HANDBOOK OF

NATURE-STUDY

For Teachers and Parents

Based on the Cornell Nature-Study Leaflets, with Much Additional Material and Many New Illustrations

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In Nature's infinite book of secrecy
A little can I read.

—SHAKESPEARE.

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PART I.

THE TEACHING OF NATURE-STUDY

WHAT NATURE-STUDY IS

ATURE-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

IRST, 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 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.

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

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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. 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

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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 over-crowded 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"

O 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 pretence, 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 her 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

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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.

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 and 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 fall on her knees before 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 rather than to punish because of 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, there were eight or ten of the children 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,

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an aquarium for fish, many small aquaria for insects and each had one or two absorbingly 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 terrarium 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" and 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 Archaeopteryx, then the swimming and the 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 he notes the things about the habits and appearance of the robin that may be perceived by intimate observation. 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 the same. Nature-study does not start out with the classification given in books, but in the end it builds up a classification in the child's mind which is based on fundamental knowledge; it is a classification like that evolved by the first naturalists, it is built on careful personal observations of both form and life.

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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!

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.

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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 for telling 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

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grasshopper has the hind legs much longer than the others, he will inevitably note that there are two other pairs of legs and he 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 thefield. The 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 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

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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, 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

N 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 be made a source of added interest ofttimes. For instance, to thus see the scales on the butterfly's wing affords the child pleasure as well as edification. Field or opera glasses, while indispensible 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.

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USES OF PICTURES, CHARTS AND BLACKBOARD DRAWINGS

ICTURES 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

ISQUIETING 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.

If the teacher says: "I have a pink hepatica. Can anyone find me a blue one?" the children, who naturally like grown-up 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

ANY 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 discov-

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ered 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 nor 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 nor an insect nor 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 NATURE-STUDY ATTITUDE TOWARD LIFE AND DEATH

ERHAPS 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 ordi-

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nary 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 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 the fact that one of the conditions imposed upon every living being in the woods and fields, is that it is entitled to a meal when it is hungry, if it is clever enough to get it. The child naturally takes this view of it. I remember well 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 is 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.

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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 it 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 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 NOTE-BOOK

A field note-book may be made a joy to the pupil and a help to the teacher. Any kind of a 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 note-book 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 should be encouraged for illustrating what is observed. A graphic drawing is far better than a long description of a natural object.

(c) The note-book 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 observing certain plants or animals may be placed in the note-book previous to the field excursion so as to give definite points for the work.

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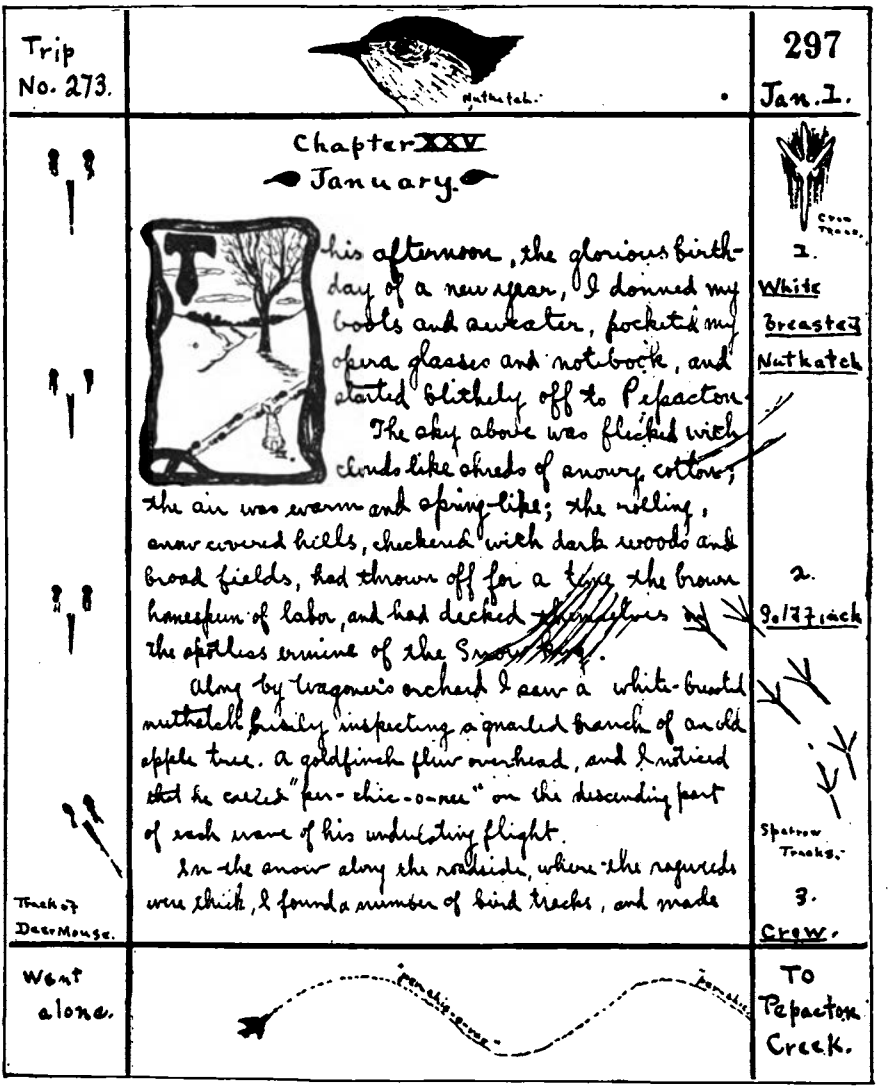
(e) No child should be compelled to have a note-book.

The field note-book 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 where to find the starting point for cultivating larger intelligence and a wider interest.



A page from the field note-book of a lad of fourteen who read Thoreau and admired the books of Thompson-Seton.

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I have examined many field note-books 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 with 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 life of the pet make interesting subject matter for a note-book. 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 note-books regarding my experiences with "Furry." I include this record as a suggestion for the children that they should keep note-books of their pets. It will lead

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them to closer observation and to a better and more natural expression of their experiences.

THE CORRELATION OF NATURE-STUDY WITH LANGUAGE WORK

ATURE-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 mis-

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takes 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.

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, 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 gives every year in the Goodyear School of Syracuse an exhibition of the drawings made by the children in the nature-study classes; and these are universally so excellent that most people regard them as an exhibition from the Art Department; and yet many of these pupils have never had lessons in drawing. They have learned to draw because they like to make pictures of the living objects which they have studied. One year there were many pictures of toads in various stages in this exhibit, 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 allows the pupils to choose their own medium, pencil, crayon, or water-color, and says that they seem to feel which is best. For instance, when drawing the outline of trees in winter they choose pencil, but when representing the trillium or iris they prefer the water-color, while for bitter-sweet and crocuses they choose 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.

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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 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 school-house, 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 cat-tails grow in swamps where there is not too much water, and why the mullen 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 or 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 there are many of the most commonly seen creatures which 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

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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.

Perhaps in no other way may 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*.

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.

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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 may 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 in making 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.

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NATURE-STUDY AND AGRICULTURE

UCKILY, 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 corn-field 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 weeds, or the insects that visit the golden-rod 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 is 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 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 along the lines of agriculture solely? Why should not the child begin nature-study with the cabbage rather than 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 why the wild flowers may be selected for begin-

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ning the nature-study of plants, is because 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 pocket-books; 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 meadow-lark 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 would a man be as an engineer who knew nothing of his engine except how to start and stop it.

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

HE organizing of a club by the pupils for the purpose of 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 constitution and by-laws. The proceedings of the club meetings should be conducted according to parliamentary rules; but the field excursions should be entirely informal.

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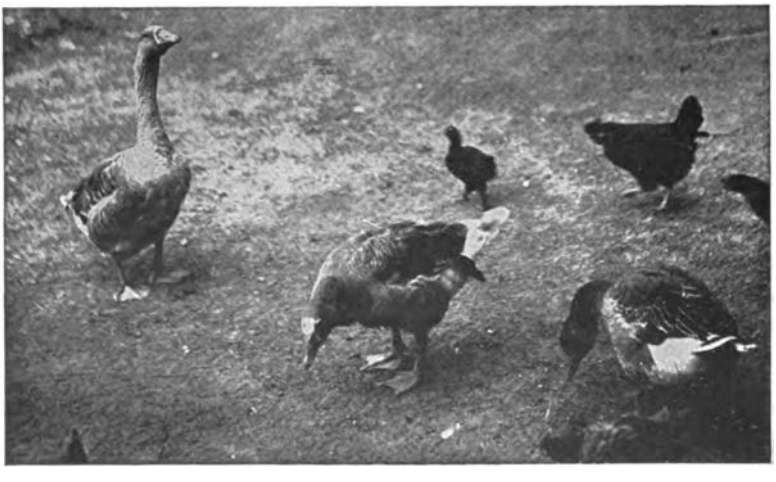
GEESE

Teacher's Story

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 corn field; 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 corn field 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.

In ancient Greece maidens made pets of geese; and often there was such a devotion between the bird and 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, N. Y., 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 whipped with his wings so severely that it was a test of bravery among the boys to so challenge him. His fidelity to his master was extreme; once when the boy



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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 much the famous Grecian nose. The plumage of geese is very beautiful and abundant and for this reason they are profitable domestic birds. The "picking" occurs 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; it hurts their dignity 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 to 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; although when running, her body may waddle somewhat, 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 h ave 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 grayish brown. The white Chinese are shaped like the brown Chinese but the knob and bill are orange and the eyes light blue.

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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 probably 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 were all 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 defence. The eggs are about twice as large as those of the hen and have the ends more 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, 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, and 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

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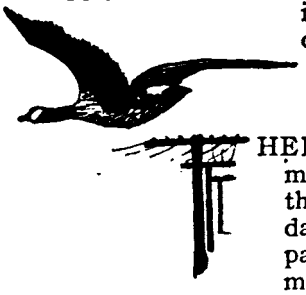
which a gander gave me when I was a child, holding me fast by the blouse while he laid on the blows.

Geese feed much more largely upon land vegetation than do ducks; a good growth of clover and grass make 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.



WILD GEESE

THERE is a sound, that, to the weather-wise 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 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 only four or five eggs laid and both parents are

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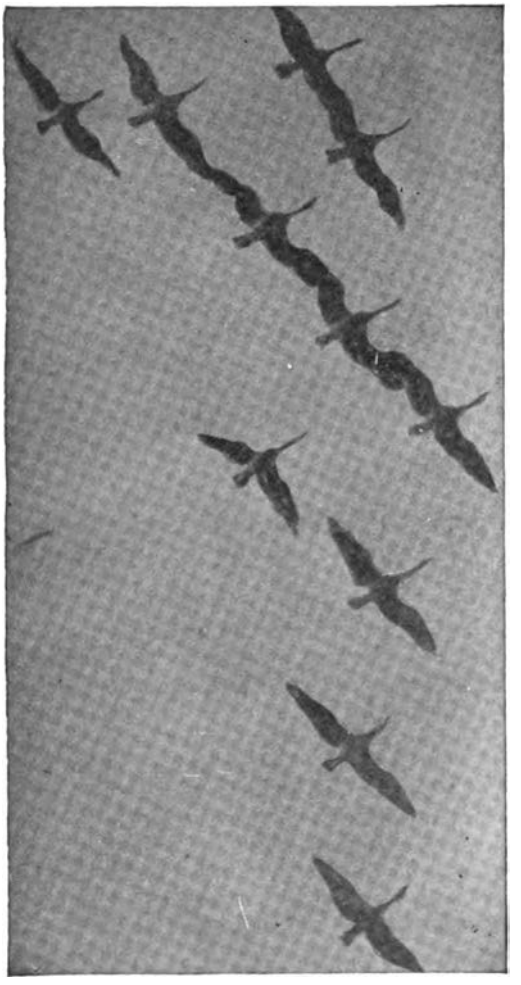
devoted to the young, the gander bravely defending his nest and family from the attacks of any enemies.

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 make another guide to follow.



Wild geese flying in even ranks.
Photographed directly underneath by A. R. Dugmore.
Courtesy of *Country Life in America.*

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 web feet, uneasy resting place. Finally, after many days of tribulation,

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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.

LESSON XXXIII

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 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 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?

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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 is defiance and distrust expressed? How does a goose look when hissing? What is the constant note of the gosling?

7. Give such instances as you may know illustrating the intelligence of geese, their loyalty and bravery.

8. Write an English Theme on "The Canada Goose, its appearance, nesting habits, and migrations."

Supplementary reading—Birds that Hunt and are Hunted, Blanchan; "In Quest of Waptonk The Wild," Northern Trails, Long; "The Homesickness of Kehonka," Kindred of the Wild, Roberts; Wild Geese, Celia Thaxter.

A sea-gull.
Photo by G. K. Gilbert.

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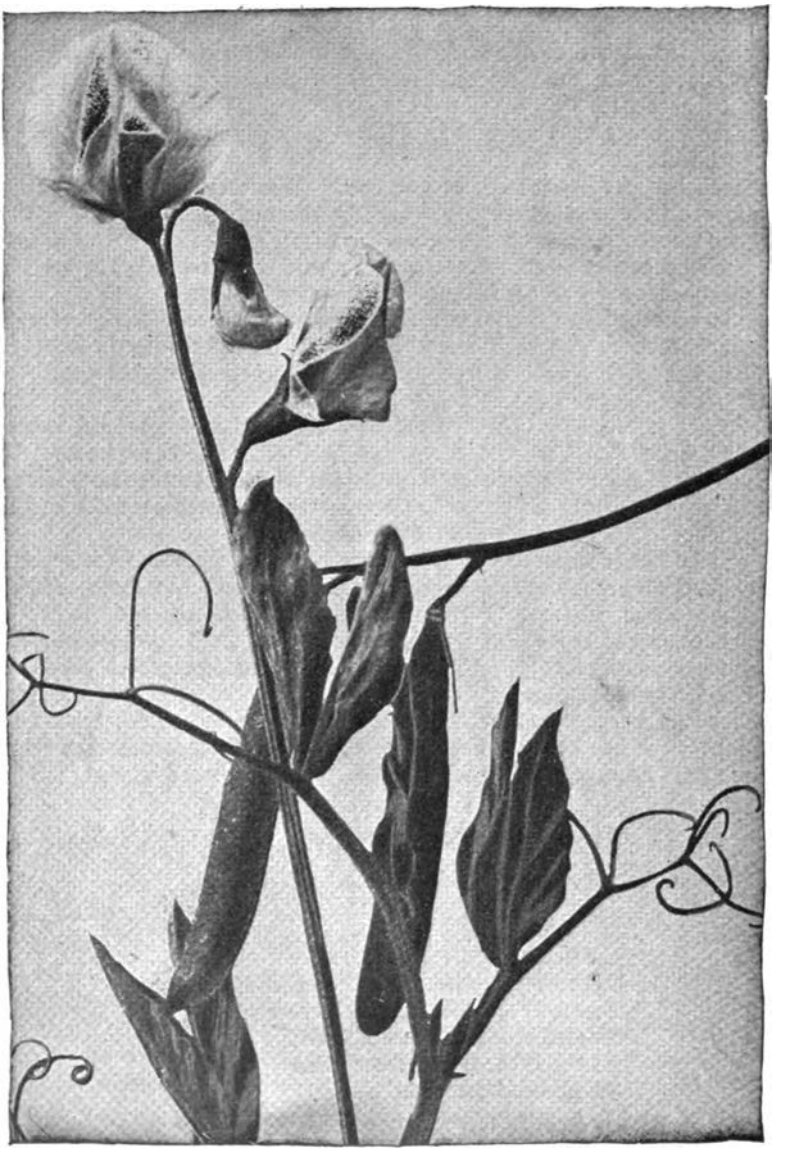

Sweet Peas.

"Here are sweet peas on tip 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.

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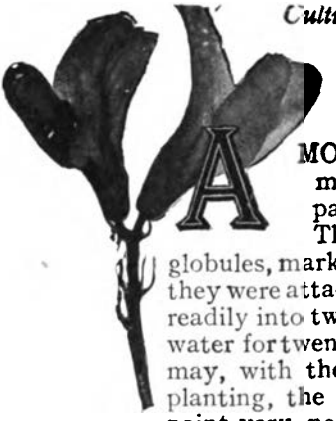

THE SWEET PEA

Teacher's Story

AMONG the most attractive of the seeds which make up the treasure of the children's seed packets, the sweet peas are of the prettiest. They are smooth, little white or brown globules, marked with a scar on the side, showing where they were attached to the pod. One of these peas divides readily into two sections; and after it has been soaked in water for twenty-four hours, the germ 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 leaf shoots emerge from the same place; but the two act very differently. The leaf 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 feeding roots, which take up the food 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 stems 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 thrive 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

Blossom sweet pea with parts labelled.

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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 stigma-ward. 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 the stigma of another flower. 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 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 mechanism, sweet peas, of all flowers are the most difficult to cross-pollenate, since they are so likely to receive some of their own pollen during this process.

Sweet pea pod bursting in spiral.

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 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 CLXV

The Sweet Pea

Leading thought—The sweet pea has 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.

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?

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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 a compound leaf? Describe the petiole and the basal leaves. How far apart are the leaflets on the mid-stem? Compare the stem 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 stem often change to tendrils? Why do you think so? Why must the sweet pea have tendrils? 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?

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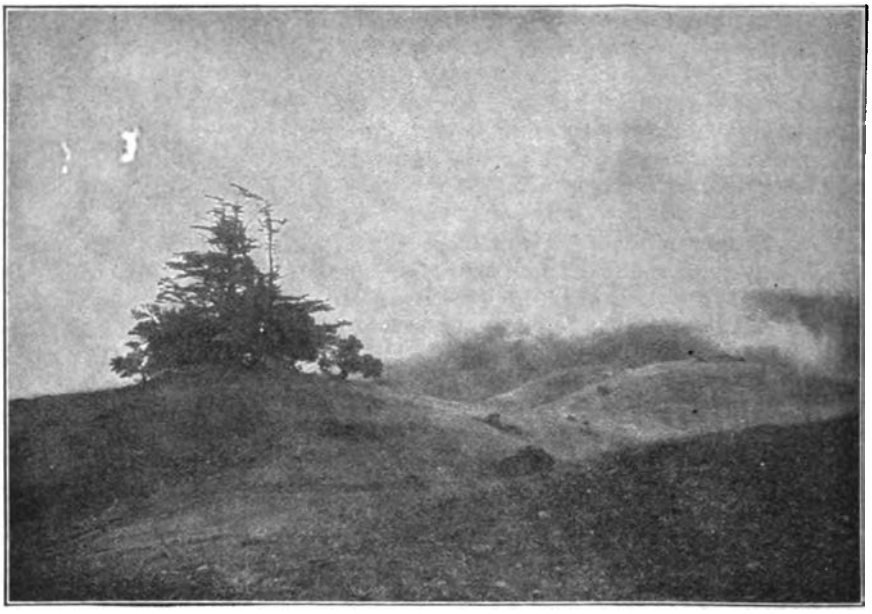

Fog on Mount Tamalpais, California.
Photo by G. K. Gilbert.

WATER FORMS

Teacher's Story

Water, in its various changing forms, 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 impersonates:

> "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

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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 window-pane 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 if the night be very cold, we find next morning upon the window-pane 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 raincloud 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, 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. Moreover, 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 including air spaces set in symmetrical patterns: and some of the crystals may be columnar in form, the column being *six*-sided. While those snow crystals formed in the lower currents of air, and therefore in warmer regions, show their six rays marvellously ornamented. The reason why the snow crystals are so much more beautiful and perfect than the crystals of hoar frost or ice, is because they are formed from water vapor, and grow freely in the regions of the upper air. Mr. W. A. Bentley, who has spent many years photographing the snow crystals, has found more than 1300 distinct types.

Composite snow crystal formed in high and medium clouds.
Photomicrograph by W. A. Bentley.

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Snow crystal formed in high clouds.
Photomicrograph by W. A. Bentley.

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 means that 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.

Blizzard type of snow crystal formed in low cloud.
Photomicrograph by W. A. Bentley.

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. The one 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 window-pane 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 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 moun-

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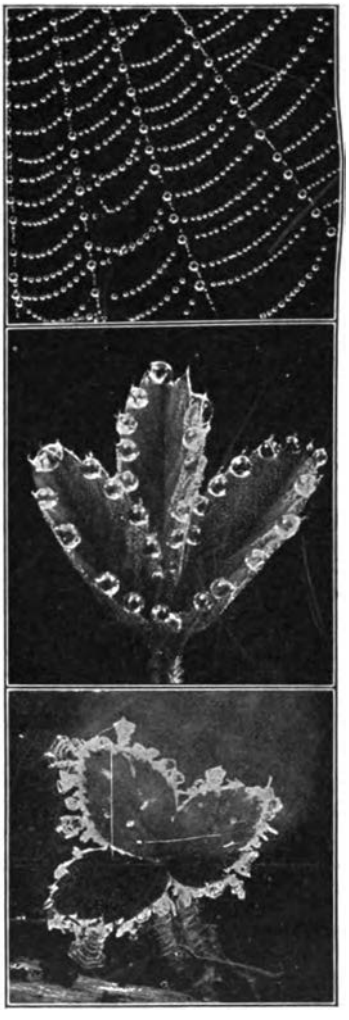
tainous regions, the fog may be seen streaming and boiling over a mountain peak, and yet always disappears at a certain distance below it. This is because the temperature around the peak is cold and condenses the water vapor as fast as the wind brings it along, but the mist passes over and soon meets 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.



Dew on spider's web; Dewdrops on strawberry leaf; Hoar frost on strawberry leaf.
Photographs by W. A. Bentley.

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 pumped up by the plants, which could not evaporate in the cold night air. On windy nights, the stratum of air cooled by the surface of the earth is moved along and more air takes 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 begins to form usually 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.

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Frost crystals on window-pane.
Photo by W. A. Bentley.

LESSON CCXXI
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 nor disturb it. Place another saucer filled with water near this but cover it with a tight box. From which saucer does the water evaporate most 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

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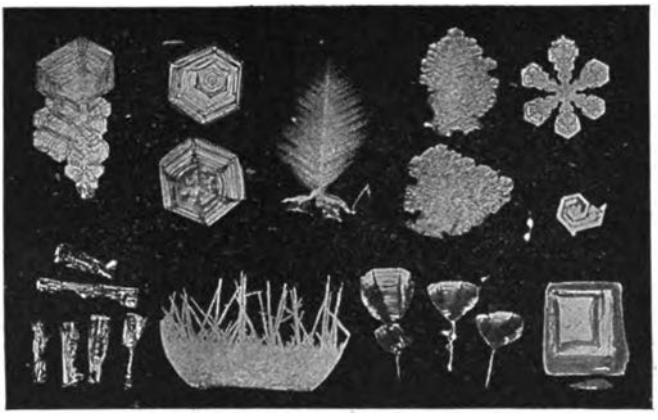
water as it is boiling. Notice that near its spout there is no mist, but what we call steam is formed beyond this. Why is this so? What is steam? Why does water boil away? Do kettles boil dry sooner on some days than on others? Why?

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



Forms of hoar frost.
Photo by W. A. Bentley.

as soon as they enter a warm room after having been out in the cold? Why do the window-panes become covered with mist during cold weather? Is the mist on the outside or on the 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 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?

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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.

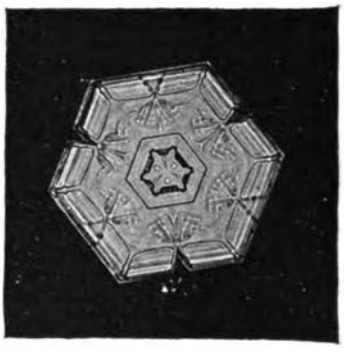
10. Place a bottle of water out of doors in freezing weather. How does the ice appear in it at first? What happens later? Why does the bottle break? How is it that water which has filled the crevices of rocks scales off pieces of the rock in cold weather? Why does winter wheat "winter-kill" on wet soil?

11. Why does frost form on a window-pane? How many different figures can you trace on a frosted pane? Are there any long, needlelike 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 window-pane?

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 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?

Supplementary reading—Water Wonders, Thompson; Forms of Water, Tyndall.



High cloud snow crystal.
Photomicrograph by W. A. Bentley.

"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.

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