Century Co., Inc., New York. 1901. 490 pages. $5.00. Classic reference for plant and animal life. *Adult.*

THE SEA FOR SAM. By W. Maxwell Reed and Wilfrid S. Bronson. Harcourt, Brace & Co., Inc., New York. 1935. 374 pages. $3.00. A carefully prepared, well-illustrated reference on the sea and its life. *Grade 6 and above.*

SMITHSONIAN SCIENTIFIC SERIES. By Charles G. Abbot, editor-in-chief. Smithsonian Institute Series, Inc., Smithsonian Institute, Washington, D. C. 1929–1932. 12 volumes. $99.00, patrons' edition; leather memorial edition, $198.00. An excellent series, treating all phases of science, written for lay readers, by specialists in the various fields. *Adult.*

THE STORY-BOOK OF SCIENCE. By Jean-Henri C. Fabre. D. Appleton-Century Co., Inc., New York. 1919. 400 pages. $2.50. True stories about plants, animals, planets, metals, and other subjects, translated from the works of a famous French scientist. *Grade 6 and above.*

THE STORY BOOK OF THINGS WE USE. By

Maud F. and Miska Petersham. The John C. Winston Co., Philadelphia. 1933. 128 pages. $2.00; or in four volumes, $.60 each. Attractively illustrated, simple material on houses, clothing, food and transportation. *Grades 3 to 5.*

THE STORY OF EVOLUTION. By Benjamin C. Gruenberg. Garden City Publishing Co., Garden City, New York. 1929. 489 pages. $1.00 (Star books). Non-technical, authentic explanation of the subject and its influence on modern thinking. *Adult.*

TREES, STARS AND BIRDS. By Edwin L. Moseley. World Book Co., Yonkers, N. Y. Revised edition, 1935. 426 pages. $1.60. Accurate information, written simply, interspersed with frequent suggestions for observations, and presenting the subject of conservation well. *Grade 6 and above.*

WONDERS OF SCIENCE. Selected and arranged by Eva M. Tappan. Houghton Mifflin Co., Boston. 1927. 257 pages. $1.00 (school edition). Thirty-five short articles by various authors, about many phases of science. *Grade 7 and above.*

THE WONDERS OF THE SEA. By F. Martin Duncan and L. T. Duncan. Oxford University Press, New York. 1928–1929. 6 volumes, 72 to 86 pages each. $.40 or $.55 each. English books, useful on the Atlantic Coast of America, presenting abundantly illustrated material on plants and animals of the sea. *Grades 4 to 8.*

Publications of various departments of the United States Government, particularly of the Department of Agriculture, contain much valuable information on subjects covered by this book. Much is also published by the States, by other national governments, by colleges and universities, and by other public and private agencies. Much of this material is free or inexpensive. Lists of available publications often may be procured.

ESSAYS AND TRAVEL

ADVENTURES IN GREEN PLACES; GRAY EAGLE; THE WAY OF THE WILD. All by Herbert R. Sass. G. P. Putnam's Sons, New York. 1926, 1927, 1925. 293, 269, 321 pages. $3.50, $2.50, $2.50. Studies of swamps and deltas of South Carolina and of the wild life there. *Age 11 and above.*

BEYOND THE PASTURE BARS; HIGHLANDS AND HOLLOWS; A WATCHER IN THE WOODS. All by Dallas L. Sharp. D. Appleton-Century Co., Inc., New York. 1914, 1923, 1901. 160, 120, 205 pages. $.85, $.75, $1.35 (student's edition, $.50). Selections about animals, from Sharp's delightful essays. *Grade 6 and above.*

A BOOK LOVER'S HOLIDAYS IN THE OPEN. By Theodore Roosevelt. Charles Scribner's Sons, New York. 1916. 373 pages. $3.00. Other volumes of essays and travels, by the same author, published by Scribner, include: *African Game Trails*, 1924, 583 pages, $6.00; *Outdoor Pastimes of an American Hunter*, 1908, 409 pages, $3.00; *Through the Brazilian Wilderness*, 1914, 383 pages, $3.00. *Adult.*

THE BOOK OF A NATURALIST. By William H. Hudson. E. P. Dutton & Co., New York. 1919. 360 pages. $2.50. An English naturalist's accounts of simple everyday things of nature. Other books by the same author, published by Dutton include: *Birds in London*, 1924, 339 pages, $2.50; *Far Away and Long Ago*, 1924, 332 pages, $2.00; *Hampshire Days*, 1923, 315 pages, $2.00; *The Naturalist in La Plata*, 1922, 394 pages, $3.00; and other titles. *Adult.*

CAMP FIRES IN THE CANADIAN ROCKIES. By William T. Hornaday. Charles Scribner's Sons, New York. 1906. 353 pages. $5.00. Adventures, incidents of camp life and sketches of wild life. *Adult.*

CAMPS AND CRUISES OF AN ORNITHOLOGIST; MY TROPICAL AIR CASTLE; LIFE IN AN AIR CASTLE. All by Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1908, 1929, 1938. 431, 417, 262 pages. $4.00, $3.50, $3.00. Delightful descriptions of experiences on collecting trips for the American Museum of Natural History, and with tropical wild life on Barro Colorado, an island in the Panama Canal Zone. *Adult.*

THE CLERK OF THE WOODS; A FLORIDA SKETCHBOOK; FOOTING IT IN FRANCONIA. All by Bradford Torrey. Houghton Mifflin Co., Boston. 1893, 1924, 1901. 280, 242, 251 pages. $2.00 each. Entertaining essays by a naturalist whose chief interest was perhaps in bird life. *Adult.*

THE COMPLEAT ANGLER. By Izaak Walton and Charles Cotton. E. P. Dutton & Co., New York. 1925. 215 pages. $.90 or $1.00 (Everyman's Library), American edition, $10.00. Classic essays on fish, fishing, and other subjects. *Adult.*

DWELLERS OF THE SILENCES. By Alexander Sprunt, Jr. Dodd, Mead & Co., New York. 1928–1931. 345 pages. $2.50. Fascinating stories of wild life, especially birds, in the Carolina low country. *Age 12 and above.*

ENDS OF THE EARTH. By Roy Chapman Andrews. Garden City Publishing Co., Garden City, N. Y. 1929. 299 pages. $1.00. A thrilling tale of ten years spent on whaling ships. *Adult.*

EXPLORING FOR PLANTS. By David G. Fairchild. The Macmillan Co., New York. 1930. 591 pages. $3.50. Accounts of experiences in many lands, in search of plants which could be introduced in the United States. *Adult.*

EXPLORING WITH BEEBE: Selections for Younger Readers from the Writings of William Beebe. G. P. Putnam's Sons, New York. 1932. 213 pages. $2.50. Other popular accounts of scientific expeditions to many lands and seas, by the same author, published by Putnam, include: *The Arcturus Adventure*, 1928, 439 pages, $7.50; *Beneath Tropic Seas*, 1929, 234 pages, $3.50; *Galapagos, World's End*, 1928, 443 pages, $6.00; *Pheasant Jungles*, 1927, 248 pages, $3.00. Grade 6 and above. *Beneath Tropic Seas* is also published in a $1.59 edition, by Blue Ribbon Books, Inc., New York.

THE FACE OF THE FIELDS. By Dallas L. Sharp. Houghton Mifflin Co., Boston. 1911. 260 pages. $2.00. Other volumes of Sharp's delightful essays on nature subjects, also published by Houghton Mifflin, include: *The Lay of the Land*, 1908, 214 pages; *The Hills of Hingham*, 1916, 221 pages; *Roof and Meadow*, 1904, 281 pages; *Where Rolls the Oregon*, 1914; $2.00 each. *Adult.*

THE FALL OF THE YEAR; WINTER; THE SPRING OF THE YEAR; SUMMER (Nature Series, Books 1, 2, 3, and 4). By Dallas L. Sharp. Houghton Mifflin Co., Boston. 1911, 1912, 1909, 1914. 126, 148, 148, 132 pages. $1.12 each. Collections of Sharp's delightful essays, arranged for supplementary reading in *grade 6 and above.*

FIELD AND HEDGEROW; THE STORY OF MY HEART. Both by Richard Jefferies. Longmans, Green & Co., New York. 1890, 1896. 331, 206 pages. $2.40, $1.40. The first consists of enjoyable sketches about familiar things, by an English literary artist; the second is autobiographical. *Adult.*

FISHERMAN'S LUCK; LITTLE RIVERS. Both by Henry Van Dyke. Charles Scribner's Sons, New York. 1920, 1920, (New editions). 256, 290 pages. Leather, $3.50, cloth, $3.00 each. A nature lover's thoughts, experiences and reminiscences. Also published by Scribner's are the author's *Days Off*, 1920, 293 pages; *The Blue Flower*, 1920, 271 pages; leather, $3.50, cloth, $3.00 each; all four books also in the Sylvanora edition, $1.50 each. *Adult.*

FRESH FIELDS. By John Burroughs. Houghton Mifflin Co., Boston. 1895. 284 pages. $2.25. A collection of charming essays by a famous nature writer.

The twenty-three volumes of Burroughs' *Works* include also: *Leaf and Tendril*, 1908, 288 pages; *Locusts and Wild Honey*, 1907, 235 pages; *Signs and Seasons*, 1886, 271 pages; *Wake Robin*, 1899, 233 pages; *Ways of Nature*, 1905, 279 pages; *Winter Sunshine*, 1875, 241 pages. $2.25 each. *Adult*. The Riverside Literature Series, Houghton Mifflin Co., includes several collections of Burroughs' writings, selected for readers of *grade 7 and above*, at $.32 or $.48.

GLIMPSES INTO THE WORLD OF SCIENCE. By Mary G. Phillips and William H. Geisler. D. C. Heath & Co., Boston. 1929. 337 pages. $.80. Sketches drawn partly from the writings of eminent scientists of many fields. *Adult*.

THE GRAND CANYON OF THE COLORADO; THE DESERT. Both by John C. Van Dyke. Charles Scribner's Sons, New York. 1920, 1918. 218, 233 pages. $2.50, $3.00. Studies in "Natural Appearances" by a professor of the history of art. *Adult*.

GREEN MOUNTAINS TO SIERRAS. By Zephine Humphrey. E. P. Dutton & Co., Inc., New York. 1936. 253 pages. $2.50. A unique, American travel book. *Adult*.

HALF-MILE DOWN. By William Beebe. Harcourt, Brace & Co., Inc., New York. 1934. 363 pages. $5.00. Good reading about the author's deep-sea diving adventures, especially the descent in the bathysphere during the summer of 1934. *Adult*.

HAPPY NATURE ADVENTURES. By Mary C. Butler. Dorrance & Co., Philadelphia. 1937. 113 pages. $1.25. A small volume of short essays on various subjects. *Adult*.

HUNTING WILD LIFE WITH CAMERA AND FLASHLIGHT. By George Shiras, 3rd. National Geographic Society, Washington, D. C. 1935. 2 volumes, 471, 458 pages. $5.00. A beautifully illustrated record of sixty-five years' visits to the woods and waters of North America. *Adult*.

JUNGLE ISLAND. By W. C. Allee and M. H. Allee. Rand, McNally Co., Chicago. 1925. 215 pages. $.88. A well-illustrated, interesting account of the animal life on a small tropical island in Gatun Lake. *Grades 6 to 8*.

JUNGLE PORTRAITS. By Mrs. Delia J. Akeley. Robert M. McBride & Co., New York. 1930. 251 pages. $1.75. Chronicles of experiences on collecting trips in Africa. *Adult*.

THE LAND OF LITTLE RAIN. By Mary Austin. Houghton Mifflin Co., Boston. 1903. 281 pages. $3.00. Charmingly written essays, by an author who has written much about the southwestern United States. *Adult*.

LOG OF THE SUN; JUNGLE PEACE. Both by William Beebe. Henry Holt & Co., Inc., New York. 1926, 1928. 321, 297 pages. $2.50 each. Popular accounts of scientific expeditions. *Adult*.

THE MOUNTAINS OF CALIFORNIA; THE YOSEMITE. Both by John Muir. D. Appleton-Century Co., Inc., New York. 1911, 1912. 389, 284 pages. $3.50, $4.00. Well-told, interesting accounts of the exploring trips of a renowned natural scientist. *Adult*.

MY FIRST SUMMER IN THE SIERRAS. By John Muir. Houghton Mifflin Co., Boston. 1911. 354 pages. $3.50. Interesting accounts of the exploring trips of a well-known natural scientist. Other books by the same author, published by Houghton Mifflin, include: *Travels in Alaska*, 1915, 326 pages; *Steep Trails*, 1918, 390 pages; *The Cruise of the Corwin*, 1917, 278 pages; *A Thousand Mile Walk to the Gulf*, 1916, 219 pages; each $3.00. *Adult*.

THE NATURAL HISTORY OF SELBORNE. By Gilbert White. E. P. Dutton & Co., New York. 1912. 255 pages. $.90 or $1.00 (Everyman's Library); American edition, $10.00; Kings' Treasuries of Literature, $.50. Interesting and accurate observations of a famous 18th century English naturalist. *Adult*.

NATURE RAMBLES: AN INTRODUCTION TO COUNTRY LORE, SPRING, SUMMER, AUTUMN, WINTER. By Oliver P. Medsger. Frederick Warne & Co., New York.

1931, 1932. Four volumes, 160 pages each. $2.00 each. Informal talks to the reader, in which the author points out interesting things to see, particularly in northeastern United States. *Grade 6 and above.*

Our National Parks. By John Muir. Houghton Mifflin Co., Boston. 1909. 382 pages. $3.50, or $4.00 with 32 views and maps. Muir's plea for appreciation and conservation of national parks. *Adult.*

Our Wonderful World. By Frances J. Olcott. Little, Brown & Co., Boston. 1935. 320 pages. $2.50. 130 stories and articles, written by various authors, many of them well-known scientists. *Grade 7 and above.*

The Rocky Mountain National Park. By Enos A. Mills. Houghton Mifflin Co., Boston. New edition, 1932. 262 pages. $2.50. The story of Estes Park and its discovery and development. Other books about the Rocky Mountain region, by the same author, also published by Houghton Mifflin Co., include: *Wild Life in the Rockies*, 1909, 263 pages, $2.50; *The Rocky Mountain Wonderland*, 1915, 362 pages, $2.50; *The Spell of the Rockies*, 1911, 355 pages, $3.00; *Waiting in the Wilderness*, 1932, 254 pages, $2.50; *Romance of Geology*, 1932, 245 pages, $2.50; *Bird Memories of the Rockies*, 1931, 263 pages, $2.50; *Adventures of a Nature Guide*, 1932, 271 pages, $2.50. *Adult.*

Sanctuary! Sanctuary! By Dallas L. Sharp. Harper & Brothers, New York. 1926. 227 pages. $2.50. A plea for appreciation of wild life. *Adult.*

Science in Literature. Edited by Frederick H. Law. Harper & Brothers, New York. 1929. 364 pages. $1.20. A series of essays, by many authors, covering many fields of science. Each essay is preceded by a brief biography of the author, and followed by a list of books for further reading. *Grade 6 and above.*

Tales from Nature's Wonderlands. By William T. Hornaday. Charles Scribner's Sons, New York. 1924. 235 pages. $2.50. Tales of strange phenomena, of the habits of little known animals, and of queer corners of the earth, by the former director of the New York Zoological Park. *Grade 7 and above.*

Through the Woods; the English Woodland — April to April. By Herbert E. Bates. The Macmillan Co., New York. 1936. 141 pages. $3.00. A discourse illustrated with attractive wood engravings. *Adult.*

Voyage of the Beagle. By Charles Darwin. E. P. Dutton & Co., Inc., New York. 1920. 496 pages. $.90 (Everyman's Library). An epoch-making account of a naturalist's explorations. *Adult.*

Walden. By Henry David Thoreau. Houghton Mifflin Co., Boston. 1893. 522 pages. $2.50. One of the best-known volumes of Thoreau's works. Others, published by Houghton Mifflin, include: *Cape Cod*, 1914, 336 pages; *The Maine Woods*, 1892, 328 pages; *A Week on the Concord and Merrimack Rivers*, 1894, 530 pages; *Early Spring in Massachusetts*, 1881, 318 pages; *Summer*, 1884, 382 pages; *Autumn*, 1892, 470 pages; *Winter*, 1888, 439 pages; each $2.50. *Adult. Walden* is also published, in a dollar edition, by Grosset & Dunlap, New York.

Whale Hunting with Gun and Camera. By Roy Chapman Andrews. D. Appleton-Century Co., Inc., New York. 1926. 333 pages. $5.00. An interesting account of the author's experiences. *Adult.*

Wild Honey. By Samuel Scoville, Jr. Little, Brown & Co., Boston. 1929. 203 pages. $3.00. Experiences with wild folk, entertainingly told. *Adult.*

Your National Parks. By Enos A. Mills. Houghton Mifflin Co., Boston. 1917. 431 pages. $3.00. A well-written plea for preservation of natural wonderlands. *Adult.*

POETRY

BIRD AND BOUGH. By John Burroughs. Houghton Mifflin Co., Boston. 1906. 70 pages. $1.50. A volume of poems by a famous writer-naturalist. *Adult.*

THE BIRD-LOVER'S ANTHOLOGY. Edited by Jessie B. Rittenhouse and Clinton Scollard. Houghton Mifflin Co., Boston. 1930. 299 pages. $2.00. An attractive collection of poems.

CHILD'S GARDEN OF VERSE. By Robert Louis Stevenson. Various editions, at different prices, are available from several publishers, among them Charles Scribner's Sons, New York, John C. Winston Co., Philadelphia, M. A. Donohue & Co., Chicago. Favorite poems of children. *Grade 4 and above.*

HIGH TIDE; THE MELODY OF EARTH; STAR POINTS. All arranged by Mrs. Waldo Richards. Houghton Mifflin Co., Boston. 1916, 1918, 1921. 206, 295, 229 pages. Cloth, $2.00; leather, $2.75 each. Anthologies containing many worthwhile nature poems. *Adult.*

THE NATURE LOVER'S KNAPSACK. By Edwin O. Grover. Thomas Y. Crowell Co., New York. 1927. 304 pages. $2.50. A pleasing anthology. *Grade 8 and above.*

POEMS OF SCIENCE. By William Pallister. Playford Press, New York. 1931. 248 pages. $2.50–$3.50. A collection of original poems designed to encourage appreciation of the beauty as well as of the usefulness of science. *Adult.*

POETRY'S PLEA FOR ANIMALS. By Frances E. Clarke. Lothrop, Lee & Shepard Co., New York. 1927. 426 pages. $3.00. "An anthology of justice and mercy for our kindred in fur and feathers." *Grade 7 and above.*

THE POSY RING. By Kate Douglas Wiggin and Nora Archibald Smith. Houghton Mifflin Co., Boston. 1903. 297 pages. $1.10. A collection of poems for children.

SILVER PENNIES. By Blanche J. Thompson. The Macmillan Co., New York. 1925. 138 pages. $.88. A collection of poems, many of them nature poems, for children of the first six grades.

SONGS OF SUMMER; GREEN FIELDS AND RUNNING BROOKS; RHYMES OF CHILDHOOD. All by James Whitcomb Riley. Bobbs-Merrill Co., Indianapolis, Ind. 1908, 1895, 1891. 189, 224, 186 pages. $1.00, $2.00, $2.00. Many of this poet's nature poems appeal to children of grades 5 to 8.

UNDER THE TENT OF THE SKY. Selected by John E. Brewton. The Macmillan Co., New York. 1937. 221 pages. $2.00. A collection of poems about animals, including new verses as well as many old favorites. *Ages 6 to 14.*

Well-known nature poems will be found in the collected poems of these and other poets, among them Elizabeth Barrett Browning, William Cullen Bryant, Rupert Brooke, Robert Burns, Emily Dickinson, Ralph Waldo Emerson, Jean Ingelow, Sidney Lanier, Lucy Larcom, Henry Wadsworth Longfellow, James Russell Lowell, Alfred Tennyson, Henry Van Dyke, John Greenleaf Whittier, and Walt Whitman. Various editions, from many publishers.

HISTORY AND BIOGRAPHY

ADVENTURES IN BIRD PROTECTION; AN AUTOBIOGRAPHY. By T. Gilbert Pearson. D. Appleton-Century Co., Inc., New York. 1937. 473 pages. $3.50. Written by one of the founders of the National Association of Audubon Societies, who for thirty-five years has been working for bird conservation and protection. *Adult.*

AMERICAN INVENTORS; AMERICAN SCIENTISTS. Both by Clarence J. Hylander. The Macmillan Co., New York. 1934, 1935. 231, 199 pages. $2.00 each. Brief biographies of nineteen inventors and twenty-six scientists. *Grades 6 to 8.*

AMERICAN NATURISTS. By Henry C. Tracy. E. P. Dutton & Co., New York. 1930. 282 pages. $3.00. Stimulating sketches of a group of American students and writers of nature. *Adult.*

BUILDERS OF EMPIRE. By Floyd L. Darrow. Longmans, Green & Co., New York. 1930. 303 pages. $2.00. Short accounts of many men whose achievements have helped to build American civilization. *Grades 6 to 8.*

AUDUBON. By Constance Rourke. Harcourt, Brace & Co., Inc., New York. 1936. 342 pages. $3.00. An abundantly illustrated, interesting biography. *Adult.*

AUTOBIOGRAPHY OF A BIRD LOVER. By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1933. 433 pages. $3.75. A famous American ornithologist, curator of birds in the American Museum of Natural History, tells the story of his career and of his work. *Adult.*

CHARLES DARWIN. By Gamaliel Bradford. Houghton Mifflin Co., Boston. 1926. 314 pages. $3.50. A pleasing, informal account of the life of a great naturalist. *Adult.*

FAMOUS MEN OF SCIENCE. By Mrs. Sarah Knowles Bolton. Thomas Y. Crowell Co., New York. Revised and enlarged edition, 1938. 383 pages. $2.00. A group of biographies, which have been revised and reprinted several times. *Grades 7 to 10.*

GREEN LAURELS. By Donald C. Peattie. Simon & Schuster, Inc., New York. 1936. 368 pages. $3.75. A popular collection of biographical sketches of great naturalists. *Adult.*

HEROES OF SCIENCE. By Joseph Cottler and Haym Jaffe. Little, Brown & Co., Boston. 1932. 205 pages. $.90. Biographies of nineteen heroes of pure science, biology and medicine, part of the authors' *Heroes of Civilization. Grade 7 and above.*

IMPRESSIONS OF GREAT NATURALISTS. By Henry Fairfield Osborn. Charles Scribner's Sons, New York. 1928. 216 pages. $2.50. A revised and enlarged edition of an interesting group of biographical sketches of great naturalists. *Adult.*

THE LIFE AND LETTERS OF CHARLES DARWIN. Edited by Francis Darwin. D. Appleton-Century Co., Inc., New York. 1911. 2 volumes. $8.00. A detailed treatment, including an autobiographical chapter. *Adult.*

LIFE AND LETTERS OF JOHN MUIR. By William F. Badè. Houghton Mifflin Co., Boston. 1924. 2 volumes, 454 pages. $7.50. An interesting study of a famous American natural scientist.

MADAME CURIE: A BIOGRAPHY. By Eve Curie. Doubleday, Doran & Co., Garden City, N. Y. 1937. 393 pages. $3.50. A very popular account of the life of the codiscoverer of radium, written by her daughter. *Grade 8 and above.*

MEN WHO FOUND OUT. By Amabel Williams-Ellis. Coward, McCann, Inc., New York. 1930. 259 pages. $2.00. Delightful sketches of the lives and work of a number of well-known scientists. *Grades 6 to 8.*

MICROBE HUNTERS. By Paul de Kruif. Harcourt, Brace & Co., Inc., New York. 1927. 363 pages. $3.50. One of the best-known of the author's dramatically told sketches of scientists and scientific discoveries. Others, also published by Harcourt, Brace, are: *Hunger Fighters,* 1928, 376 pages, $3.50; *Men Against Death,* 1932, 363 pages, $1.49; *Why Keep Them Alive?* 1936, 293 pages, $1.49; *The Fight for Life,* 1938, 342 pages, $3.00. *Adult.*

THE STORY OF MY BOYHOOD AND YOUTH. By John Muir. Houghton Mifflin Co., Boston. 1913. 293 pages. $3.00. An interesting autobiography, selected chapters of which are published by Houghton Mifflin, under the title, *The*

Boyhood of a Naturalist, 123 pages, $.32, $.48. *Grade 8 and above.*

THE WORLD WAS MY GARDEN. By David G. Fairchild. Charles Scribner's Sons, New York. 1938. 508 pages. $3.75. The autobiography of an American botanist, who, for more than twenty years, was in charge of the division of Foreign Plant Exploration and Introduction of the United States Department of Agriculture. Delightfully written and well illustrated with photographs. *Adult.*

TEXTBOOKS AND READERS

DICKY AND PEGGY IN THE ORCHARD. By Margaret S. Young. American Book Co., New York. 1936. 127 pages. $.68. Pleasant nature stories, arranged seasonally, with four colored plates illustrating plants and animals considered. *Grade 1 or 2.*

DISCOVERING OUR WORLD. By Wilbur L. Beauchamp, Mary Melrose and Glenn O. Blough. Scott, Foresman & Co., Chicago. Book 1, 1937, 288 pages, $.88; Book 2, 1938, 352 pages, $.96; Book 3, in preparation. Attractive, carefully prepared books, arranged on the unit-problem plan, designed for a course in science for grades 4, 5, and 6, to follow *Science Stories*, Books 1, 2, and 3.

EASY EXPERIMENTS IN ELEMENTARY SCIENCE. By Herbert McKay. Oxford University Press, New York. 1925. 144 pages. $.60. A practical little book for use with young students. *Grade 5 and above.*

ELEMENTARY SCIENCE BY GRADES. Edited by Frank W. Ballou. D. Appleton-Century Co., Inc. 1928–1933. 128–340 pages each. Books 1, 2, 3, by Ellis C. Persing and Elizabeth K. Peeples, revised editions, $.72, $.72, $.80; Book 4, by E. C. Persing and Edward E. Wildman, $.92; Book 5, by E. C. Persing and C. L. Thiele, $.96; Book 6, by E. C. Persing and John A. Hollinger, $1.00. Usable and dependable material for *grades 1 to 6.*

THE FIND OUT BOOKS. By Orange County Teachers. University of North Carolina Press, Chapel Hill, N. C. Volume 1, 1934, volume 2, 1937. 112, 144 pages. $.60, $.75. Readers, chiefly in the field of biology, for *grades 1 and 2.*

FIRST LESSONS IN NATURE STUDY. By Edith M. Patch. The Macmillan Co., New York. Revised edition, 1932. 303 pages. $1.20. Charmingly written, accurate material about many common plants and animals. *Grades 3 and 4.*

FIRST STEPS IN SCIENCE. By Herbert McKay. Oxford University Press, New York. 1929. 6 volumes, 64 pages each. $.40 each. Simple experiments and observations are suggested in each of the books: *Rain in the Garden, Sound and Noise, Candles and Lamps, The Air and the Wind, Looking Glasses,* and *The Sun and the Moon. Grades 4 to 6.*

HANDBOOK OF FARMING FOR BOYS AND GIRLS. By Richard A. Power and Vincent E. Kivlin. E. M. Hale & Co., Milwaukee, Wis. 1937. 684 pages. $2.00. A textbook on farm life and work, arranged according to the seasons. *Grade 7 and above.*

MAGNETISM AND ELECTRICITY (*Living in a World of Science* Series). By Morris Meister. Charles Scribner's Sons, New York. One of a set of 4 volumes, 1929–1935. 210–238 pages each. $1.12 each, or bound in two volumes, $1.40 each. Valuable and practical information and suggestions for study. Other volumes in the series are: *Water and Air; Heat and Health; Energy and Power. Grades 7 and 8, and teachers of elementary grades.*

MAGNETISM AND ELECTRICITY (*Science Related to Life* Series, Book 3). By Frank Reh. American Book Co., New York. 1932. 188 pages. $.64. Three additional volumes, *Water, Air and Sound; Heat and Health; Light, Forces and Machines,* complete this simple useful

series, available in two volumes at $.96 and $1.00, or in four at $.64 each. *Grades 5 to 8.*

MOTHER NATURE SERIES. Book 1, *Baby Animals;* Book 2, *By the Roadside;* Book 3, *In Field and Forest.* By Fannie W. Dunn and Eleanor Troxell. Row, Peterson Co., Evanston, Ill. 1928. 160, 256, 288 pages. $.68, $.76, $.80. Stories, chiefly of animal life. *Grades 2, 3, and 4.*

NATURE AND SCIENCE READERS. By Edith M. Patch and Harrison E. Howe. The Macmillan Co., New York. 1932–1935. 6 books: Book 1, *Hunting,* 169 pages, $.72; Book 2, *Outdoor Visits,* 223 pages, $.72; Book 3, *Surprises,* 320 pages, $.76; Book 4, *Through Four Seasons,* 345 pages, $.76; Book 5, *Science at Home,* 464 pages, $.80; Book 6, *Work of Scientists,* 496 pages, $.80. A carefully prepared, accurate series, in which the first books are predominantly biological, but the books for higher grades introduce a considerable amount of interestingly organized physical science. *Grades 1 to 6.*

NATURE — BY SEASIDE AND WAYSIDE. By Mary G. Phillips and Julia M. Wright. D. C. Heath & Co., Boston. 1936. 4 books: Book 1, *Some Animals and Their Homes,* 151 pages, $.64; Book 2, *Some Animal Neighbors,* 196 pages, $.68; Book 3, *Plants and Animals,* 252 pages, $.72; Book 4, *Our Earth and Its Life,* 288 pages, $.76. A revised series, dealing chiefly with biological science. *Grades 2 to 6.*

THE NATURE HOUR. By Lucile Nicol, S. M. Levenson, and Teressa Kahn. Silver, Burdett & Co., New York. 1935. 4 volumes, two for fifth year and two for sixth year, 118, 114, 132, 134 pages. 5th year, $.76 each; 6th year, $.80 each. Much worthwhile material in the field of biology, and considerable emphasis on conservation. *Grades 5 and 6.*

NATURE IN AGRICULTURE. By Walter L. Conway, Harry N. Kauffman, and William H. Lancelot. Webb Publishing Co., St. Paul, Minn. 1928. 256 pages. $1.20. Elementary school agriculture. *Grade 6 and above.*

NATURE SCIENCE SERIES. By G. Clyde Fisher and Marion L. Langham. Noble and Noble, Publishers, Inc., New York. 1934–1936. Six books: *Our Pets,* 221 pages; *On the Farm,* 233 pages; *World of Nature,* 210 pages; *Ways of the Wild Folk,* 251 pages; *Our Wonder World,* 245 pages; *In Field and Garden,* 246 pages. $.96 each. A set of nature readers for grades 1 to 6, combining informational material about plants and animals with myths and poems.

NATURE STORIES FOR CHILDREN. Books 1 and 2, by Nora Albright and Jennie Hall, 1927, 96 pages each, $.72 each; *Autumn and Spring,* by Eva L. Gordon and Jennie Hall, 1926, 1927, 90, 88 pages, $.72 each; *Elementary Science,* by Grace Holtz and Jennie Hall, 1930, 160 pages, $.80. Mentzer-Bush & Co., Chicago. The first four books, for grades 1 and 2, are based on actual field and classroom experiences; the last, for grade 3, contains stories of the ways in which living things make use of the world about them.

NATURE STUDY AND HEALTH EDUCATION. By Alice Jean Patterson. McKnight and McKnight, Bloomington, Ill. Grades 1 and 2 (teacher's text), 1928, 164 pages, $.80; grade 3, 1928, 184 pages, $.60; grade 4, 1927, 131 pages, $.60; grade 5, 1926, 192 pages, $.70; grade 6, 1927, 224 pages, $.80. Workbooks, grade 3, 1928, 96 pages, $.40; grade 4, 1926, 80 pages, $.40; grade 5, 1926, 78 pages, $.40; grade 6, 1927, 96 pages, $.40. Science for the Junior High School (text), 1929, 360 pages, $1.40, *grades 7 and 8.* Sane, well-planned course.

NATURE STUDY AND SCIENCE. By Gilbert H. Trafton. The Macmillan Co., New York. 1927. 393 pages. $1.20. A textbook, arranged on a seasonal plan, presenting simple information, and outlining 170 projects, some for individual and some for group work. *Grades 4 to 6.*

OUR ANIMAL BOOKS. Edited by Frances E. Clarke. D. C. Heath & Co., Boston. 1937. 7 books: Primer, *Fuzzy Tail,* by A. Sondergaard, 139 pages, $.72; Book

1, *Sniff*, by J. S. Tippett and M. Tippett, 190 pages, $.80; Book 2, *Pets and Friends*, by E. Myers, 192 pages, $.84; Book 3, *The Pet Club*, by K. Masters, 230 pages, $.92; Book 4, *On Charlie Clarke's Farm*, by K. Keelor, 202 pages, $.72; Book 5, *Our Town and City Animals*, by F. Clarke and K. Keelor, 224 pages, $.76; Book 6, *Paths to Conservation*, by J. S. Tippett, 311 pages, $.88. An interesting series in humane education. *Grades 1 to 6.*

OUR FARM BABIES; OTHER FARM BABIES. By Oliver S. Hamer and Anna M. Hamer. McKnight & McKnight, Bloomington, Ill. 1934. 133, 136 pages. $.80 each. Supplementary readers, which present much information about common domestic and wild animals of farms. *Grades 2 to 3.*

OUTDOOR ADVENTURES. By Albert E. Shirling. World Book Co., Yonkers, N. Y. 1928. 250 pages. $1.08. Accurate supplementary reader.

PATHWAYS IN SCIENCE. By Gerald S. Craig and Co-authors. Ginn & Co., Boston. 1932–1933. 194–462 pages each. Book 1, *We Look About Us*, $.72; Book 2, *Out of Doors*, $.80; Book 3, *Our Wide, Wide World*, $.80; Book 4, *The Earth and Living Things*, $.80; Book 5, *Learning About Our World*, $.84; Book 6, *Our Earth and Its Story*, $.84. A series containing much good material in many fields. Teachers' manual with each book. *Grades 1 to 6.*

SCIENCE STORIES. By Wilbur L. Beauchamp and Others. Scott, Foresman & Co., Chicago. Book 1, by W. L. Beauchamp, Gertrude Crampton and W. S. Gray, 1933, 144 pages, $.64; Books 2 and 3, by W. L. Beauchamp, Harriet M. Fogg, Gertrude Crampton and W. S. Gray, 1935, 1936, 176, 256 pages, $.72, $.80; Teacher's Guidebook, $.28. Excellently planned and well-written material in both physical and biological science. Attractive in makeup and illustration, and designed to prompt and direct much child activity. *Grades 1 to 3*, to precede *Discovering Our World.*

SCIENTIFIC LIVING SERIES. By George W. Frasier and Helen Dolman. L. W. Singer Co., Syracuse, N. Y. 1937, 1938. *We See* (Pre-Primer), 32 pages, $.20; *Sunshine and Rain* (Primer), 64 pages, $.60; *Through the Year* (Book 1), 156 pages, $.72; *Winter Comes and Goes* (Book 2), 224 pages, $.84. Exceptionally attractive in makeup and illustration, with content closely related to child experiences. *Grades 1 and 2.*

STORIES OF OUTDOOR SCIENCE. By Lewis M. Dougan. Lyons & Carnahan, Chicago. 1933. 376 pages. $.80. An introduction to science for children of the Mississippi Valley. *Grades 5 to 7.*

UNIT STUDY BOOKS. By various authors. American Education Press, Inc., Columbus, Ohio. 1934–1936. 36 pages each. $.10 each. Factual material in science and social science, graded for use in grades 1 to 6 or 7, fifteen or more pamphlets on different topics for each grade.

BOOKS FOR PARENTS AND TEACHERS

CHILD AND UNIVERSE. By Bertha Stevens. Reynal & Hitchcock, Inc., New York. 1931. 249 pages. $3.75. A beautifully illustrated book which presents some interesting ideas for teaching small children about the universe. *Adult.*

THE DOORWAY TO NATURE. By Raymond T. Fuller. Reynal & Hitchcock, New York. 1931. 284 pages. $2.50. A pleasantly written book suggesting nature explorations near home. *Adult.*

NATURE STUDY AND LIFE. By Clifton F. Hodge. Ginn & Co., Boston. 1902. 514 pages. $2.40. A long used reference for teachers. *Adult.*

OUR LIVING WORLD. By Elliot R. Down-ing. Longmans, Green and Co., New York. 1928. 494 pages. $2.00. Both this and the author's *Guide in Biological Nature Study*, 1924, 120 pages, $1.80, contain helpful material in content and method, as does the author's *Our Physical World*, 1925, 367 pages, $2.00. *Adult.*

PRACTICAL NATURE STUDY AND ELEMENTARY AGRICULTURE. By J. M. Coulter and Alice J. Patterson. D. Appleton-Century Co., Inc., New York. 1909. 354 pages. $1.60. A manual for teachers and normal school students.

A PROGRAM FOR TEACHING SCIENCE. By the Committee on Science Teaching, National Society for the Study of Education. Thirty-first Yearbook, Part I. Public School Publishing Co., Bloomington, Ill. 1932. 370 pages. Cloth, $2.50, paper, $1.75. Suggestions and materials for a twelve-year program in science. *Adult.*

SCIENCE IN THE ELEMENTARY SCHOOL. By W. C. Croxton. McGraw-Hill Book Co., Inc., New York. 1937. 466 pages. $3.00. Discussion of such topics as the aims, the method, and the place of elementary science, and about 300 pages of concrete suggestions for an activity program. *Adult.*

SCIENCE IN THE NEW EDUCATION. By S. R. Slavson and R. K. Speer. Prentice-Hall, Inc., New York. 1934. 396 pages. $2.50. An extensive treatment applied to the elementary school. *Adult.*

THE STUDY OF NATURE. By Alice Jean Patterson. Public School Publishing Co., Bloomington, Ill. 1923. 238 pages. $.90. Graded lessons in nature study and health for the first six grades. *Adult.*

MAGAZINES AND PERIODICALS

AMERICAN FORESTS. Published by the American Forestry Association, Washington, D. C. Monthly. $4.00 a year. Well-illustrated magazine, emphasizing forests and forest life, but presenting some related material.

BIRD LORE. Published by the National Association of Audubon Societies, 1006 Fifth Ave., New York. Bimonthly. $1.50 a year in the United States, $1.75 foreign. Well-illustrated articles on birds, with suggestions for bird study.

CORNELL RURAL SCHOOL LEAFLETS. Prepared and supervised by E. Laurence Palmer. New York State College of Agriculture at Cornell University, Ithaca, N. Y. Four issues a year: January, March, September, November. $.50 a year; teachers' number (September), $.20; children's numbers, $.10 each. Each of the children's numbers deals with a phase of biological or physical science; the teachers' numbers emphasize applications to school situations and articles of general interest. Illustrated. Useful to elementary teachers, and for students above grade 3.

NATIONAL GEOGRAPHIC MAGAZINE. Published by the National Geographic Society, Washington, D. C. Monthly. $3.50 a year. Abundantly and beautifully illustrated material, much of it in the field of natural science.

NATURAL HISTORY. Published by the American Museum of Natural History, 79th St. and Central Park W., New York. Monthly except July and August. $3.00 a year. Well-illustrated records of the Museum's expeditions, and other articles of interest to students of natural history. The museum also publishes *Junior Natural History*, monthly, $1.00 a year.

NATURE MAGAZINE. Published by the American Nature Association, Washington, D. C. Monthly. $3.00 a year. Beautifully illustrated articles of general interest, in many fields of natural history. The American Nature Association publishes, also, bulletins concerning conservation, nature education and related subjects, and serves as a source of varied information for teachers and students of nature study and for those who desire camp experience.

SCIENCE DIGEST. Published by Science Digest, Inc., 631–643 St. Clair St., Chicago. Monthly. $2.50 a year. Similar in makeup to the *Readers' Digest*, but presenting "the pertinent news of all branches of science."

SCIENCE GUIDE FOR ELEMENTARY SCHOOLS. Published by the California State Department of Education. Monthly except June and July. $1.25 a year, single copies $.15 each. Obtainable from the Division of Textbooks and Publications, California State Department of Education, Sacramento. These pamphlets discuss many groups of living things and various phases of physical science, combining content and suggestions for study. They are particularly helpful for West Coast schools, but many general numbers could be used anywhere. Illustrated.

SCIENCE NEWS LETTER. Published by Science Service, Inc., 2101 Constitution Ave., Washington, D. C. Weekly. $5.00 a year. Short articles, presenting a summary of current science.

ANIMAL LIFE

ANIMALS IN GENERAL

All About Pets. By Margery Bianco. The Macmillan Co., New York. 1929. 134 pages. $2.00. Information and stories about pet animals, with directions for caring for them. In *More About Animals*, 1934, 127 pages, $1.75, the author tells twelve more stories about pet animals. *Grades 5 to 7.*

The American Natural History. By William T. Hornaday. Charles Scribner's Sons, New York. New edition, 1935. 474 pages. $5.00. Useful information about mammals, birds, reptiles, amphibians and fishes. *Grade 7 and above.* Other books about animals, by the same author, published by Scribner's, are: *A Wild-Animal Roundup*, 1925, 372 pages, $5.00 (stories of the past and present); and *The Minds and Manners of Wild Animals*, 1922, 328 pages, $2.50.

Animal Friends Story Book. By Watty Piper. Platt & Munk Co., New York. 1927–1935. 88 pages. $2.00. Simple stories, with large illustrations, partly in color, of several kinds of domestic animals. *Grades 2 to 3.*

Animal Heroes. By Ernest T. Seton. Grosset & Dunlap, New York. 1905. 362 pages. $1.00. Stories of animal life, based on actual happenings. *Grade 6 and above.*

The Animal Kingdom. The Orthovis Co., Chicago. 1933. Unpaged. $2.00. Pictures of animal groups from the Field Museum in Chicago, with descriptive text. The pictures have a three-dimensional appearance when viewed through an orthoscope, which comes with the book. The *Footprint Series*, Sets 1 and 2, 1934–1935, four 16-page volumes each, $1.00 each, are similar. *All grades.*

Animal Secrets Told. By Harry C. Brearley. F. A. Stokes Co., New York. 1911. 274 pages. $2.50. Brief explanations of animal structures under such headings as eyes, ears, noses and claws. *Grade 6 and above.*

Animals in Black and White. By Eric F. Daglish. William Morrow & Co., New York. 1938. 255 pages. $2.50. A one-volume edition of an English series illustrating and describing mammals, birds, reptiles and fish from many parts of the world. *Grade 4 and above.*

At the Zoo. By Captain R. Cheyne-Stout. Farrar & Rinehart, Inc., New York. 1937. 56 pages. $2.00. A unique book combining brief descriptions of about forty animals with stereoscopic pictures, to be viewed through a device contained in the book. *All grades.*

At the Zoo. By Arthur O. Cooke. Platt & Munk Co., New York. 1935. 152 pages. $1.25. A large book, describing and illustrating forty zoo animals, mostly mammals. *Grades 4 to 6.*

Baby Animals on the Farm. By Kate E. Agnew and Margaret Coble. World Book Co., Yonkers, N. Y. 1933. 153 pages. $.76. Experiences of a boy and girl, with kittens, puppies and other baby animals. *Grade 1.*

Backyard Exploration. By Paul G. Howes. Doubleday, Doran & Co., Garden City, N. Y. New edition, 1935. 227 pages. $3.00. A volume of information about common living things other than birds and mammals, well illustrated. *Adults and older children.*

Bird and Animal Paintings. By R. Bruce Horsfall. Nature Magazine, Washington, D. C. 1928. 58 pages. Cloth, $1.50. 168 colored pictures of birds, mammals

and insects, with notes on their life history. *All grades.*

THE BOOK ABOUT ANIMALS. Frederick Warne & Co., New York. 1933. 100 pages. $2.00. Attractive large book, illustrated with twelve color plates and many excellent photographs of both native and exotic birds and mammals. Simple text. *Grades 3 to 4.*

THE BOOK OF WILD PETS. By Clifford B. Moore. G. P. Putnam's Sons, New York. 1937. 553 pages. $5.00. A comprehensive and well-illustrated book on the care, feeding and habits of many kinds of animals in captivity. In five parts: the terrarium, the aquarium, insects and spiders, mammals, and birds, each with a bibliography. *Adult.*

A CHILD'S STORY OF THE ANIMAL WORLD. By Edward G. Huey. Reynal & Hitchcock, Inc., New York. 1935 355 pages. $3.50. A survey of the chief groups of animals, emphasizing the vertebrates. *Grades 5 to 8.*

COMMON PESTS. By Rennie W. Doane. Charles C. Thomas, Springfield, Ill. 1931. 397 pages. $4.00. Essential facts about and suggestions for control of many kinds of pests. *Adult.*

DENIZENS OF THE MOUNTAINS. By Edmund C. Jaeger. Charles C. Thomas, Springfield, Ill. 1930. 168 pages. $2.00. Authentic life history sketches of some of the more familiar and interesting mammals and birds. *Grade 6 and above.* The author's *Denizens of the Desert,* 1922, 299 pages, $3.00, published by Houghton Mifflin Co., Boston, is similar in its scope.

FARM ANIMALS; WILD ANIMALS. Both by James G. Lawson. Rand, McNally & Co., Chicago. 1935. 64 pages each. $.10 each. Photographs and descriptions of one hundred important animals are contained in each book. *Grade 5.*

FIELD BOOK OF ANIMAL LIFE IN WINTER. By Ann H. Morgan G. P. Putnam's Sons, New York. 1939. 416 pages. $3.50. A well-illustrated guide to a most interesting field of study, by the author of the *Field Book of Ponds and Streams. Adult, but younger students can use it.*

HAND BOOK FOR THE CURIOUS. By Paul G. Howes. G. P. Putnam's Sons, New York. 1936. 372 pages. $3.75. An abundantly illustrated, helpful source of information about many animals of eastern United States, covering the principal groups except the protozoans, the birds, and the mammals. *Grade 6 and above.*

IN THE ZOO. By W. Reid Blair. Charles Scribner's Sons, New York. 1929. 195 pages. $2.50. This book discusses how animals are cared for and fed in the zoo, and includes many anecdotes. Written by the Director of the New York Zoological Park, and illustrated with photographs, it will interest readers of many ages.

LIVES OF THE HUNTED. By Ernest T. Seton. Charles Scribner's Sons, New York. 1901. 360 pages. $2.50. This and other stories by the same author are interesting portrayals of wild animal life. *Grade 6 and above.*

A MANUAL OF LAND AND FRESH WATER VERTEBRATE ANIMALS OF THE UNITED STATES (EXCLUSIVE OF BIRDS). By Henry S. Pratt. P. Blakiston's Son & Co., Inc., Philadelphia. Second edition, 1935. 416 pages. $6.00. A well-illustrated guide to identification and study. *Adult.*

MANUAL OF THE VERTEBRATE ANIMALS. By David Starr Jordan. World Book Co., Yonkers, N. Y. 1929. 446 pages. $4.00. A classic guide for identification and study.

THE MUSEUM COMES TO LIFE. By Maribelle Cormack and William P. Alexander. American Book Co., New York. 1931. 208 pages. $.84. Information about the habits and lives of common animals, presented through an imaginative story. *Grades 3 to 5.*

NATURE NARRATIVES, I and II. By Austin H. Clark. Williams & Wilkins Co., Baltimore, Md. 1929, 1931. 143, 100 pages. $1.00 each. In each volume are fifty short accounts of animals from all over the world. *Grades 6 to 8.*

Now for Creatures! By Shelby Shackelford. Charles Scribner's Sons, New York. 1936. 130 pages. $2.00. Interesting stories of little animals, presented through a small boy's experiences. *Grades 4 to 6.*

Our Backdoor Neighbors. By Frank C. Pellett. The Abingdon Press, New York. 1917. 209 pages. $1.50. Experiences of the author with familiar small animals, illustrated with photographs. *Grade 6 and above.*

Parade of the Animal Kingdom. By Robert Hegner, assisted by Jane Z. Hegner. The Macmillan Co., New York. 1935. 675 pages. $5.00. A comprehensive survey of the animal kingdom, written in nontechnical language, and abundantly and excellently illustrated. *Grade 6 and above.*

The Pet Book. By Anna B. Comstock. Comstock Publishing Co., Inc., Ithaca, N. Y. 1914. 310 pages. $3.50. Well-illustrated descriptions of habits, suggested housing and care of many kinds of pet animals. *Grade 6 and above.*

Pets for Pleasure and Profit. By A. Hyatt Verrill. Charles Scribner's Sons, New York. 1915. 373 pages. $2.75. Directions for the care of many kinds of pet animals. *Grade 7 and above.*

The Picture Book of Animals; The Second Picture Book of Animals. Selected by Isabel E. Lord. The Macmillan Co., New York. 1931, 1933. 114, 120 pages. $2.50 each. Attractive books containing large photographs of many kinds of animals, from many parts of the world. Very brief text. *Grades 1 to 8.*

Standard Natural History. Edited by W. P. Pycraft. Frederick Warne & Co., New York. 1931. 960 pages. $6.00. A survey of the animal kingdom, from amoeba to man, written by several distinguished authors. Good reading, with abundant illustrations, partly in color. *Adult, but useful also with younger readers.*

The Stir of Nature. By William H. Carr. Oxford University Press, New York. 1930. 208 pages. (Out of print.) Much excellent information about some animals, particularly of northeastern United States, combined with helpful suggestions for learning about them. *Grades 5 to 7.*

Tracks and Trails. By Leonard Rossell. The Macmillan Co., New York. 1928. 138 pages. $1.25. Track studies in story form, illustrated with photographs and sketches by the author. *Grade 6 and above.*

Vanishing Wilderness. By Francesca R. La Monte and Micaela H. Welch. Liveright Publishing Corp., New York. 1934. 351 pages. $2.50. Well-written, interesting accounts of the life and habits of nineteen kinds of animals, many of which are in danger of becoming extinct, or of becoming restricted to protected areas or zoos. *Age 10 and above.*

Watchers of the Trails. By Charles G. D. Roberts. L. C. Page & Co., Boston. 1904. 361 pages. $3.00. Nature fiction based on animal life, excelling in descriptive detail. *Adult.* Other books by the same author, from the same publisher, are: *Haunters of the Silences*, 1907, 316 pages; *House in the Water*, 1908, 301 pages; *The Kindred of the Wild*, 1902, 374 pages. $3.00 each.

Who Goes There? By Dorothy P. Lathrop. The Macmillan Co., New York. 1935. 40 pages. $1.50. Common small animals of eastern United States, and their tracks in the snow, beautifully pictured. Simple story. *Grades 1 to 3.*

Wild Animal Pets. By William L. and Irene Finley. Charles Scribner's Sons, New York. 1928. 311 pages. $3.50. True accounts of experiences in photographing wild animals. *Grade 6 and above.*

Wild Animals I Have Known. By Ernest T. Seton. Grosset & Dunlap, Inc., New York. 1898. 358 pages. $1.00. Well-known stories built about real animal characters and real incidents. *Grade 6 and above.*

Wild Folk. By Samuel Scoville, Jr. Little, Brown & Co., Boston. 1922. 184 pages. $2.50. Readable stories of the raccoon, black bear, skunk, chipmunk, fisher, red fox and other animals. *More Wild Folk*, 1924, 184 pages, $2.00, a companion book, is published by D. Appleton-Century Co., Inc., New York. *Grade 6 and above.*

WILD LIFE OF THE SOUTH. By Archibald Rutledge. F. A. Stokes Co., New York. 1935. 262 pages. $1.75. Eighty short sketches about wild life in South Carolina. *Grade 6 and above.*

WORLD NATURAL HISTORY. By E. G. Boulenger. Charles Scribner's Sons, New York. 1937. 268 pages. $3.00. A survey of the animal kingdom, well illustrated with photographs and drawings, written for the general reader, by the Director of the Aquarium and Curator of Reptiles in the London Zoo. The same author has written *A Natural History of the Seas*, 1936, 215 pages, $3.00, published by D. Appleton-Century Co., Inc., New York; and *The London Zoo*, 1938, 220 pages, $2.00; and *Infants of the Zoo*, 1934, 158 pages, $2.00, both published by E. P. Dutton & Co., New York.

MAMMALS

(See also *Nature Study in General* and *Animals in General*)

ANIMALS OF AMERICA: "Mammals of America." Edited by H. E. Anthony and J. W. McSpadden. Garden City Publishing Co., Garden City, N. Y. 1917, 1937. 362 pages. $2.19. A new edition of a formerly expensive book, describing and illustrating about 200 kinds of animals. *All grades.*

AQUATIC MAMMALS. By A. Brazier Howell. Charles C. Thomas, Springfield, Ill. 1930. 332 pages. $5.00. A comprehensive and valuable work, written in nontechnical language. *Adult.*

AZAM; THE STORY OF AN ARABIAN COLT AND HIS FRIENDS. By Irvin S. Cobb. Rand, McNally & Co., Chicago. 1937. 79 pages. $1.50. A simply told story of the life and training of a colt on a California farm, illustrated with excellent photographs. *All grades.*

BAMBI — A LIFE IN THE WOODS. By Felix Salten. Simon & Schuster, Inc., New York. 1928. 293 pages. $2.50. An appealing story of a deer. A $.75 edition is published by Grosset & Dunlap, New York. *Grade 7 and above.*

BANNERTAIL: THE STORY OF A GRAY SQUIRREL. By Ernest T. Seton. Charles Scribner's Sons, New York. 1922. 259 pages. $2.50. This and other stories by the same author are interesting and sympathetic portrayals of wild animal life. *Grade 6 and above.*

THE BEAVER: ITS WORKS AND ITS WAYS. By Edward R. Warren. Williams & Wilkins Co., Baltimore, Md. 1927. 177 pages. $1.00. Simple, authentic information, abundantly illustrated with photographs. *Grade 8 and above.*

BEAVER PIONEERS. By Wendell Chapman and Lucie Chapman. Charles Scribner's Sons, New York. 1937. 167 pages. $2.00. A delightful, attractively presented story of beaver life based on personal observations by the authors. *Grades 6 to 8.*

BETTER DAIRY FARMING. By E. S. Savage and L. A. Maynard. Savage-Maynard Co., Ithaca, N. Y. 1923. 250 pages. (Out of print.) A discussion of the breeding, feeding, handling and care of dairy cattle. *Adult.*

THE BIOGRAPHY OF A SILVER FOX; THE BIOGRAPHY OF A GRIZZLY. Both by Ernest T. Seton. D. Appleton-Century Co., Inc., New York. 1909, 1918. 209, 167 pages. $2.50, $2.00. Other editions of these well-liked stories and others by the same author are available. *Grade 6 and above.*

THE BLOT: LITTLE CITY CAT. By Phyllis Crawford. Peter Smith & Co., New

York. 1930. 56 pages. $1.25. A well-told story for little children.

The Book of Animal Life. By Thora Stowell and Thornton W. Burgess. Little, Brown & Co., Boston. 1937. 327 pages $2.50. Nontechnical information about the characteristics, lives and habits of mammals, large and small, domestic and wild. *Grade 7 and above.*

The Book of Dogs. By James G. Lawson. Rand, McNally & Co., Chicago. 1936. 64 pages. $.10. Photographs and descriptions of more than a hundred breeds of dogs. *All grades.*

The Book of Zoography. By Raymond L. Ditmars. J. B. Lippincott Co., Philadelphia. 1934. 64 pages. $2.00. A survey of mammal life throughout the world, illustrated with colorful maps on which the chief forms are pictured. *Grades 6 to 8.*

Bozo, the Woodchuck. By Dorothy L. Brown and Marguerite Butterfield. American Book Co., New York. 1933. 116 pages. $.52. A simply written story of a pet woodchuck from the time he was captured to his return to wild life. *Grade 4.*

The Call of the Wild. By Jack London. Grosset & Dunlap, Inc., New York. 1903. 211 pages. $1.00. New edition of an excellent dog story. *Grade 8 and above.*

Deer at Night in the North Woods. By Tappan Gregory. Charles C. Thomas, Springfield, Ill. 1930. 212 pages. $4.00. A record in words and splendid photographs of some twenty years of experience photographing wild animals at night. *Adult.*

The Dog Book. By Diana Thorne and Albert P. Terhune. Saalfield Publishing Co., Akron, Ohio. 1932. 96 pages. $1.00. Twelve well-known breeds of dogs, pictured in full-page, pastel portraits, with descriptions by Mr. Terhune. *All grades.*

Feeds and Feeding. By F. B. Morrison. Morrison Publishing Co., Ithaca, N. Y. 1937. Abridged edition. 503 pages. $2.75. A handbook for the student and stockman.

Field Book of North American Mammals. By H. E. Anthony. G. P. Putnam's Sons, New York. 1928. 625 pages. $5.00. A standard guide, nontechnical and well illustrated. *Grade 7 and above.*

Flat Tail. By Alice C. Gall and Fleming H. Crew. Oxford University Press, New York. 1935. 126 pages. $1.50. An interesting story of a year in a beaver's life. *Grades 3 to 5.*

A Friend in the Dark. By Ruth A. Knight. Grosset and Dunlap, Inc., New York. 1937. 71 pages. $1.00. A well-told story of the training and work of a "Seeing Eye" dog. *Grade 5 and above.*

Fuzzy and His Neighbors. By José F. Nonidez. D. Appleton-Century Co., Inc., New York. 1932. 147 pages. $1.50. A true story of the chipmunk and other little animals that the author met in his garden on Cape Cod. *Ages 6 to 10.*

Gray Squirrel. By Joseph W. Lippincott. Penn Publishing Co., Philadelphia. 1921. 144 pages. $1.50. A sympathetic story based on the author's observations. *Grade 6 and above.* The same author has written other stories of animals, also published by Penn.

The Grizzly; our Greatest Wild Animal. By Enos A. Mills. Houghton Mifflin Co., Boston. 1919. 289 pages. $2.50. Interesting and instructive sketches based on personal experiences. *Adult.*

Homes and Habits of Wild Animals. By Karl P. Schmidt. M. A. Donohue & Co., Chicago. 1934. 64 pages. $1.50. A large, beautifully illustrated book of excellent information about North American Mammals. *Grade 5 and above.*

In Beaver World. By Enos A. Mills. Houghton Mifflin Co., Boston. 1913. 228 pages. $2.50. A good general account, based largely on experiences of the author. *Adult.*

Jimmie, the Story of a Black Bear Cub. By Ernest H. Baynes. The Macmillan Co., New York. 1923. 134 pages. $2.00. A delightful story of the antics of a mischievous pet cub. *Grades 5 to 8.*

JINNY; THE STORY OF A FILLY. By Bert C. Thayer. Farrar & Rinehart, New York. 1934. 102 pages. $2.50. Appealing photographs and brief text about a colt's first year. *Ages 8 to 10.*

KEEMA OF THE MONKEY PEOPLE. By Walter J. Wilwerding. The Macmillan Co., New York. 1936. 120 pages. $2.00. An excellent story of the life of an East African blue monkey. *Grade 5 and above.*

KEO THE OTTER. By Virgie Bernhardt. Grosset & Dunlap, New York. 1937. 47 pages. $.25. An interestingly illustrated brief life history. *Grades 2 and 3.*

LAD, A DOG. By Albert P. Terhune. E. P. Dutton & Co., New York. 1926. 371 pages. $2.00. A well-liked story, by an author who has written much about dogs. *Grade 6 and above.*

THE LITTLE WOLF. By Wendell Chapman and Lucie Chapman. Charles Scribner's Sons, New York. 1936. 140 pages. $2.00. A story of the Rocky Mountain coyote, and of the animals with whom he lived. *Grades 4 to 6.*

LIVES OF GAME ANIMALS. By Ernest T. Seton. Doubleday, Doran & Co., Garden City, N. Y. 1929. 8 or 4 vols., 3111 pages. (Out of print.) Detailed, interesting accounts of North American mammals, written in popular style, and well illustrated. Obtainable in many libraries. *Grade 8 and above.*

MILD ANIMALS. By Julius King. Grosset & Dunlap, Inc., New York. 1936. 39 pages. $.50. Full-page color plates and page-length descriptions of twenty common small mammals of eastern North America. *Grades 5 to 7.*

NATURAL HISTORY ANIMALS. By George Jennison. The Macmillan Co., New York. 1927. 343 pages. $3.75. A profusely illustrated "Who's Who" of the animal world, by an English author. *All ages.*

OUR GREAT OUTDOORS: MAMMALS. By C. W. G. Eifrig. Rand, McNally & Co., Chicago. 1928. 270 pages. $1.40. Useful information about American mammals and some notable forms from foreign countries. *Grades 6 to 8.*

OUR WILD ANIMALS. By Edwin L. Moseley. D. Appleton-Century Co., Inc., New York. 1927. 322 pages $1.75. A survey of North American mammals, most of them widely distributed in the United States and Canada. *Grades 5 to 7.*

POLARIS, THE STORY OF AN ESKIMO DOG. By Ernest H. Baynes. The Macmillan Co., New York. 1923. 137 pages. $2.00. An account of the puppy days of a dog whose parents took Peary to the North Pole, and who himself was sent to Dr. Grenfell in Greenland. *Grades 5 to 8.*

PRESENT DAY MAMMALS. By Claude W. Leister. New York Zoological Park, New York. 1931. 74 pages. $1.15. An illustrated chart of the orders of mammals, of value in large libraries. *Grade 7 and above.*

RED FOX. By Charles G. D. Roberts. L. C. Page & Co., Boston. 1905. 340 pages. $3.00. A fox story well worth reading. *Grade 6 and above.*

RINGTAIL. By Alice C. Gall and Fleming H. Crew. Oxford University Press, New York. 1933. 115 pages. $1.00. A well-written story of a year in the life of a young raccoon. *Grades 3 to 5.*

SAJO AND THE BEAVER PEOPLE. By Grey Owl. Charles Scribner's Sons, New York. 1936. 201 pages. $2.50. An appealing story built around the experiences of two Indian children and their two pet beavers, illustrated with particularly interesting pencil drawings. *Grade 6 and above.*

SCARFACE, THE STORY OF A GRIZZLY. By Dorr G. Yeager. The Penn Publishing Co., Philadelphia. 1935. 254 pages. $2.00. The story of a grizzly bear, from his birth, through thirty years, until his death. *Grade 6 and above.*

SILVER BOY. By Vance Joseph Hoyt. Lothrop, Lee & Shepard Co., New York. 1929. 265 pages. $2.00. Well-told life story of a California gray fox. *Ages 10 to 14.* The same author has written *Bar-Rac: the Biography of a Raccoon,* 1931, 111 pages, and *Zorra: the Biography of a Gray Fox,* 1933, 125 pages,

$1.50 each, both published by Lothrop, Lee & Shepard.

SKINNY, THE GRAY FOX. By Agnes A. Atkinson. The Viking Press, Inc., New York. 1936. 111 pages. $1.50. A story which resulted from ten years' observation of gray foxes near the author's home in the West. *Ages 8 to 12.*

THE SPRITE; THE STORY OF A RED FOX. By Ernest H. Baynes. The Macmillan Co., New York. 1924. 134 pages. $2.00. A favorite story of a fox brought up as a pet. *Grades 5 to 8.*

SQUIRRELS AND OTHER FUR-BEARERS. By John Burroughs. Houghton Mifflin Co., Boston. 1875–1928. School edition, 150 pages. $.96. Short observations of common mammals, written by a famous nature writer. *Grades 6 to 8.*

STICKEEN; THE STORY OF A DOG. By John Muir. Houghton Mifflin Co., Boston. 1909. 82 pages. Cloth, $.48. An exciting story of a battle for life on an Alaskan glacier, and one of the best dog stories ever written. *Grade 7 and above.*

THE STORY OF MATKA. By David Starr Jordan. World Book Co., Yonkers, N. Y. Revised edition, 1921. 80 pages. $.72. The life of the fur seals of Alaska, with information about the seal-fur industry, useful in conservation studies. *Grade 6 and above.*

THE STORY OF SCOTCH. By Enos A. Mills. Houghton Mifflin Co., Boston. 1916. 63 pages. $1.25. A very good dog story. *Grade 6 and above.*

TAMI, THE STORY OF A CHIPMUNK. By Bertha C. Cady. Slingerland-Comstock Publishing Co., Ithaca, N. Y. 1927. 104 pages. $1.00. Charming story of a pet. *Ages to 10.*

WATCHED BY WILD ANIMALS; WILD ANIMAL HOMESTEADS. Both by Enos A. Mills. Houghton Mifflin Co., Boston. 1922, 1923, new editions, 1932. 251, 270 pages. $2.50 each. Stories of mammals based chiefly on the author's long experience with animals of the Rocky Mountains. *Grade 6 and above.*

WHO'S WHO IN THE ZOO. Edited by Ralph De Sola and Staff. Blue Ribbon Books, New York. 1937. 223 pages. $1.69. A beautiful book prepared by workers of the Federal Writers' project in the City of New York, which contains brief accounts and excellent photographs and range-maps of more than a hundred wild animals. *All grades.*

WILD ANIMALS AT HOME. By Ernest T. Seton. Grosset & Dunlap, Inc., New York. 1913. 241 pages. $1.00. Short tales of American mammals, based chiefly on observations made in the Rocky Mountains over a period of nearly thirty years. *Grades 5 to 8.*

WILD ANIMALS OF NORTH AMERICA. By Edward W. Nelson. The National Geographic Society, Washington, D. C. Revised edition, 1930. 254 pages. $2.00. Accurate biographies of 119 mammals of North America, with about fifty pages of colored portraits by L. A. Fuertes, many photographs, and a helpful section on mammal tracks, by Ernest T. Seton. *All grades.*

WILDERNESS WANDERERS. By Wendell Chapman and Lucie Chapman. Charles Scribner's Sons, New York. 1937. 318 pages. $3.75. Fascinating stories of Rocky Mountain animals. *Grades 6 to 8.*

ZEKE, THE RACCOON. By Rhea Wells. The Viking Press, New York. 1933. 159 pages. $2.00. An amusing story of a pet raccoon. *Ages to 10.*

BIRDS

(See also *Nature Study in General* and *Animals in General*)

The ABC of Attracting Birds. By Alvin M. Peterson. Bruce Publishing Co., Milwaukee. 1937. 146 pages. $1.50. The newest and most attractive book on the subject, giving many simple, clear suggestions. *Grade 5 and above.*

American Bird Biographies. By Arthur A. Allen. Comstock Publishing Co., Inc., Ithaca, N. Y. 1934. 238 pages. $3.50. Complete life histories of twenty birds, told in autobiographical form and beautifully illustrated with photographs and colored plates. *Grades 5 to 8.*

American Birds. By William L. Finley. Charles Scribner's Sons, New York. 1908. 256 pages. $3.00. Accurate accounts, with pen and camera, of about thirty western American birds. *Grade 8 and above.*

American Land Birds. By Alice E. Ball. Tudor Publishing Co., New York. New edition, 1936. 295 pages. $1.69. Accounts of about 200 birds, arranged according to season, illustrated in color. *Grade 6 and above.*

Audubon Bird Cards: set 1, 50 Winter Birds; set 2, 50 Spring Birds; set 3, 50 Summer Birds. By Allan Brooks. National Association of Audubon Societies, New York. Each set, $1.00. Colored, postcard-size pictures of birds of eastern North America, with text, by Alden H. Hadley. *All grades.*

Audubon Bird Leaflets. Published by the National Association of Audubon Societies, New York. 4 pages each. $.05 each. More than a hundred leaflets, each an account of a bird, illustrated in color. *All grades.*

The Bird Book. By Neltje Blanchan, pseud. Doubleday, Doran & Co., Garden City, N. Y. 1932. 568 pages. $2.95. A new edition, combining in one volume, *Bird Neighbors* and *Birds that Hunt and are Hunted. Grade 7 and above.*

The Bird Book. By Fannie H. Eckstorm. D. C. Heath & Co., Boston. 1901. 281 pages. $1.28. An old book, which contains much interesting material. *Grade 6 and above.*

Bird Flight. By Gordon C. Aymar. Dodd, Mead & Co., New York. 1935. 246 pages. $4.00. More than 175 action photographs of birds in flight, with explanatory text on bird flight and related topics. *Adult.*

Bird Friends. By Gilbert H. Trafton. Houghton Mifflin Co., Boston. 1916. 330 pages. $3.50. An older book for general study of American birds.

Bird Guide: Land Birds East of the Rockies; Bird Guide: Water Birds, Game Birds and Birds of Prey East of the Rockies. Both by Chester A. Reed. Doubleday, Doran & Co., Garden City, N. Y. 1925, 1921. 238, 240 pages. $1.25 or $1.50 each. Widely used pocket guides. *Grade 4 and above.*

Bird-House to Let. By Mary F. Terrel. F. A. Stokes Co., New York. 1931. 146 pages. $1.50. A simple story-record of the birds that nested in a New Jersey garden. *Ages 6 to 10.*

Bird Houses Boys Can Build. By Albert F. Siepert. The Manual Arts Press, Peoria, Ill. Revised edition, 1936. 64 pages. $.65. Pictures and drawings of houses and suggestions on feeding and attracting birds. *Grade 7 and above.*

The Bird Kingdom. The Orthovis Co., Chicago. 1934. 42 pages. $2.00. Photographs of habitat groups in the Field Museum of Natural History in Chicago, with accompanying pictures to be viewed through an orthoscope which makes the pictures appear three-dimensional. A companion book, *The Animal*

Kingdom, $2.00, and the *Footprint Series*, two sets of four books at $1.00 a set, are also available. *All grades.*

BIRD LIFE. By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. Revised edition, 1924. 284 pages. $5.00. A standard guide to the study of common birds. *Grade 7 and above.*

BIRD STORIES. By Edith M. Patch. Little, Brown & Co., Boston. 1921. 212 pages. $1.75. Biographies of twelve birds, written entertainingly. *Grades 4 to 6.*

BIRD STORIES FROM BURROUGHS. By John Burroughs. Houghton Mifflin Co., Boston. 1911. School edition. 174 pages. $1.12. Stories and poems about common American birds, by a famous naturalist. *Grade 7 and above.*

BIRD STUDY FOR SCHOOLS SERIES. Published by the National Association of Audubon Societies, New York. $.05 or $.10 each. Various articles covering such topics as general activities, field trips, winter feeding, bird houses, bird day, and building a nature interest. Chiefly for teacher's use.

BIRDS, books 1, 2, and 3. By Julius King. Harter Publishing Co., Cleveland, Ohio. 1934. Various pages. $.10 each. Each book describes fifteen common birds. Illustrations in color, from paintings by Allan Brooks. *Grade 3 and above.*

BIRDS AND THEIR ATTRIBUTES. By Glover M. Allen. Marshall Jones Co., Boston. 1925. 326 pages. $3.50. General survey of the life and structure of birds and their relation to man. *Adult.*

BIRDS IN THEIR RELATION TO MAN. By Clarence M. Weed and Ned Dearborn. J. B. Lippincott Co., Philadelphia. Fourth edition, 1935. 420 pages. $3.50. An older book, which contains a general survey of the foods of birds, with material on various groups. *Adult.*

BIRDS IN THE WILDERNESS. By George M. Sutton. The Macmillan Co., New York. 1936. 214 pages. $3.50. An informal and interesting account of the author's experiences while on bird-study expeditions in United States and Canada. *Adult.*

BIRDS OF AMERICA. Edited by T. Gilbert Pearson. Garden City Publishing Co., Garden City, N. Y. 1936. 1000 pages. $3.95. A new edition of an older, expensive publication, which illustrates in color and describes about a thousand kinds of American birds. *All grades.*

BIRDS OF CANADA. By P. A. Taverner. David McKay Co., Philadelphia. 1938. 445 pages. $4.00. Guides for study and identification. *Adult.*

BIRDS OF MASSACHUSETTS AND OTHER NEW ENGLAND STATES. By Edward H. Forbush. State Board of Agriculture, Boston. 1929. 3 vols., 1408 pages. $15.00. An excellent extensive treatment, with superior colored illustrations by L. A. Fuertes and Allan Brooks. *Adult.*

THE BIRDS OF MINNESOTA. By Thomas S. Roberts. University of Minnesota Press, Minneapolis, Minn. 1932. 2 vols., 1512 pages. $15.00. Excellently illustrated in color, and valuable in Minnesota and adjacent regions. *Bird Portraits in Color*, 186 pages, $3.50, a collection of the color plates from the two volumes, with a page of text for each plate is also available, as are *A Manual for the Identification of the Birds of Minnesota and Neighboring States*, 279 pages, $1.50; and *Two Hundred and Ninety-five American Birds*, 1936, 92 pages colored pictures in spiral binding, $2.00, or loose in portfolio, $1.50.

THE BIRDS OF NEW YORK. By Elon H. Eaton. New York State Museum, Albany, New York. 1916. 2 vols. 1220 pages. $6.00, plus transportation. A comprehensive treatment, illustrated in color by L. A. Fuertes. *Adult.*

BIRDS OF THE OCEAN. By W. B. Alexander. G. P. Putnam's Sons, New York. 1928. 428 pages. $3.50. Convenient guide for identification. *Adult.*

BIRDS OF THE PACIFIC COAST. By William A. Eliot. G. P. Putnam's Sons, New York. 1926. 211 pages. $3.50. Illustrated field guide. *Adult.*

BIRDS OF THE PACIFIC STATES. By Ralph A. Hoffman. Houghton Mifflin Co., Boston. 1927. 353 pages. $5.00. A manual for adults.

Birds of the South. By Charlotte H. Green. University of North Carolina Press, Chapel Hill, N. C. 1933. 292 pages. $1.50. A beginner's book, illustrated in color. *Grades 6 to 8.*

Birds of the Wild — How to Make Your Home Their Home. By Frank C. Pellett. A. T. De La Mare Co., Inc., New York. 1928. 128 pages. $1.00. Well-written discussion for those who wish to attract birds to their home grounds. *Adult.*

The Book of Bird Life. By Arthur A. Allen. D. Van Nostrand Co., Inc., New York. 1930. 426 pages. $3.50. A very readable book, discussing bird life in general, and methods of bird study. Well illustrated with photographs. For adults, but usuable in grade 6 and above.

The Book of Birds. Edited by Gilbert Grosvenor and Alexander Wetmore. The National Geographic Society, Washington, D. C. 1937. 738 pages. $5.00. Two volumes, made up of material which has appeared in the National Geographic Magazine, illustrating in color and describing nearly a thousand birds of North America north of Mexico. *All grades.*

Boy Bird House Architecture. By Leon H. Baxter. Bruce Publishing Co., Milwaukee. 1920. 62 pages. $1.00. Simple detailed plans, accompanied by brief text which discusses problems of attracting birds. *Grade 4 and above.*

Chanco; a United States Army Homing Pigeon. By Helen O. Watson. Harper & Brothers, New York. 1938. 163 pages. $2.00. A fascinating story of incidents and events in the lives of real homers. *Grade 5 and above.*

Cher Ami; the Story of a Carrier Pigeon. By Marion B. Cothren. Little, Brown & Co., Boston. 1934. 83 pages. $1.25. A story of the World War. *Grade 4 and above.*

The Children's Book of Birds. By Olive Thorne Miller. Houghton Mifflin Co., Boston. 1927 edition. 360 pages. $3.00. A single volume combining the *First Book of Birds*, and the *Second Book of Birds*. The *First Book*, a good general discussion, is obtainable separately, at $.96. *Grades 4 to 6.*

Field Book of Wild Birds and Their Music. By F. Schuyler Mathews. G. P. Putnam's Sons, New York. Revised edition, 1921. 325 pages. $3.50. A guide for identification for adults.

Field Book of the Birds of the Panama Canal Zone. By B. B. Sturgis. G. P. Putnam's Sons, New York. 1928. 466 pages. $3.50. A popular illustrated handbook for identification. *Adult.*

The Fieldbook of Birds of the Southwestern United States. By L. E. Wyman and Elizabeth Burnell. Houghton Mifflin Co., Boston. 1925. 308 pages. $3.50. *Adult.*

A Field Guide to the Birds. By Roger T. Peterson. Houghton Mifflin Co., Boston. 1934. 188 pages. $2.75. A small book, distinguished for its unique help in outdoor identification of birds of eastern North America. *Grade 7 and above.*

The Golden Plover and Other Birds — American Bird Biographies, Second Series. By Arthur A. Allen. Comstock Publishing Co., Inc., Ithaca, N. Y. 1939. 324 pages. $3.00. Stories of twenty-seven birds, similar in style and illustration to *American Bird Biographies*. *Grade 5 and above.*

A Guide to Bird Songs. By Aretas A. Saunders. D. Appleton-Century Co., Inc., New York. 1935. 302 pages. $2.50. Detailed popular presentation of songs and singing habits of 150 common land birds east of the Rockies. *Adult.*

Handbook of Birds of Eastern North America. By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1932. 581 pages. $5.00. The standard manual for the region, for adults or older students.

Handbook of Birds of the Western United States. By Florence M. Bailey. Houghton Mifflin Co., Boston. 1935. 590 pages. $6.00. Standard manual for the West. *Adult.*

THE HAWKS OF NORTH AMERICA; THEIR FIELD IDENTIFICATION AND FEEDING HABITS. By John B. May. National Association of Audubon Societies, New York. 1935. 172 pages. $1.25. A complete, well-illustrated book written as a part of an intensive educational campaign in behalf of these birds. *Grade 6 and above.*

HOW TO HAVE BIRD NEIGHBORS. By S. Louise Patteson. D. C. Heath & Co., Boston. 1917. 131 pages. $.92. The author's experiences in attracting birds. *Age 10 and above.*

THE LIFE STORY OF BIRDS; HOW TO SEE BIRDS. Both by Eric F. Daglish. William Morrow & Co., New York. 1930, 1932. 236, 128 pages. $3.00, $1.50. Books by an English author, the first a general account of the habits of birds, the second a discussion of attracting and watching birds, and of such topics as beaks, feet, song, and nests. *Grade 7 and above.*

METHODS OF ATTRACTING BIRDS. By Gilbert H. Trafton. Houghton Mifflin Co., Boston. 1910. 180 pages. $2.00. A small book, for grade 6 and above.

ORNITHOLOGY LABORATORY NOTEBOOK FOR INTENSIVE STUDY OF THE BIRDS OF EASTERN NORTH AMERICA. By A. A. Allen, L. A. Fuertes, and Miles Pirnie. Comstock Publishing Co., Inc., Ithaca, N. Y. Fourth edition, 1941. 272 pages. $3.00. Illustrated outlines for study, with a key for identification of birds' nests in winter. *Adult.*

OUR BIRD FRIENDS AND FOES. By William A. DuPuy. John C. Winston Co., Philadelphia. 1925. 319 pages. $1.00. A discussion of adaptations, general habits, and relation to man. *Grades 5 to 8.*

OUR WINTER BIRDS. By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1918. 180 pages. Student's edition, $.80. Well-written short accounts of winter birds, with suggestions for caring for them. Small, but useful colored pictures. *Grades 6 to 8.*

PADDLEWINGS: THE PENGUIN OF GALAPAGOS. By Wilfrid S. Bronson. The Macmillan Co., New York. 1931. 106 pages. $2.00. An excellent story, into which much information has been woven, illustrated with amusing and instructive drawings. *Grades 4 to 6.*

PERMANENT BIRD HOUSES. By Gladstone Califf. Bruce Publishing Co., Milwaukee, Wis. 1924. 64 pages. $1.00. Plans and instructions for several types. *Grade 7 and above.*

PRACTICAL VALUE OF BIRDS. By Junius Henderson. The Macmillan Co., New York. 1927. 342 pages. $2.50. Good general and systematic discussions. *Adult.*

RED BOOK OF BIRDS OF AMERICA; BLUE BOOK OF BIRDS OF AMERICA; GREEN BOOK OF BIRDS OF AMERICA. By Frank G. Ashbrook. Whitman Publishing Co., Racine, Wis. 1931. 96 pages each. $.10 each. Pocket-sized guides, illustrated with fair colored pictures. *All ages.*

THE RESTLESS ROBIN. By Marjorie Flack. Houghton Mifflin Co., Boston. 1937. 48 pages. $1.50. An attractive picture-story book in color, presenting many facts about robins. *Grades 3 to 4.*

SONG-BIRD SANCTUARIES; WITH TABLES OF TREES, SHRUBS AND VINES ATTRACTIVE TO BIRDS. By Roger T. Peterson. National Association of Audubon Societies, New York. 1937. 30 pages. $.25. Prepared with the cooperation of the New York State College of Forestry. *Adult.*

SONGS OF WILD BIRDS; MORE SONGS OF WILD BIRDS. Both by Albert R. Brand. Thomas Nelson & Sons, New York. 1934, 1936. 91, 116 pages. $2.00, $2.50. Unique books designed to aid in learning to recognize birds by their songs. The first contains two double-faced unbreakable phonograph records of the songs, recorded from nature, of 35 birds of eastern North America, and the second, three records, with 43 songs. *All grades, particularly 5 to 8.*

TRAVELING WITH THE BIRDS. By Rudyerd Boulton, M. A. Donohue & Co., Chicago. 1933. 64 pages. $1.50. A large book, illustrated in color, which tells the story of bird migration. *Grades 4 to 6.*

Travels of Birds. By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1916. 160 pages. $.76. A very satisfactory discussion for children of the problems of bird migration. *Grades 5 to 7.*

United States Department of Agriculture Farmers' Bulletins, Circulars and Other Publications. Superintendent of Documents, Government Printing Office, Washington, D. C. Numerous publications on birds, and other subjects, a list of which is available.

Wake Robin. By John Burroughs. Houghton Mifflin Co., Boston. 1899. 233 pages. $2.25. Delightful interpretations of bird life. *Adult.*

Western Bird Guide. By Chester A. Reed. Doubleday, Doran & Co., Garden City, N. Y. 1913. 255 pages. $1.75. Convenient pocket guide. *All ages.*

What Bird Is That? By Frank M. Chapman. D. Appleton-Century Co., Inc., New York. 1935 edition. 158 pages. $1.50. A compact guide, illustrated with small colored pictures, for identification of the land birds of eastern United States. *Grade 6 and above.*

Wild Bird Guests; How to Entertain Them. By Ernest H. Baynes. E. P. Dutton & Co., New York. 1915. 326 pages. $1.00. An old, but very useful book, discussing many phases of bird protection. *Grades 5 to 8.*

A Year in the Wonderland of Birds. By Hallam Hawksworth (G. F. Atkinson). Charles Scribner's Sons, New York. 1925. 245 pages. $1.00. Birds and bird life, presented seasonally. *Grade 6 and above.*

See also, Nature Study in General, Animals in General, Textbooks and Readers, Nature Poetry.

REPTILES, AMPHIBIANS AND FISH

(See also *Nature Study in General* and *Animals in General*)

All About Fish and Other Denizens of the Seas and Rivers; All About Reptiles (including Frogs and Toads). Both by W. S. Berridge. Robert M. McBride & Co., New York. 1934, 1935. 253, 270 pages. $2.50 each. Information for the layman, by an English author. *Adult.*

American Food and Game Fishes. By David S. Jordan and Barton W. Evermann. Doubleday, Doran & Co., Garden City, N. Y. 1934. 572 pages. $5.00. Standard work on fishes north of Panama. *Adult.*

Animals in the Sun. By William W. Robinson. Harper & Brothers, New York. 1934. 63 pages. $2.00. Brief, well-written information about crocodiles, alligators, lizards, turtles, and snakes, chiefly of North America. *Grades 5 to 8.*

Biology of the Amphibia. By G. Kingsley Noble. McGraw-Hill Book Co., Inc., New York. 1931. 577 pages. $5.00. A comprehensive study of the group. *Adult.*

The Book of Fishes. By John O. La Gorce and others. National Geographic Society, Washington, D. C. 1924. 243 pages. $2.00. Articles and fish biographies, well illustrated in color and with photographs. *All grades.*

The Book of Living Reptiles. By Raymond L. Ditmars. J. B. Lippincott Co., Philadelphia. 1936. 64 pages. $2.00. Brief information about reptiles all over the world, illustrated with maps on which are placed species native to the region. *Grades 5 to 7.*

Do You Know About Fishes? By Janet Smalley. William Morrow & Co., New York. 1936. 45 pages. $1.25. Attractive colored pictures, accompanied by simple text. *Grades 2 to 4.*

Fingerfins: the Tale of a Sargasso Fish. By Wilfrid S. Bronson. The

Macmillan Co., New York. 1930. 52 pages. $2.00. A lively, interesting narrative, excellently illustrated by the author. *Grades 3 to 5.*

FISHES: THEIR JOURNEYS AND MIGRATIONS. By Louis Roule. W. W. Norton & Co., Inc., New York. 1935. 319 pages. $3.75. An interesting, nontechnical account, translated from the French. *Adult.*

FISHES IN THE HOME. By Ida M. Mellen. Dodd, Mead & Co., New York. 1927. 178 pages. $2.00. Care of aquarium fishes, particularly tropical fishes. *Adult.*

THE FROG BOOK. By Mary C. Dickerson. Doubleday, Doran & Co., Garden City, N. Y. 1931 edition. 253 pages. $5.00. A reprint of an excellent nontechnical study of North American frogs and toads, well illustrated. *Grade 6 and above.*

GOLDFISH, THEIR CARE IN SMALL AQUARIA AND PONDS. By E. C. Fearnow, Commissioner of Fisheries, Washington, D. C. (Document 980). 1924. 16 pages. $.05. Valuable suggestions for amateurs. *Grade 6 and above.*

GOLDFISH CULTURE FOR AMATEURS. By A. E. Hodge and A. Derham. F. A. Stokes Co., New York. 1928. 103 pages. $2.00. How to breed and rear goldfish in aquaria and ponds. *Adult.*

HANDBOOK OF FROGS AND TOADS. By Anna A. Wright and Albert H. Wright. Comstock Publishing Co., Inc., Ithaca, N. Y. 1934. 244 pages. $2.50. General discussion, followed by accounts of many species, abundantly illustrated with excellent photographs. *Grade 7 and above.*

A HISTORY OF FISHES. By J. R. Norman. F. A. Stokes Co., New York. 1931. 463 pages. $7.50. An interesting answer to many questions about the life and habits of fish. *Adult.*

HUMPHREY; ONE HUNDRED YEARS ALONG THE WAYSIDE WITH A BOX TURTLE. By Marjorie Flack. Doubleday, Doran & Co., Garden City, N. Y. 1934. 84 pages. $2.00. An attractively illustrated story in which much information about the turtle is combined with incidents in American History. *Grades 2 and 3.*

THE LIFE STORY OF THE FISH. By Brian Curtis. D. Appleton-Century Co., Inc., New York. 1938. 260 pages. $3.00. A well-written, scientifically true discussion, which has been very well received. *Adult.*

LITTLE TOAD. By Frances M. Fox. Viking Press, Inc., New York. 1938. 79 pages. $1.00. An imaginative story which presents the facts of the life history and habits of a toad, written for small children.

MARINE FISHES OF THE ATLANTIC COAST. By Charles M. Breder. G. P. Putnam's Sons, New York. 1929. 375 pages. $3.50. Popular guide. *Adult.*

MINNOWS OF MICHIGAN. By Carl Hubbs and Gerald Cooper. Bulletin 8, Cranbrook Institute of Science, Bloomfield Hills, Mich. 1936. 95 pages. $.50. A brief discussion by recognized authorities. *Adult.*

OUR GREAT OUTDOORS: REPTILES, AMPHIBIANS, AND FISHES. By C. W. G. Eifrig. Rand, McNally & Co., Chicago. 1930. 257 pages. $1.40. General surveys of the groups, followed by short accounts of many American species. *Grades 6 to 8.*

POLLWIGGLE'S PROGRESS. By Wilfrid S. Bronson. The Macmillan Co., New York. 1932. 122 pages. $2.00. The life story of a bullfrog, from egg to adult, illustrated with interesting and very valuable drawings by the author. *Grades 3 to 5.*

REPTILES AND AMPHIBIANS; THEIR HABITS AND ADAPTATIONS. By Thomas Barbour. Houghton Mifflin Co., Boston. Revised edition, 1934. 149 pages. $4.00. Readable, thoroughly scientific account. *Adult.*

THE REPTILES OF NORTH AMERICA. By Raymond L. Ditmars. Doubleday, Doran & Co., Garden City, N. Y. Revised edition. 1936. 627 pages. $6.75. A review of reptiles, of all groups, inhabiting the United States and northern Mexico, prepared particularly for use in identifying them. Eight colored plates and many photographs. *Grade 7 and above.*

REPTILES OF THE WORLD. By Raymond L. Ditmars. The Macmillan Co., New York. Revised edition, 1933. 341 pages. $5.00; Imperial edition, $1.98. General information about reptiles, of all groups, from both hemispheres, abundantly illustrated. *Grade 7 and above.*

SEA-HORSE ADVENTURE. By Irmengarde Eberle and Else Bostelmann. Holiday House, Inc., New York. 1937. 53 pages. $2.00. A colorfully illustrated story, based on scientific information. *Grades 4 to 6.*

SNAKES ALIVE AND HOW THEY LIVE. By Clifford H. Pope. The Viking Press, New York. 1937. 250 pages. $2.50. General information about snakes, with an appendix telling how to identify the snakes of the United States. Well illustrated. *For adults, but usable in the upper grades.*

SNAKES AND THEIR WAYS. By C. Howard Curran and Carl F. Kauffeld. Harper & Brothers, New York. 1937. 302 pages. $3.50. A scientifically accurate, nontechnical account. *Adult.*

SNAKES OF THE WORLD. By Raymond L. Ditmars. The Macmillan Co., New York. 1937. 207 pages. $5.00; Imperial edition, $1.98. A popular account of general habits of snakes, with brief discussions of species. Excellent photographic illustrations. *Grades 6 to 8.*

THE STORY OF FROGS. By Mary B. Herring. (Unit Study Book, 351) American Education Press, Inc., Columbus, Ohio. 1934. 36 pages. $.10. Very good material for grade 3.

STRANGE REPTILES AND THEIR STORIES. By A. Hyatt Verrill. L. C. Page & Co., Boston. 1937. 209 pages. $2.50. A frankly popular account, not of great value as a reference, but interesting in its treatment of prejudices and superstitions about snakes. *Grade 7 and above.*

TIM TADPOLE AND THE GREAT BULLFROG. By Marjorie Flack. Doubleday, Doran & Co., Garden City, N. Y. 1934. 32 pages. $1.00. Information in the form of fiction, interestingly illustrated by the author. *Ages 4 to 8.*

TROUT STREAMS. By Paul R. Needham. Comstock Publishing Co., Inc., Ithaca, N. Y. 1940. 233 pages. $3.00. A study of the conditions that determine the productivity of trout streams, and suggestions for stream and lake management, written for anglers, sportsmen and conservationists. *Adult.*

WAGTAIL. By Alice C. Gall and Fleming H. Crew. Oxford University Press, New York. 1932. 131 pages. $1.00. A story of the life of a tadpole and his associates, told with some personification, and illustrated with very attractive drawings. *Grades 3 to 5.*

THE YOUNG FOLKS' BOOK OF FISHES. By Ida M. Mellen. Dodd, Mead & Co., New York. 1927. 170 pages. $2.00. Decidedly readable material, giving both general and specific information. *Grades 6 to 8.*

INSECTS AND OTHER INVERTEBRATES

(See also *Nature Study in General* and *Animals in General*)

ANIMALS OF THE SEASHORE. By Horace G. Richards. Bruce Humphries, Inc., Boston. 1938. 273 pages. $3.00. A new, illustrated guide to seashore animals of the Atlantic Coast, particularly between Cape Cod and Cape Hatteras. *Grade 7 and above.*

ANT HILLS AND SOAP BUBBLES. By Mary G. Phillips. D. C. Heath & Co., Boston. 1927. 265 pages. $.92. Accurate information about ants, in fairy-tale setting. *Grade 4 and above.*

THE BEE PEOPLE. By Margaret W. Morley. A. C. McClurg & Co., Chicago.

Revised edition, 1937. 177 pages. $2.00. Detailed story of bee structure and function, illustrated attractively in color. *Grade 4 and above.*

BUMBLEBEES AND THEIR WAYS. By Otto E. Plath. The Macmillan Co., New York. 1934. 217 pages. $4.50. Information about the life history and interesting habits of bumblebees, illustrated, partly in color. *Adult.*

THE BUSY LITTLE HONEYBEE. By Josephine M. True. Rand, McNally Co., Chicago, Ill. 1936. 63 pages. $.10. Simple information about bees. *Grade 4 and above.*

BUTTERFLIES OF AMERICA; BUGS OF AMERICA. Both by Lillian D. Fazzini. Whitman Publishing Co., Racine, Wis. 1934, 1937. 96 pages each. $.10 each. Pocket-sized guides, one to the common species of fairly large-sized moths and butterflies, the other to insects of other groups. *For beginners.*

BUTTERFLY AND MOTH BOOK. By Ellen Robertson-Miller. Charles Scribner's Sons, New York. Revised and enlarged edition, 1931. 277 pages. $2.50. Detailed life histories of 40 moths and butterflies, well illustrated with photographs. *Grade 5 and above.*

THE BUTTERFLY BOOK. By W. J. Holland. Doubleday, Doran & Co., Garden City, N. Y. Revised and enlarged edition, 1931. 440 pages. $10.00. Standard guide to butterflies north of the American-Mexican border, particularly valuable for the many colored illustrations. *Adult.*

THE BUTTERFLY GUIDE. By W. J. Holland. Doubleday, Doran & Co., Garden City, N. Y. 1916. 237 pages. $1.25 or $1.50. Pocket manual for the commoner North American species. *Adult.*

CATERPILLARS AND THEIR MOTHS. By Ida M. Eliot and Caroline G. Soule. D. Appleton-Century Co., Inc., New York. 1902. 299 pages. $3.00. Detailed, interesting accounts of the writers' experiences in life history studies of 43 species. *Adult.*

THE CHILDREN'S LIFE OF THE BEE. By Maurice Maeterlinck. Dodd, Mead & Co., New York. 1919. 192 pages. $2.00. A beautifully told story, consisting of selected passages from the author's book for adults. *Grades 6 to 8.*

DESTRUCTIVE AND USEFUL INSECTS. By C. L. Metcalf and W. P. Flint. McGraw-Hill Book Co., Inc., New York. 1928. 918 pages. $7.50. An extensive discussion of the habits and control of insects. *Adult.* The same authors have published (McGraw-Hill) *The Fundamentals of Insect Life,* 1932, 581 pages, $4.00.

DIRECTIONS FOR COLLECTING AND PRESERVING INSECTS. By A. B. Klots. Ward's Natural Science Establishment, Inc., Rochester, N. Y. 1932. 30 pages. $.15. A helpful pamphlet. *Adult.*

DO YOU KNOW? By Janet Smalley. William Morrow & Co., Inc., New York. 1934. 46 pages. $1.25. A colorful little book presenting information about twelve common insects and spiders. *Grades 2 to 4.*

ELEMENTARY LESSONS ON INSECTS. By James G. Needham. Charles C. Thomas, Springfield, Ill. 1928. 206 pages. $2.00. A simple introduction, especially valuable for the suggestions on collecting. *Grade 7 and above.*

FIELD BOOK OF INSECTS. By Frank E. Lutz. G. P. Putnam's Sons, New York. 1935. 510 pages. $3.50. Third revised edition of an excellent guide to insects of North America north of Mexico. *Grade 6 and above.*

FLORIDA SEA SHELLS. By Bertha Aldrich and Ethel Snyder. Houghton Mifflin Co., Boston. 1936. 156 pages. $1.50. A simple guide to Florida shells and shell collecting. *Adult.*

FOREST INSECTS. By R. W. Doane, E. C. Van Dyke, W. J. Chamberlin and H. E. Burke. McGraw-Hill Book Co., Inc., New York. 1936. 463 pages. $4.50. A useful source of information on forest insects and their control, for foresters and students. *Adult.*

FRESH WATER BIOLOGY. By Henry B. Ward and George C. Whipple. John Wiley & Sons, New York. 1918. 1109 pages. $7.00. An excellent reference. *Adult.*

A HANDBOOK FOR SHELL COLLECTORS. By Walter F. Webb. Published by the Author, Rochester, N. Y. 1936. 291 pages. $2.50. An inexpensive guide to the shells of the world which appear most commonly in collections. *Adult.*

HONEY BEES AND FAIRY DUST. By Mary G. Phillips. D. C. Heath & Co., Boston. 1926. 213 pages. $.88. Accurate information about bees, in fairy-tale setting. *Grade 4 and above.*

HOW TO KNOW THE BUTTERFLIES. By John H. Comstock and Anna B. Comstock. Comstock Publishing Co., Inc., Ithaca, N. Y. 1929. 323 pages. $3.50. A popular, illustrated manual describing 152 species and varieties common in the eastern half of the United States. *Primarily for adult* use.

INSECT ADVENTURES; FABRE'S BOOK OF INSECTS. Both by Jean-Henri C. Fabre. Dodd, Mead & Co., New York. 1917, 1926. 287, 271 pages. $2.50, $2.00. Selections from the writings of the famous French student of insects, retold for children. *Grade 5 and above.*

INSECT ALLIES. By Eleanor King and Wellmer Pessels. Harper & Brothers, New York. 1938. 45 pages. $1.25. Well-written, well-illustrated material on the relation of insects to man, stressing modern methods of biological control. *Grade 5 and above.*

THE INSECT BOOK. By Leland O. Howard. Doubleday, Doran & Co., Garden City, N. Y. 1923. 456 pages. $5.00. A 1937 reissue of a popular account of the bees, wasps, ants, grasshoppers, flies and other North American insects exclusive of the butterflies, moths and beetles. *Adult.*

INSECT ENEMIES OF SHADE TREES. By Glenn W. Herrick. Comstock Publishing Co., Inc., Ithaca, N. Y. 1935. 417 pages. $4.50. A well-illustrated, nontechnical discussion. *Adult.*

INSECT LIFE. By John H. Comstock. D. Appleton-Century Co., Inc., New York. New edition, 1924. 349 pages. $5.00. Detailed lessons on the insects of eastern United States, and some spiders. *High school and above.*

INSECT PEOPLE. By Eleanor King and Wellmer Pessels. Harper & Brothers, New York. 1937. 63 pages. $1.25. An attractive book, illustrated with photographs, which presents information about many common insects and some spiders. *Grades 5 to 8.*

INSECT PESTS OF FARM, GARDEN AND ORCHARD. By E. Dwight Sanderson and L. M. Peairs. John Wiley & Sons, Inc., New York. Third edition, 1931. 568 pages. $4.50. Good general manual, grouping insects according to food plants. *Adult.*

INSECT SINGERS: A NATURAL HISTORY OF THE CICADAS. By J. G. Myers. George Routledge & Sons, London, Eng. 1929. 304 pages. 21s. An interesting, informative account. *Adult.*

INSECT WAYS. By Clarence M. Weed. D. Appleton-Century Co., Inc., New York. 1930. 325 pages. $1.36. Interesting accounts of the lives of many common insects occurring in North America. *Grade 6 and above.*

INSECTS (Western Nature Study Series). Edited by Gayle Pickwell. Suttonhouse, Ltd., Publishers, Los Angeles, Calif. 1933. 304 pages. $3.00. A book for teachers, students and others interested in insects. *Adult.*

INSECTS INJURIOUS TO THE HOUSEHOLD AND ANNOYING TO MAN. By Glenn W. Herrick. The Macmillan Co., New York. Revised, 1926. 478 pages. $3.50. A standard work on the group. *Adult.*

INSECTS — MAN'S CHIEF COMPETITORS. By W. P. Flint and C. L. Metcalf. Williams & Wilkins Co., Baltimore, Md. 1933. 133 pages. $1.00. One of the Century of Progress Series of discussions of popular science. *Adult.*

INSECTS OF WESTERN NORTH AMERICA. By E. O. Essig. The Macmillan Co., New York. 1929. 1035 pages. $7.50 or $10.00. Standard manual for identification. *Adult.*

AN INTRODUCTION TO ENTOMOLOGY. By John H. Comstock. Comstock Publishing Co., Inc., Ithaca, N. Y. 1940. 1064 pages. $5.00. A standard manual, interestingly written and well illustrated. *Adult.*

LEAF MINING INSECTS. By James G. Needham, S. W. Frost, and Beatrice W. Tothill. Williams & Wilkins Co., Baltimore, Md. 1928. 351 pages. $2.50. A comprehensive study, with lists of insects and of host plants. *Adult.*

LITTLE BLACK ANT. By Alice C. Gall and Fleming H. Crew. Oxford University Press, New York. 1936. 128 pages. $1.50. A humanized, but sympathetic and informative story of ant life, attractively illustrated. *Grades 3 to 5.*

A MANUAL FOR THE STUDY OF INSECTS. By John H. Comstock and Anna B. Comstock. Comstock Publishing Co., Inc., Ithaca, N. Y. Revised by Glenn W. Herrick, 1938. 401 pages. $4.00. An elementary work, well illustrated, planned for teachers and older students.

A MANUAL OF THE COMMON INVERTEBRATE ANIMALS (EXCLUSIVE OF INSECTS). By Henry S. Pratt. P. Blakiston's Son & Co., Inc., Philadelphia. Revised edition, 1935. 854 pages. $7.50. A standard, illustrated manual for identification. *Adult.*

MANUAL OF INJURIOUS INSECTS. By Glenn W. Herrick. Henry Holt & Co., Inc., New York. 1925. 489 pages. $4.75. *Valuable reference for adults.*

THE MOTH BOOK. By W. J. Holland. Doubleday, Doran & Co., Garden City, New York. 1933. 600 pages. $5.00. New printing of a well-illustrated, standard book on moths. *Adult.*

MOTHS AND BUTTERFLIES. By Lina M. Johns and May Averill. F. A. Owen Publishing Co., Dansville, N. Y. New edition, 1930. 128 pages. $.72. Very brief stories of sixteen common moths and butterflies, illustrated with photographs and drawings. *Grades 3 to 4.*

OUR INSECT FRIENDS AND FOES. By William A. DuPuy. The John C. Winston Co., Philadelphia. 1925. 318 pages. $1.00. A book which aims "to show the general reader the vastly important relationship which exists between insects and human beings." *Grades 5 to 8.*

OUR INSECT FRIENDS AND FOES AND SPIDERS. The National Geographic Society, Washington, D. C. 1935. 252 pages. $2.50. A collection of splendidly illustrated material that has appeared in the National Geographic Magazine. *All grades.*

SEASHORE ANIMALS OF THE PACIFIC COAST. By Myrtle E. Johnson and Harry J. Snook. The Macmillan Co., New York. 1927. 659 pages. $6.00. Excellent manual, touching chiefly invertebrate animals. *Adult.*

SOCIAL LIFE AMONG THE INSECTS. By William M. Wheeler. Harcourt, Brace & Co., New York. 1923. 375 pages. $5.00. An extremely interesting, comprehensive account. The same author has written *Ants, Their Structure, Development and Behavior,* 1926, 663 pages, $7.50, published by the Columbia University Press, New York; and *Colony-Founding Ants,* 1933, 189 pages, $2.00, published by Harvard University Press, Cambridge, Mass. *Adult.*

SOCIAL LIFE IN THE INSECT WORLD; THE WONDERS OF INSTINCT. Both by Jean-Henri C. Fabre. D. Appleton-Century Co., Inc., New York. 1912, 1918. 327, 322 pages. $4.00 each. Charmingly told studies, by a noted French scientist. *Adult.* Others of his writings about insects and their kin include: *The Life of the Spider,* 1913, 404 pages; *Bramble Bees and Others,* 1915, 456 pages; *The Hunting Wasps,* 1915, 427 pages; *The Sacred Beetle and Others,* 1918, 425 pages; *More Beetles,* 1922, 322 pages; *The Glow-worm and Other Beetles,* 1919, 488 pages; *More Hunting Wasps,* 1921, 376 pages; *The Life of the Weevil,* 1922, 346 pages; *The Life of the Scorpion,* 1923, 344 pages; all published by Dodd, Mead & Co., New York, $2.50 each.

THE SPIDER BOOK. By John Henry Comstock. Doubleday, Doran & Co., Garden City, N. Y. 1940. 729 pages. $6.00.

Excellent manual, obtainable at many libraries. *Adult.*

SPIDER WEBS AND SUNFLOWERS. By Mary G. Phillips. D. C. Heath & Co., Boston. 1928. 257 pages. $.88. Authentic information about spiders, in a fairy-tale setting. *Grade 4 and above.*

STRANGE SEASHELLS AND THEIR STORIES. By A. Hyatt Verrill. L. C. Page & Co., Boston. 1936. 211 pages. $2.50. Unusual information about shelled animals, emphasizing forms found along the coasts of the United States. *Grade 6 and above.*

TERMITE CITY. By Alfred E. Emerson and Eleanor Fish. Rand, McNally Co., Chicago. 1937. 127 pages. $1.50. An absorbing and excellently told story, attractive in illustration and makeup. *Grades 5 to 8.*

THE WITCHERY OF WASPS. By Edward G. Reinhard. D. Appleton-Century Co., Inc., New York. 1929. 291 pages. $2.50. Vividly described studies of the various kinds of American solitary wasps. *Adult.*

THE WONDER WORLD OF ANTS. By Wilfrid S. Bronson. Harcourt, Brace & Co., Inc., New York. 1937. 87 pages. $1.50. An excellently illustrated, well-told account of the structure of ants, and of the habits of many kinds. *Grades 4 to 6.*

WONDERS OF INSECT LIFE. By F. Martin Duncan and L. T. Duncan. Oxford University Press, New York. 1927–1929. 6 volumes, 84 to 88 pages each. $.40 or $.55 each. Simply written material on butterflies and moths, bees, wasps and ants, beetles and flies, spiders and scorpions, curious insects, and insects in pond and stream. Prepared in England. *Grades 5 to 8.*

PLANT LIFE

PLANTS IN GENERAL

(See also *Nature Study in General*)

THE BOOK OF PLANTS. By Bertha M. Parker and Henry C. Cowles. Houghton Mifflin Co., Boston. 1925. 252 pages. $1.16. Simply written material planned to present certain fundamental ideas about plant life, for the most part through concrete examples. *Grades 6 to 8.*

THE COMMON NAMES OF PLANTS AND THEIR MEANINGS. By Willard N. Clute. W. N. Clute & Co., Indianapolis, Ind. 1931. 164 pages. $3.00. Interesting folklore. *Adult.*

ECONOMIC BOTANY. By Albert F. Hill. McGraw-Hill Book Co., Inc., New York. 1937. 592 pages. $4.00. A college textbook of useful plants and plant products. *Adult.*

FIELD BOOK OF WESTERN WILD FLOWERS. By Margaret Armstrong. G. P. Putnam's Sons, New York. 1927. 596 pages. $3.50. Good guide. *Adult.*

FIRST BOOK OF GRASSES. By Mrs. Agnes Chase. W. A. Silveus, 832 Cambridge Oval, San Antonio, Texas. Revised edition, 1937. 138 pages. $1.25. Explanations of the structure of grasses, based on a study of the commoner species, for beginners. *Adult.*

FIRST STUDIES OF PLANT LIFE. By George F. Atkinson. Ginn & Co., Boston. 1901. 266 pages. $.96. An older book, which gives accurate, detailed information in simple form. *Grade 5 and above.*

FLORA OF THE PRAIRIES AND PLAINS OF CENTRAL NORTH AMERICA; FLORA OF THE ROCKY MOUNTAINS AND ADJACENT PLAINS. Both by P. A. Rydberg. Published by the Author, New York Botanical Garden, Bronx Park, N. Y. 1932, 1922. 969, 1110 pages. $5.50. Valuable manuals. *Adult.*

FLORA OF THE SOUTHEASTERN UNITED STATES. By John K. Small. John K. Small, New York. 1913. 1370 pages. $5.00. Best manual for the region. *Adult.*

FLORA OF SOUTHERN CALIFORNIA. By Philip Munz. J. W. Stacey, Inc., Distributor, San Francisco, Calif. 1935. 642 pages. $5.00. Valuable manual for the region. *Adult.*

FLORIDA WILD FLOWERS. By Mary F. Baker. The Macmillan Co., New York. New edition, 1938. 258 pages. $3.50. An enlarged, more profusely illustrated edition. *Adult.*

THE FLOWER AND THE BEE. By John H. Lovell. Charles Scribner's Sons, New York. 1918. 286 pages. $3.00. An interesting study of plant life and plant pollination. *Adult.*

FLOWER FAMILIES AND ANCESTORS. By F. E. and Edith S. Clements. H. W. Wilson Co., New York. 1928. 156 pages. $2.40. An interesting and well-illustrated introduction to the study of plants and plant relationships. *Adult.* The Clements Flower Books, published by Wilson, include also: *Flowers of Coast and Sierra,* 1928, 226 pages, $3.00; *Flowers of Mountain and Plain,* second edition, 1928, 79 pages, $1.50; *Rocky Mountain Flowers,* 1928, 392 pages, $3.50.

THE FLY-AWAYS AND OTHER SEED TRAVELERS. By Francis M. Fultz. Public School Publishing Co., Bloomington, Ill. 1928 edition. 186 pages. $.75. An old book, which contains much simple information on seed dispersal. *Grades 3 and 4.*

THE FRAGRANT PATH. By Louise B. Wilder. The Macmillan Company, New York. 1932. 407 pages. $3.00. A book about sweet-scented flowers and leaves. *Adult.*

THE GREEN LEAF. By D. T. MacDougal.

D. Appleton-Century Co., Inc., New York. 1930. 141 pages. $2.00. A discussion of the work of green leaves, one of Appleton's New World of Science Series. *Adult.*

HOW PLANTS GET THEIR NAMES. By Liberty Hyde Bailey. The Macmillan Co., New York. 1933. 215 pages. $2.50. An explanation of the principles and practices of naming plants, told in a narrative rather than in a technical way. *Adult.*

HOW TO KNOW WILD FRUITS. By Maude G. Peterson. The Macmillan Co., New York. 1923. 383 pages. $2.50. Descriptions of about 200 species of plants of the northeastern States, which have attractively colored fruits, arranged according to color of ripe fruit. *Written for adults, but useful in grade 6 and above.*

ILLUSTRATED FLORA OF NORTHERN UNITED STATES, CANADA, *and* THE BRITISH POSSESSIONS. By N. L. Britton and A. Brown. H. de la Montagne, Jr., New York Botanical Garden, Bronx Park, New York. Second edition, 1913. Three volumes, 680, 733, 637 pages. $13.50. A complete, usable manual. *Adult.*

ILLUSTRATED FLORA OF THE PACIFIC STATES. By Leroy Abrams. Stanford University Press, Stanford University, Calif. 1923. 570 pages. $9.00. Volume One, Ferns to Birthworts, has been published, two more volumes are in preparation. *Adult.*

LESSONS IN BOTANY. By Asa Gray. American Book Co., New York. 1887. 226 pages. $1.32. A clearly illustrated, understandable "grammar and dictionary" for use with manuals of botany. *Adult.*

MANUAL OF CULTIVATED PLANTS. By Liberty Hyde Bailey. The Macmillan Co., New York. 1924. 891 pages. $5.00. Standard handbook. *Adult.*

MANUAL OF THE FLOWERING PLANTS OF CALIFORNIA. By W. L. Jepson. Associated Students Store, Berkeley, Calif. 1925. 1238 pages. $7.50. Technical work for the West. *Adult.*

NEW MANUAL OF BOTANY. By Asa Gray. American Book Co., New York. 1908. 926 pages. $3.50. The classic manual for the central and northeastern United States and adjacent Canada. *Adult.*

A NEW MANUAL OF THE BOTANY OF THE CENTRAL ROCKY MOUNTAINS. By John M. Coulter and A. Nelson. American Book Co., New York. 1909. 646 pages. $3.50. Standard manual for the region. *Adult.*

OUR PLANT FRIENDS AND FOES. By William A. DuPuy. The John C. Winston Co., Philadelphia. 1930. 277 pages. $1.00. Accounts of many plants, most of them of economic importance. *Grades 6 and 7.*

PLANT LIFE AND PLANT USES. By John M. Coulter. American Book Co., New York. 1913. 480 pages. $1.80. The work of a recognized authority. *Adult.*

PLANTS AND THEIR CHILDREN. By Mrs. William S. Dana (Mrs. Frances T. Parsons). American Book Co., New York. 1896. 272 pages. $.84. Information on plant life, arranged seasonally. *Grades 4 to 6.*

PLANTS USEFUL TO MAN. By Wilfred W. Robbins and Francis Ramaley. P. Blakiston's Son & Co., Philadelphia. 1933. Second edition, 422 pages. $3.50. Interesting information, chiefly about crop plants. *Adult.*

POISONOUS PLANTS OF THE UNITED STATES. By W. C. Muenscher. The Macmillan Co., New York. 1939. 300 pages. $3.00 approx. Accounts of more than 150 species of plants poisonous to the touch or when eaten by human beings or other animals. 75 full-page illustrations. *Adult.*

THE PRINCIPLES OF FLOWER ARRANGEMENT. By Edward A. White. A. T. De La Mare Co., Inc. (Dodd, Mead & Co.), New York. Third edition, revised, 1936. 200 pages. $3.00. Useful to those who wish to display flowers effectively. *Adult.*

SCIENCE OF PLANT LIFE. By Edgar N. Transeau. World Book Co., Yonkers, N. Y. 1919. 336 pages. $1.68. A high school text for a half year course in botany, useful as a reference. *Grade 8 and above.*

SOUTHERN WILD FLOWERS AND TREES. By Alice Lounsberry. F. A. Stokes Co., New York. 1901. 570 pages. $5.00. Good handbook for the Southeast. *Adult.*

SPRING WILD FLOWERS OF THE OPEN FIELD. (Western Nature Study Series.) Edited by Gayle Pickwell. Suttonhouse, Ltd., Publishers, Los Angeles, Calif. 1933. 156 pages. $2.50. A well-illustrated presentation of the wild flowers of California hills and lowlands. *Adult.*

TEXAS WILD FLOWERS. By Ellen D. Schulz. Laidlaw Brothers, Chicago. 1928. 505 pages. $3.00. The best popular book for the region. *Adult.*

USEFUL PLANTS OF THE WORLD. By Willard N. Clute. W. N. Clute & Co., Indianapolis, Ind. Second edition, 1928. 237 pages. $3.75. Discussion of many species, both cultivated and wild, grouped according to use. *Adult.*

USEFUL WILD PLANTS OF THE UNITED STATES AND CANADA. By Charles F. Saunders. Robert M. McBride & Co., New York. 1920. 275 pages. (Out of print.) Information about wild plants used for food, beverages, soaps, medicines and for other purposes. *Grade 6 and above.*

WESTERN FLOWER GUIDE. By Charles F. Saunders. Doubleday, Doran & Co., Garden City, N. Y. 1917. 286 pages. $1.75. An illustrated, pocket-sized guide to easy identification. The same author has written *Western Wild Flowers and Their Stories*, 1933, 334 pages, $3.00, history and myths concerning flowers and flowering shrubs, also published by Doubleday. Adult.

WILD FLOWERS AND FERNS IN THEIR HOMES AND IN OUR GARDENS. By Herbert Durand. G. P. Putnam's Sons, New York. 1925. 410 text pages. $3.50. Revised and enlarged edition of a book concerned with wild plants and their culture. Well illustrated. *Adult.*

WILD FLOWERS AND WEEDS

ACCORDING TO SEASON. By Frances Theodora Parsons (Mrs. William Starr Dana). Charles Scribner's Sons, New York. New edition, 1924. 197 pages. $1.50. Talks about the flowers in the order of their appearance. *Adult.*

THE BOOK OF WILD FLOWERS. Edited by W. J. Showalter. The National Geographic Society, Washington, D. C. Revised edition, 1933, 243 pages. $3.00. A compilation of material from the National Geographic Magazine describing and illustrating about 250 species, including some familiar grasses. *All grades.*

THE BOOK OF WILD FLOWERS FOR YOUNG PEOPLE. By F. Schuyler Mathews. G. P. Putnam's Sons, New York. 1923. 412 pages. $3.00. Information presented through conversations, arranged according to seasonal sequence. *Grades 6 to 8.*

FIELD BOOK OF AMERICAN WILD FLOWERS. By F. Schuyler Mathews. G. P. Putnam's Sons, New York. 1929. 610 text pages. $3.50. Useful, pocket-sized guide which illustrates and describes many species of flowering plants found east of the 100th meridian. *Grade 6 and above, although planned for adults.*

THE FLOWER FINDER. By George L. Walton. J. B. Lippincott Co., Philadelphia. Revised edition, 1935. 394 pages. $2.50. Handbook for identification, illustrated with pen and ink drawings. *Adult.*

FLOWER GUIDE: WILD FLOWERS EAST OF THE ROCKIES. By Chester A. Reed. Doubleday, Doran & Co., Garden City, New York. 1911. 228 pages. $1.25. A handy pocket guide, illustrated in color, useful but not complete. *Grade 6 and above.*

FLOWERS OF THE WILD: THEIR CULTURE AND REQUIREMENTS. By Frank C. Pellett. A. T. De La Mare Co., Inc.

(Dodd, Mead & Co.), New York, 1931. 170 pages. $1.00. Accounts of most of the common wild flowers suited for naturalization or cultivation in the northeastern States and some from the West. *Adult.*

A GUIDE TO THE WILD FLOWERS. By Alice Lounsberry. F. A. Stokes Co., New York. 1899. 347 pages. $5.00. Well-known, illustrated handbook. *Adult.*

A GUIDE TO THE WILD FLOWERS EAST OF THE MISSISSIPPI AND NORTH OF VIRGINIA. By Norman Taylor. Garden City Publishing Co., Garden City, N. Y. 1928. 367 pages. $1.59. Nontechnical keys and descriptions of 1200 kinds of wild flowers, vines and water plants. Illustrated. *Grade 7 and above.*

HOW TO KNOW THE WILD FLOWERS. By Mrs. Frances T. Parsons. Charles Scribner's Sons, New York. New edition, 1921. 346 pages. $3.50. An old, but useful guide to the names, haunts and habits of about 400 wild flowers of eastern United States. *Grade 7 and above.*

A MANUAL OF WEEDS. By Ada Georgia. The Macmillan Co., New York. 1914. 593 pages. $3.00. An excellent source of information about common weed plants. *Written for adults, but useful in grade 6 and above.*

MY WILD FLOWER GARDEN. By Herbert Durand. G. P. Putnam's Sons, New York. 1927. 242 pages. $2.75. Charming descriptions of making wild flower gardens. *Adult.*

OUR EARLY WILD FLOWERS; THE WAYSIDE FLOWERS OF SUMMER; OUR NORTHERN AUTUMN. All by Harriet L. Keeler. Charles Scribner's Sons, New York. 1916, 1917, 1920. 252, 288, 194 pages. $2.50, $2.00, $2.00. Helpful, accurate information, pleasant to read. *Grade 7 and above.*

SOME FAMILIAR WILD FLOWERS. Compiled by James E. Jones. The Macmillan Co., New York. 1930. 98 pages. $.50. A pocket manual for identification of wild flowers of northern United States and Canada. Small photographs, arranged according to color of flower, with brief text. *Grade 6 and above.*

WEEDS. By W. C. Muenscher. The Macmillan Co., New York. 1935. 599 pages. $6.00. An excellent, illustrated guide to the weeds of the United States and Canada, and their control. *Adult.*

WILD FLOWERS. By Homer D. House. The Macmillan Co., New York. Imperial edition, 1936. 626 pages. $3.95. An extensive treatment, containing probably the largest collection of colored illustrations available in any one book, and considering many species of plants, most of which grow in eastern United States, although a few are western species. *All grades.*

WILD FLOWERS AT A GLANCE. By Julius King. Harter Publishing Co., Cleveland, Ohio. 1935. 62 pages. $.10. A small guide, illustrated in color, to some of the commoner wild flowers. *All ages.*

WILD FLOWERS OF THE ALLEGHANIES. By Joseph E. Harned. Published by the Author, Oakland, Md. 1936. 707 pages. $3.75. An illustrated guide to identification. *Adult.*

WILD FLOWERS OF AMERICA. By Jane Harvey. Whitman Publishing Co., Racine, Wis. 1932. 96 pages. $.10. Pocket-sized guide, with a brief description of each flower, and fair colored illustrations. *All ages.*

FLOWERLESS PLANTS

FERN ALLIES OF NORTH AMERICA. By Willard N. Clute. W. N. Clute & Co., Indianapolis, Ind. 1928. 288 pages. $4.00. Best popular guide to the horsetails, club mosses or ground pines and closely related plants. Well illustrated. *Adult.*

FERNS OF THE NORTHWEST. By Theodore

C. Frye. Binfords & Mort, Portland, Ore. 1934. 184 pages. $2.00. Useful guide. *Adult.*

FERNS OF THE SOUTHEASTERN STATES. By John K. Small. Science Press Printing Co., Lancaster, Pa. 1938. 517 pages. $3.50. Standard manual. The same author has prepared *The Ferns of New York City*, 1935, 285 pages, $2.50, published by Science Press. *Adult.*

FIELD BOOK OF COMMON FERNS. By Herbert Durand. G. P. Putnam's Sons, New York. 1928. 220 pages. $2.50. Pocket-sized guide to 50 common ferns of eastern North America. *Grade 6 and above.*

FIELD BOOK OF COMMON MUSHROOMS. By William S. Thomas. G. P. Putnam's Sons, New York. 1936. 392 pages. $3.50. A helpful, pocket-sized guide, illustrated with 17 color plates, which considers about 100 species of common mushrooms. *Grade 6 and above.*

GUIDE TO EASTERN FERNS. By Edgar T. Wherry. Science Press Printing Co., Lancaster, Pa. 1937. 220 pages. $1.00. A helpful guide to about 100 ferns and fern allies (horsetails, club mosses and their relatives) of eastern North America, particularly the middle Atlantic region. Somewhat technical, well illustrated. *Grade 7 and above.*

HOW TO KNOW THE FERNS. By Frances T. Parsons. Charles Scribner's Sons, New York. 1922. 215 pages. $2.50. Manual, concisely and interestingly written. *Adult.*

HOW TO KNOW THE MOSSES. By Mrs. Elizabeth M. Dunham. Houghton Mifflin Co., Boston. 1916. 287 pages. $2.50. A beginner's guide to the mosses of northeastern United States, describing about 150 species. *Grade 6 and above.*

THE LICHEN FLORA OF THE UNITED STATES. By Bruce Fink. University of Michigan Press, Ann Arbor, Mich. 1935. 426 pages. $4.00. Technical manual. *Adult.*

MOSSES WITH A HAND-LENS. By A. J. Grout. A. J. Grout, New Brighton, Conn. 1924. 339 pages. $3.50. Popular guide to the common or conspicuous mosses and liverworts of northeastern United States. *Adult.*

THE MUSHROOM BOOK. By Nina L. Marshall. Doubleday, Doran & Co., Garden City, N. Y. 1936. 203 pages. $3.00. A reissue of an older guide to the commoner fungi, with special emphasis on the edible varieties. *Adult.*

THE MUSHROOM HANDBOOK. By Louis C. C. Krieger. The Macmillan Co., New York. 1935. 552 pages. $3.50. A popular, reliable guide to the higher fungi, describing 238 species. Abundantly illustrated. *Grade 7 and above.*

MUSHROOMS. By W. B. McDougall. Houghton Mifflin Co., Boston. 1925. 160 pages. $3.50. Handbook of edible and inedible species, describing about 100 kinds. *Grade 6 and above.*

MUSHROOMS OF FIELD AND WOOD. By Margaret McKenny. Reynal & Hitchcock, Inc., New York. 1929. 210 pages. $2.00. Guide to about 130 species of the larger and more conspicuous forms of mushrooms. *Grade 7 and above.*

OUR FERNS; THEIR HAUNTS, HABITS AND FOLKLORE. By Willard N. Clute. W. N. Clute & Co., Indianapolis, Ind. 1938. 338 pages. $4.00. An abundantly illustrated, popular account of all ferns east of the Mississippi and north of the Gulf States. *Adult.*

GARDEN FLOWERS AND CULTIVATED CROP PLANTS

ADVENTURES IN GARDENING FOR BOYS AND GIRLS. By Maurice G. Kains. Greenberg Publisher, Inc., New York. 1937. 288 pages. $2.50. Detailed story of gardening, which suggests many experiments. *Ages 10 to 15.*

BEGINNING TO GARDEN. By Helen P. Wodell. The Macmillan Co., New

York. 1928. 104 pages. $1.00. A satisfactory guide for beginning gardeners. *Grades 4 to 7.*

The Book of Annuals; The Book of Perennials. Both by Alfred C. Hottes. A. T. De La Mare Co., Inc. (Dodd, Mead & Co.), New York. 1928, 1927. 182, 200 pages. $1.50, $2.00. Profusely illustrated guides. *Adult.*

Botany of Crop Plants. By Wilfred W. Robbins. P. Blakiston's Son & Co., Inc., Philadelphia. Third revised edition, 1931. 639 pages. $4.00. Standard reference and textbook. *Adult.*

The Children Make a Garden. By Dorothy H. Jenkins. Doubleday, Doran & Co., Garden City, N. Y. 1936. 70 pages. $1.50. Practical and simple directions and suggestions. *Grades 3 to 5.*

The Child's Food Garden. By Van Evrie Kilpatrick. World Book Co., Yonkers, N. Y. 1918. 64 pages. $.36. A brief guide, emphasizing food plants. *Grade 4 and above.*

Corn and Corn Growing. By Henry A. Wallace and Earl N. Bressman. John Wiley & Sons, Inc., New York. Fourth edition, revised, 1937. 436 pages. $2.75. Extensive discussion, one of the Wiley Farm Series. *Adult.*

Cotton and Other Useful Fibers. By N. B. Allen. Ginn & Co., Boston. 1929. 368 pages. $.96. One of the *Stories of Raw Materials. Grades 5 to 7.*

Flowers and Their Travels. By Frances M. Fox. Bobbs-Merrill Co., Indianapolis, Ind. 1936. 229 pages. $1.50. Accounts of the origin and cultivation of many garden plants, of weeds and their travels, of famous botanists, and other material about plants. *Grade 5 and above.*

Garden Bulbs in Color. By J. Horace McFarland, R. Marion Hatton and Daniel J. Foley. The Macmillan Co., New York. 1938. 296 pages. $3.50. 275 colored pictures and numerous halftones, with text describing each plant and evaluating it for the average garden. *Adult.*

Garden Flowers in Color. By Glendon A. Stevens. The Macmillan Co., New York. 1934. 320 pages. $3.75; Imperial edition, $1.98. A picture cyclopedia of flowers, prepared for adults, but useful also for children.

Garden Guide: the Amateur Gardeners' Handbook. Edited and published by A. T. De La Mare Co., Inc. (Dodd, Mead & Co.), New York. 1917, rewritten and enlarged, 1934. 576 pages. $2.00. A comprehensive illustrated guide of established popularity. *Adult.*

The Garden Month by Month. By Mabel C. Sedgwick. F. A. Stokes Co., New York. 1935. 516 pages. $8.50. Well illustrated, with text in tabular form. *Adult.*

The Gardener's First Year; The Gardener's Second Year. Both by Alfred Bates. Longmans, Green & Co., New York. 1936, 1937. 256, 287 pages. $2.00 each. The first of these simply written guides for beginning gardeners discusses culture and kinds of annuals; the second perennials and bulbs. *Grade 6 and above.*

Gardening Indoors. By F. F. Rockwell and Esther C. Grayson. The Macmillan Co., New York. 1938. 201 pages. $2.50. Discussions of types of indoor gardens and suggestions for starting and maintaining them. *Adult.*

Gardens in Glass. By Mildred N. Andrews. A. T. De La Mare Co., Inc. (Dodd, Mead & Co.), New York. 1934. 120 pages. $1.50. An interesting volume on the art of terrarium building. *Adult.*

Hortus. A Concise Dictionary of Gardening, General Horticulture, and Cultivated Plants in North America. Compiled by L. H. Bailey and Ethel Z. Bailey. The Macmillan Co., New York. 1935. 755 pages. $5.00. A newly revised edition, with a supplement.

The Junior Gardener. By Dorothy W. Greene and Rosetta C. Goldsmith. Vanguard Press, New York. 1934. 53 pages. $1.25. Suggestions for the child's first garden, presented attractively. *Ages 8 to 14.*

Peter and Penny Plant a Garden. By

Gertrude Dubois and Frances Dubois. F. A. Stokes Co., New York. 1936. 220 pages. $1.25. An elementary garden book, presented in story form. *Grades 4 to 6.*

THE STORY BOOK OF FOODS FROM THE FIELD. By Maud F. and Miska Petersham. The John C. Winston Co., Philadelphia. 1936. 128 pages. $2.00; or in four separate volumes, $.60 each. Well-told information, beautifully illustrated in color, about wheat, corn, rice and sugar. *Grades 3 to 6.*

THE STORY OF COTTON. By Dorothy Scarborough. Harper & Brothers, New York. 1933. 99 pages. $1.25. The history, cultivation and uses of cotton, written in narrative form, presenting the social and economic sides of the industry. *Ages 10 to 16.*

TREES, SHRUBS AND WOODY VINES

THE APPLE TREE. By Liberty Hyde Bailey. The Macmillan Co., New York. 1922. 117 pages. (Out of print.) A delightful means of gaining acquaintance with apple trees. *Adult.*

FIELD BOOK OF AMERICAN TREES AND SHRUBS. By F. Schuyler Mathews. G. P. Putnam's Sons, New York. 1915. 482 pages. $3.50. A helpful guide for the identification of native trees and shrubs throughout the United States, through keys, illustrations and descriptions. *Grade 6 and above.*

THE FOREST: A HANDBOOK FOR TEACHERS. By Mrs. D. Priscilla Edgerton. Superintendent of Documents, Government Printing Office, Washington, D. C. Misc. Circular 98. 1927. 72 pages. $.10. Outlines by grades, supplementary exercises and helpful suggestions for the study of trees and forestry. *Adult.*

FOREST FACTS FOR SCHOOLS. By Charles L. Pack and Tom Gill. The Macmillan Co., New York. 1931. 346 pages. $1.00. A satisfactory survey of forests and forest problems, arranged in five units. *Grades 7 and 8.*

FORESTS AND MANKIND. By Charles L. Pack and Tom Gill. The Macmillan Co., New York. 1929. 250 pages. $3.00. A comprehensive, humanistic treatment of the subject. *Adult.*

GETTING ACQUAINTED WITH THE TREES. By J. Horace McFarland. The Macmillan Co., New York. 1904. 241 pages. $1.75. Popular nonscientific sketches about common trees. *Adult.*

A GUIDE TO THE TREES. By Alice Lounsberry. F. A. Stokes Co., New York. 1900. 313 pages. $5.00. A rather literary presentation of information about nearly two hundred trees and some shrubs, most of them found in northeastern America. *Grade 7 and above.*

HANDBOOK OF TREES OF THE NORTHEASTERN UNITED STATES AND CANADA. By Romeyn B. Hough. Romeyn B. Hough Co., Lowville, N. Y. 1924. 470 pages. $6.00. A well-illustrated manual. *Adult.*

HOW A TREE GROWS. By William Somerville. Oxford University Press, New York. 1927. 212 pages. $3.50. A detailed and interesting study. *Adult.*

KNOWING YOUR TREES. By G. H. Collingwood. American Forestry Association, Washington, D. C. 1937. 109 pages. $1.00. A large book containing descriptions of fifty American trees, with photographs of the whole trees, the bark, leaf, flower and fruit, and maps showing their distribution. *Adult.*

MANUAL OF CULTIVATED TREES AND SHRUBS HARDY IN NORTH AMERICA. By Alfred Rehder. The Macmillan Co., New York. 1934. 930 pages. $5.00. A standard comprehensive manual. *Adult.*

MANUAL OF TREES OF NORTH AMERICA. By Charles S. Sargent. Houghton Mifflin Co., Boston. 1922. 910 pages. $5.00.

Standard manual for advanced students. *Adult.*

MAPLE SUGAR TIME. By Royce S. Pitkin. Stephen Daye Press, Brattleboro, Vt. 1934. 64 pages. $1.00. A simple story of two boys' experiences. *Ages 6 to 10.*

NUTS AND CITRUS FRUITS. By Francis C. Owen and Ellen M. Ramsay. F. A. Owen Publishing Co., Dansville, N. Y. 1928. 128 pages. $.72. Simply written informational material. *Grades 3 and 4.*

OUR FORESTS: A NATIONAL PROBLEM. By Ben J. Rohan. C. C. Nelson Publishing Co., Appleton, Wis. 1929. 190 pages. $1.50. A useful summary, written from the point of view of conservation; volume one of the Exploratory Science Series, which includes also *Plant and Animal Neighbors*, Conservation, by Frank B. Younger and *Our Food Supply*, Agriculture, by Alfred G. Oosterhous. *Grades 7 and 8.*

OUR NATIVE TREES AND HOW TO IDENTIFY THEM; OUR NORTHERN SHRUBS AND HOW TO IDENTIFY THEM. Both by Harriet L. Keeler. Charles Scribner's Sons, New York. 1900, 1903. 557, 551 pages. $3.00 each. Descriptions and illustrations of trees and shrubs of northeastern United States, including native species and some naturalized plants. *Adult.*

OUR TREES; HOW TO KNOW THEM. By Arthur I. Emerson and Clarence M. Weed. J. B. Lippincott Co., Philadelphia. Fifth edition, 1937. 295 pages. $2.75. A guide for use in any season, including about 140 species of trees of the United States. *Grade 6 and above.*

AN OUTLINE OF GENERAL FORESTRY. By Joseph S. Illick. Barnes & Nobles, Inc., New York. 1936. 275 pages. $1.50. Good summary, one of the college outline series of abbreviated textbooks. *Adult.*

ROCKY MOUNTAIN TREES AND SHRUBS. By Burton O. Longyear. G. P. Putnam's Sons, New York. 1927. 262 pages. $3.50. Popular manual. *Adult.*

THE STORY OF THE FOREST. By J. Gordon Dorrance. American Book Co., New York. 1916. 237 pages. $.76. A narrative account containing interesting material. *Grades 4 to 6.*

THE STORY OF A THOUSAND-YEAR PINE AND OTHER TALES OF WILD LIFE. By Enos A. Mills. Houghton Mifflin Co., Boston. 1914. 119 pages. $1.25 or $.32. Selected tales of the author's experiences. *Grade 8 and above.*

TALKING LEAVES. By Julius King. The Harter Publishing Co., Cleveland, Ohio. 1934. 62 pages. $.10. Pictures and brief descriptions to help children in identifying 59 of the most familiar American trees.

THE TREE BOOK. By Julia Ellen Rogers. Doubleday, Doran & Co., Garden City, N. Y. 1914. 589 pages. $5.00. Descriptions of many kinds of trees, and information of a general nature, written in simple, informal style, occasionally inaccurate. *Grade 6 and above.*

TREE FLOWERS OF FOREST, PARK AND STREET. By Walter E. Rogers. Published by the author, Appleton, Wis. 1935. 500 pages. $7.50. Chiefly beautiful pictures. *Adult.*

TREES. By Julia Ellen Rogers. Grosset & Dunlap, New York. 1909. 248 pages. $1.00. A simple account of common trees, written for children of grade 4 and above.

TREES. By O. L. Sponsler. George Wahr, Ann Arbor, Mich. 1923. 158 pages. $1.50. Well-illustrated, nontechnical pocket guide to trees of the Great Lakes region. *Grade 7 and above.*

TREES AS GOOD CITIZENS. By Charles L. Pack. American Nature Association, Washington, D. C. 1922. 257 pages. $2.00. Identification, selection for various places, culture, and uses of many kinds of trees. Well illustrated. *Adult.*

TREES IN WINTER, THEIR STUDY, PLANTING, CARE AND IDENTIFICATION. By Albert F. Blakeslee and C. D. Jarvis. The Macmillan Co., New York. 1926. 446 pages. $2.00. Well-illustrated handbook showing buds, bark, habit and other characters of trees of northeastern United States. *Adult.*

TREES OF NORTH AMERICA. By Donald C. Peattie. Whitman Publishing Co., Racine, Wis. 1934. 96 pages. $.10. Pocket-sized descriptive guide to 178 trees, illustrated in color. *Age 10 and above.*

TREES OF NORTHEASTERN UNITED STATES, NATIVE AND NATURALIZED. By H. P. Brown. Christopher Publishing House, Boston. 1938. 490 pages. $3.00. A book for those who are seriously interested in studying trees, containing descriptions and detailed line drawings of 152 kinds of trees. *Adult.*

TREES OF THE SOUTHEASTERN STATES. By William C. Coker and Henry R. Totten. University of North Carolina Press, Chapel Hill, N. C. 1934. 450 pages. $2.00. A scientific description, simply presented, of about 200 native, naturalized and rare species of trees and shrubs found in the region. *Adult.*

UNDER THESE TREES. By Grace Humphrey. Milton Bradley Co., Springfield, Mass. 1925. 278 pages. $1.75. Stories of ten famous trees of history.

EARTH AND SKY

THE EARTH AND ITS LIFE

The Adventures of a Grain of Dust. By F. B. Atkinson (Hallam Hawksworth, pseud.). Charles Scribner's Sons, New York. 1922. 261 pages. $1.20. Entertaining and instructive story of soil formation and maintenance. *Grade 6 and above.*

Along the Hill. By Carroll L. Fenton. Reynal & Hitchcock, New York. 1935. 103 pages. $1.25. A very satisfactory little book, presenting much information about the history and makeup of the earth. *Grades 5 to 7.*

Animals of the Past. By Frederic A. Lucas. American Museum of Natural History, New York. 1929. 221 pages. $.75. A new edition of an older book, which discusses fossils and how they are formed, why animals become extinct, and is devoted particularly to some of the more remarkable fossil animals. Illustrated. *Adult.*

Autobiography of the Earth. By John H. Bradley. Coward-McCann, Inc., New York. 1935. 347 pages. $3.00. An interesting life history of the earth and the changes through which it has passed. The author's earlier book, *The Parade of the Living,* 1930, 308 pages, $3.00, also published by Coward-McCann, is an equally interesting story of the development of life on the earth. *Adult.*

Beasts of the Tar Pits: Tales of Ancient America; Ancient Animals. Both by William W. Robinson. The Macmillan Co., New York. 1932, 1934. 55, 108 pages. $2.00 each. Two very attractive books, the first telling of the animals whose fossils have been found in the tar pits near Los Angeles, and the second devoted chiefly to the history of backboned animals. *Grades 5 to 8.*

Before the Dawn of History. By Charles R. Knight. Whittlesey House, McGraw-Hill Book Co., Inc., New York. 1935. 127 pages. $2.50. A large book, containing 44 full-page reproductions of probably the best restorations known of ancient geologic times. *Grade 5 and above.*

The Book of Minerals. By Alfred C. Hawkins. John Wiley and Sons, Inc., New York. 1935. 173 pages. $1.50. A nontechnical story of the important minerals which furnish products in daily use, or which furnish gem stones. *For adults and older children.*

The Book of Prehistoric Animals. By Raymond L. Ditmars. J. B. Lippincott Co., Philadelphia. 1935. 64 pages. $2.00. Chiefly accounts of animals that lived after the dawn of the age of reptiles, the beginning of the Triassic period, illustrated with colored pictorial maps. *Grade 6 and above.*

The Boy's Book of the Earth. By Sidney A. Small. E. P. Dutton & Co., New York. 1924. 281 pages. $1.00. An older account of the earth and the development of its life. *Grades 7 and 8.*

Conservation of the Soil. By A. F. Gustafson. McGraw-Hill Book Co., Inc., New York. 1937. 312 pages. $3.00. *Detailed discussion for adults.*

Down to Earth. By Carey Croneis and William C. Krumbein. University of Chicago Press, Chicago. 1936. 501 pages. $3.75 or $5.00. An introduction to geology, prepared both for the general reader and for use as a text. *Adult.*

The Earth Changes. By Jannette M. Lucas. J. B. Lippincott Co., Philadelphia. 1937. 88 pages. $2.50. Accounts of geologic changes, mineral deposits, climatic conditions, and the main characteristics of plant and animal life dur-

ing fourteen geologic periods since the beginning of Paleozoic time, illustrated with attractive and helpful colored maps. *Grade 5 and above.*

THE EARTH FOR SAM. By W. Maxwell Reed. Harcourt, Brace & Co., New York. 1930. 399 pages. $3.50. A long, abundantly illustrated account of geologic history, particularly since the Silurian period. *Grade 5 and above.*

EXPLORING THE UPPER ATMOSPHERE. By Dorothy Fisk. Oxford University Press, New York. 1934. 166 pages. $1.75. A popular account, interestingly written. *Grade 7 and above.*

FIELD BOOK OF COMMON ROCKS AND MINERALS. By Frederic B. Loomis. G. P. Putnam's Sons, New York. 1923. 296 pages. $3.50. A well-illustrated, standard handbook for identifying rocks and minerals. *Primarily for adults.*

THE FIRST BOOK OF THE EARTH. By Harold O. Rugg and Louise Krueger. Ginn & Co., Boston. 1937. 275 pages. $.80. Useful, simply written information about the earth and its life; volume one of the Rugg Social Science Series. *Grades 3 to 5.*

GETTING ACQUAINTED WITH MINERALS. By George L. English. Mineralogical Publishing Co., Rochester, N. Y. 1934. 324 pages. $2.50. Interestingly written book for the layman with suitable technical information. *Adult.*

LIFE LONG AGO: THE STORY OF FOSSILS. By Carroll L. Fenton. Reynal & Hitchcock, New York. 1937. 297 pages. $3.50. Perhaps the most complete account, for young readers, of fossils and of life since its beginning on earth. *Grade 6 and above.*

LITTLE WATERS, THEIR USE AND RELATIONS TO THE LAND. By H. S. Person. Superintendent of Documents, Washington, D. C. Revised, 1936. 82 pages. $.15. A simply written, abundantly illustrated study of headwater streams and other little waters in relation to flood control. *Grade 7 and above.*

THE LIVING PAST. By John C. Merriam. Charles Scribner's Sons, New York. 1930. 144 pages. $2.00. Authentic accounts of ancient life, written in simple language. *Adult.*

MIGHTY ANIMALS. By Jennie I. Mix. American Book Co., New York. 1912. 144 pages. $.60. Chiefly valuable for its description of the method by which fossil bones were recovered from rock and prepared for display. *Grades 5 to 6.*

NATURE AND PROPERTIES OF SOILS. By T. L. Lyon and H. O. Buckman. The Macmillan Co., New York. 1929. 428 pages. $3.50. A readable discussion of the physical nature of soil, plant nutrients in soils, the origin of soils, maintenance of soil fertility, acidity, nitrogen relationships and fertilizers. *Adult.*

OUR AMAZING EARTH. By Carroll Lane Fenton. Doubleday, Doran & Co., Garden City, N. Y. 1938. 363 pages. $4.50. A popular presentation of geology for the general reader. Illustrated. *Adult.*

OLD MOTHER EARTH. By Kirtley F. Mather. Harvard University Press, Cambridge, Mass. 1929. 177 pages. $2.50. A popular presentation of historical geology, with simple, clear illustrations. *Adult.*

OUR PLANET THE EARTH; THEN AND NOW. By Lillian Rifkin. Lothrop, Lee & Shepard Co., New York. 1934. 62 pages. $1.75. A brief, well-illustrated survey of the development of the earth and its life; worked out in a fifth grade classroom. *Grades 4 to 5.*

THE RIVER. By Pare Lorentz. Stackpole Sons, New York. 1938. 64 pages. $2.00. An excellently illustrated history of the Mississippi River and its valley, from the standpoint of flood and soil erosion control. *Grade 5 and above.*

SOIL EROSION AND ITS CONTROL. By Quincy C. Ayres. McGraw-Hill Book Co., Inc., New York. 1936. 365 pages. $3.50. *Adult.*

SOIL EROSION CONTROL. By Austin E. Burges. Turner E. Smith & Co., Atlanta, Ga. 1936. 221 pages. $1.60. Practical exposition of the new science of soil erosion control, for students, farmers and the general public.

THE STORY BOOK OF EARTH'S TREASURES. By Maud F. and Miska Petersham. The John C. Winston Co., Philadelphia. 1935. 128 pages. $2.00, or in four separate volumes, $.60 each. Simply written, beautifully illustrated stories of coal, gold, oil, and iron and steel. *Grades 3 to 6.*

THE STORY OF A BILLION YEARS. By W. O. Hotchkiss. Williams & Wilkins Co., Baltimore, Md. 1932. 137 pages. $1.00. An excellent short, popular account of the changes in the earth. *Adult.*

THE STORY OF EARTH AND SKY. By Carleton W. Washburne and Heluiz C. Washburne, in collaboration with Frederick Reed. D. Appleton-Century Co., Inc., New York. 1933, 1935. 388 pages. $3.50; students' edition. $1.32. A comprehensive book, containing material on the earth and its history, the solar system, stars and other heavenly bodies, with a section on *How We Found Out These Things. Grades 5 to 8.*

THE STORY OF EARTHQUAKES AND VOLCANOES. By Gaylord Johnson. Julian Messner, Inc., New York. 1938. 144 pages. $2.00. A fascinating story combining geology and history. *Grade 7 and above.*

THE STORY OF THE MINERALS. By Herbert P. Whitlock. American Museum of Natural History, New York. 1932. 144 pages. $1.00. A helpful brief story, No. 12, of the Museum Handbook Series. *Adult.*

STORIES IN STONE. By Willis T. Lee. D. Van Nostrand Co., Inc., New York. 1926. 226 pages. $3.00. A readable story of earth forms in North America. *Grade 7 and above.*

THE STRANGE ADVENTURES OF A PEBBLE. By F. B. Atkinson (Hallam Hawksworth, pseud.). Charles Scribner's Sons, New York. 1921. 309 pages. $1.20. Entertaining and instructive material about the earth, arranged for study month by month. *Grade 6 and above.*

THIS EARTH OF OURS. By Jean-Henri C. Fabre. D. Appleton-Century Co., Inc., New York. 1923. 349 pages. $2.50. Sketches on physical geography, more valuable as science literature than as a source of information. *Grade 7 and above.*

THE WORLD OF FOSSILS. By Carroll Lane Fenton. D. Appleton-Century Co., Inc., New York. 1933. 192 pages. $2.00. A discussion of the methods of the paleontologist and of discoveries about life in North America in prehistoric times. *Adult.*

WEATHER AND CLIMATE

FOGS AND CLOUDS. By W. J. Humphreys. Williams & Wilkins Co., Baltimore, Md. 1926. 104 pages. $4.00. Beautiful collection of cloud pictures. The author's *Weather Rambles*, 1937, 265 pages, $2.50, published by Williams & Wilkins, is also valuable. *Adult.*

METEOROLOGY. By Willis I. Milham. The Macmillan Co., New York. 1912. 549 pages. $4.40. A clear, understandable textbook about the weather. *Adult.*

METEOROLOGY. By Donald S. Piston. P. Blakiston's Son & Co., Philadelphia. 1931. 194 pages. $2.50. Planned as a college text in the science of weather, but useful for reference. *Adult.*

WEATHER. By E. E. Free and Travis Hoke. Robert M. McBride & Co., New York. 1928. 337 pages. $3.00, or $1.75. A popularly written book designed to tell Americans "what weather facts they yearn to know." *Adult.*

WEATHER. (NATURAL HISTORY STUDIES, No. 4.) By Gayle Pickwell. McGraw-Hill Book Company. 1937. 180 pages. $3.00. A large beautifully illustrated book, which presents a simply told story of the weather and its factors. *Grade 7 and above.*

WHY THE WEATHER? By Charles F. Brooks, with the collaboration of Eleanor S. Brooks and John Nelson. Harcourt, Brace & Co., New York. Revised and enlarged edition, 1935. 312 pages.

$2.50. A simple, readable discussion of general features of the weather. *Grade 6 and above.*

THE WONDERS OF WATER. By Marian E. Baer. Farrar & Rinehart, Inc., New York. 1938. 122 pages. $1.50. A simply told story of water, its forms and its importance to living things. *Ages 7 to 10.*

STARS AND SKY

ASTRONOMY FOR THE LAYMAN. By Frank Reh. D. Appleton-Century Co. Inc., New York. 1936. 325 pages. $3.00. An interesting and helpful book for the average reader. *Adult.*

ASTRONOMY FOR YOUNG FOLKS. By Isabel M. Lewis. Dodd, Mead & Co., New York. Revised edition, 1932. 351 pages. $2.00. A clearly written, accurate descriptive account, including directions for recognizing the constellations of each month. *Grade 5 and above.*

ASTRONOMY FROM A DIPPER. By Eliot C. Clarke. Houghton Mifflin Co., Boston. New edition, 1933. 80 pages. $1.25. A pocket handbook showing how to locate the principal stars, using the Big Dipper as a starting point. *Grades 4 to 6.*

A BEGINNER'S STAR BOOK. By Edgar G. Murphy (Kelvin McKready, pseud.). G. P. Putnam's Sons, New York. Fourth revised edition, 1937. 176 pages. $3.50. One of the best guides and sources of information for amateurs. *Adult, but useful in grade 7 and above.*

THE BOOK OF STARS FOR YOUNG PEOPLE. By William T. Olcott. G. P. Putnam's Sons, New York. 1923. 399 pages. $3.00. Good information and clear, simple directions for finding constellations at all seasons. *Grades 7 and 8.*

BOY'S BOOK OF ASTRONOMY. By Goodwin D. Swezey and J. Harris Gable. E. P. Dutton & Co., New York. Revised edition, 1936. 304 pages. $2.00. A simply written general book. *Grades 6 to 8.*

CONSIDER THE HEAVENS. By Forest R. Moulton. Doubleday, Doran & Co., Garden City, N. Y. 1935. 343 pages. $3.50. A well-written and authoritative book for the layman. *Adult.*

DAYLIGHT, TWILIGHT, DARKNESS AND TIME. By Lucia C. Harrison. Silver, Burdett & Co., New York. 1935. 224 pages. $1.24. A simply written presentation of the meaning and measurements of latitude and longitude in terms of human affairs. *Grade 8 and above.*

EVENINGS WITH THE STARS. By Mary Proctor. Harper & Brothers, New York. 1925. 219 pages. $2.50. Interesting suggestions for learning about the stars. *Grade 7 and above.*

EXPLORING THE HEAVENS. By G. Clyde Fisher. Thomas Y. Crowell Co., New York. 1937. 238 pages. $2.50. A non-technical book containing much information. *Adult.*

FIELD BOOK OF THE SKIES. By William T. Olcott and Edmund W. Putnam. G. P. Putnam's Sons, New York. Second revised edition, 1934. 549 pages. $3.50. An excellent, detailed guidebook for the study of the skies. Planned for adults, but useful in the upper elementary grades.

THE FRIENDLY STARS. By Martha E. Martin. Harper & Brothers, New York. 1907. 264 pages. $2.00. A charmingly written account emphasizing the more conspicuous stars and constellations. *Age 12 and over.*

HANDBOOK OF THE HEAVENS. By Hubert J. Bernhard, Dorothy A. Bennett, and Hugh S. Rice, editors. Whittlesey House, McGraw-Hill Book Co., Inc., New York. 1935. 147 pages. $1.00. A brief, accurate treatment, especially valuable for beginners. *Grade 8 and above.*

INTRODUCING THE CONSTELLATIONS. By Robert H. Baker. Viking Press, Inc., New York. 1937. 205 pages. $2.50. An attractive book, interestingly organized and very helpful. *Grade 7 and above.*

LET'S LOOK AT THE STARS. By Edwin B. Frost. Houghton Mifflin Co., Boston. 1935. 118 pages. $2.00. A beautiful book of simply written, accurate information. *Grade 5 and above.*

OUR STARLAND. By C. C. Wylie. Lyons & Carnahan, Chicago. 1938. 378 pages. $.88. One of the simplest and most complete easy guides to the study of the heavens. *Grade 5 and above.*

OUR STARS MONTH BY MONTH. By Mary Proctor. Frederick Warne & Co., Inc., New York. 1937. 92 pages. $1.00. A simply written book by an English author, illustrated with star charts for each month. *Grade 7 and above.*

OUR WONDERFUL UNIVERSE. By Clarence A. Chant. World Book Co., Yonkers, N. Y. 1928. 191 pages. $1.60. An informal presentation of the subject, including suggestions for many observations and experiments. *Grade 7 and above.*

THE PAGEANT OF THE STARS. By W. J. Luyten. Doubleday, Doran & Co., Garden City, N. Y. 1929. 300 pages. $2.50. An interesting book of authoritative star knowledge for the adult layman.

ROMANCE OF THE COMETS. By Mary Proctor. Harper & Brothers, New York. 1926. 210 pages. (Out of print.) Scientific information with some legends. *Adult.*

ROMANCE OF THE SUN. By Mary Proctor. Harper & Brothers, New York. 1927. 266 pages. $2.50. Sound scientific information, interestingly written. *Adult.*

STAR MYTHS FROM MANY LANDS. By Dorothy Renick. Charles Scribner's Sons, New York. 1931. 206 pages. $.88. Myths from various parts of the world and from various ages, concerning several constellations. *For older readers.*

THE STARS FOR CHILDREN. By Gaylord Johnson. The Macmillan Co., New York. 1934. 281 pages. $1.50. An elementary book on stars, planets and the moon. *Grades 3 to 6.*

THE STARS FOR SAM. By W. Maxwell Reed. Harcourt, Brace & Co., New York. 1931. 198 pages. $3.00. A discussion of recent knowledge about the Universe, not a guide to identify heavenly bodies. *Grade 7 and above.*

THE SUN. By Charles G. Abbot. D. Appleton-Century Co., Inc., New York. Revised edition, 1929. 433 pages. $3.50. An older book, presenting much information. *Adult.*

THROUGH SPACE AND TIME. By Sir James H. Jeans. The Macmillan Co., New York. 1934. 224 pages. $3.00. Excellently written information, by the author of other valuable material in the field, such as *The Mysterious Universe,* 1930, 163 pages, $2.25; *Stars in Their Courses,* 1931, 173 pages, $2.50; *The Universe Around Us,* revised edition, 1934, 380 pages, $4.00; all published by The Macmillan Company. *Adult.*

THROUGH THE TELESCOPE. By Edward A. Fath. Whittlesey House, McGraw-Hill Book Co., Inc., New York. 1936. 227 pages. $2.75. An excellently written survey, not intended as a guide for identification, but containing much information. *Primarily for adults, but useful above grade 7.*

THE UNIVERSE UNFOLDING. By Robert H. Baker. William & Wilkins, Baltimore, Md. 1932. 150 pages. $1.00. A very good survey of astronomy, one of the Century of Progress Series. *Adult.*

WHEN THE STARS COME OUT. By Robert H. Baker. Viking Press, Inc., New York. 1934. 197 pages. $2.50. An attractive book which presents much simple, interesting information. *Grade 7 and above.*

WONDERS OF THE SKY. By Mary Proctor. Frederick Warne & Co., Inc., New York. 1932. 96 pages. $.60. A small book, illustrated with diagrams, for the general reader. *Grade 7 and above.*

THE YOUNG FOLK'S BOOK OF THE HEAVENS. By Mary Proctor. Little, Brown & Co., Boston. 1924. 270 pages. $2.00. An older book, combining clear, simple information, mythology and legend. *Grade 7 and above.*

MATERIALS AND EQUIPMENT

Materials at hand or available from the outdoors will usually fill the needs of students and teachers of nature-study. Supplementary materials, or materials not readily available, may be obtained from the firms here listed.

A. I. ROOT CO., Medina, Ohio.
Observation beehives.

AUSTIN WORKSHOPS, Hanover, New Hampshire.
Ant, cricket, and spider observation houses; also bird houses and terraria.

CAMBOSCO SCIENTIFIC CO., Waverly, Mass.
Complete line of material and apparatus for biology. No living material.

CAROLINA BIOLOGICAL SUPPLY CO., Elon College, North Carolina.
All biological supplies, featuring living and preserved materials.

CELESTIAL MAP PUBLISHING CO., 244 Adams St., Brooklyn, N. Y.
Charts, maps, and other aids for sky study.

CENTRAL SCIENTIFIC CO., 460 East Ohio St., Chicago, Ill.
Standard supplies for all commonly taught sciences.

DENOYER-GEPPERT CO., 5235–57 Ravenswood Ave., Chicago, Ill.
Models, charts, lantern slides, and general scientific apparatus.

EASTERN SCIENCE SUPPLY CO., Box 1414, Boston, Mass.
Telescopes in various price ranges for sky study.

GENERAL BIOLOGICAL SUPPLY HOUSE, 761–763 East 69th Place, Chicago, Ill.
Turtox Teacher's Manual and *Biology Catalogue*. Supply almost anything needed by a science teacher including terraria and aquaria.

HAMMETT'S SCHOOL SUPPLY CO., Cambridge, Mass.
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An excellent source of living and preserved marine material.

NEW YORK SCIENTIFIC SUPPLY CO., 111–113 East 22nd St., New York, N. Y.
General apparatus and supplies including living and preserved materials.

SOUTHERN BIOLOGICAL SUPPLY CO., 517 Decatur St., New Orleans, Louisiana.
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SOUTHWESTERN BIOLOGICAL SUPPLY CO., 415 North Tyler Ave., Dallas, Texas.
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STANDARD SCIENTIFIC SUPPLY CORP., 34–38 West 4th St., New York, N. Y.
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WARD'S NATURAL SCIENCE ESTABLISHMENT, INC., 302 North Goodman St., Rochester, N. Y.
Minerals, fossils, living material, preserved specimens, and almost all supplies for natural science.

WEBB, WALTER F., 202 Westminster Road, Rochester, N. Y.
Shells from all parts of the world.

WESTERN BIOLOGICAL LABORATORIES, University Place Station, Lincoln, Nebraska.
Living and preserved materials, aquaria, supplies, and general apparatus.

Summer nature camps and biological stations offer invaluable instruction in the preparation and use of equipment of all kinds.

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