PURDUE UNIVERSITY.

# LEAFLETS ON NATURE STUDY.

LAFAYETTE, INDIANA.
JUNE 1, 1898.

*FOR THE USE OF TEACHERS.*

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# Leaflets on Nature Study.

ESPECIALLY ADAPTED TO THE USE OF TEACHERS OF SCHOOLS IN RURAL DISTRICTS.

PUBLISHED BY THE UNIVERSITY.

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# LETTER OF TRANSMITTAL.

At the present time Nature Study is receiving considerable attention from our high schools, and, to some extent, from our city and town graded schools. But little attention, however, has been given to the subject by the teachers in rural districts. While it may seem that the difficulties involved in the problem of Nature Study in rural districts are great, we think that a careful examination of the conditions will show that these are more apparent than real. Indeed, the opportunities for work in the country are very much greater than for work in the city. We think it will be found also that the introduction of Nature Study will enable the teachers of district schools to accomplish the work which they are now doing more easily and with greater success.

It is thought by many that there are influences at work upon the children in rural districts which have a tendency to withdraw their interest from their rural surroundings and to create in them a desire to leave the farm and seek their fortunes in more populous centers. That this is true to a certain extent, no one will doubt. It then becomes important to ask: how shall we enable these children to appreciate the beauties of Nature by which they are surrounded; to take a wider view of their opportunities; how shall we lead them to higher country living and country thinking, and, how shall we make the occupation in which most of them will, for a time at least, be engaged, more attractive and more profitable? The teachers are potent factors in the consideration of these important questions. It is our purpose to assist the teachers in solving them, and it is believed that we can do no more effective work in this direction than by publishing this series of Nature Study Leaflets, the purpose of which is described in Prof. Coulter's "Introduction to Nature Study," found in Leaflet No. 1.

In order to show that this kind of work has been found to be eminently practicable, we may call your attention to what is going on in a large number of elementary schools in Europe.

I quote from Appleton's Popular Science Monthly for February, 1898:

In many places in Europe school grounds are very much better managed than in this country. Not only do school authorities there aim to supply materials for study in the school room, but they mean to impart clear ideas of horticulture and related occupations by various uses of land connected with the schools. They appreciate the training which results from pruning, budding and grafting trees, plowing, hoeing and fertilizing land, hiving bees and raising silk-worms.

In 1890 there were nearly eight thousand school gardens—gardens for practical instruction in rearing trees, vegetables and fruits—in Austria.

In France, gardening is practically taught in twenty-eight thousand primary and elementary schools, each of which has a garden attached to it, and is under the care of a master capable of imparting a knowledge of the first principles of horticulture. No one can be appointed master of an elementary school unless qualified to give practical instruction in cultivating the ordinary products of the garden.

In Sweden, as long ago as 1871, twenty-two thousand children received instruction in horticulture and tree-planting, and each of two thousand and sixteen schools had for cultivation a piece of land varying from one to twelve acres.

Still more significant is the recent establishment of many school gardens in southern Russia. In one province two hundred and twenty-seven schools out of a total of five hundred and four have school gardens whose whole area is two hundred and eighty-three acres. * * * This movement has also widely spread over different provinces of central Russia.

Since 1877 every public school in Berlin has been regularly supplied with plants for study every week, elementary schools receiving specimens of four different species and secondary schools six. During the summer, at six o'clock in the morning two large wagons start from the school gardens loaded with cuttings packed and labeled for the different schools. The daily papers regularly announce what plants may be expected, and teachers consult with the gardeners as to what ought to be sown or planted. Teachers take their classes into the school gardens for lessons in botany, and are aided by the gardeners, who cut the specimens.

In a conversation which I held last fall with Governor Mount upon the condition of the children of rural districts, he showed great interest in the subject and made several important suggestions, and he afterwards made a speech before the State Agricultural Board on Jan. 4, 1898, in which he warmly endorsed the scheme for the distribution of leaflets on Nature Study, whereupon the State Delegate Board passed the following resolutions:

Resolved, That we heartily approve of Governor Mount's suggestions to the effect that the children in the public schools of the State should be systematically instructed in such matters as pertain to country life. To this end we are in favor of an amendment to the school laws of the State, by which instruction shall be given in such elementary sciences as shall pertain to agriculture and household economy.

Resolved, That until this change in the law can be secured, we suggest to officers of public schools the propriety of advising their teachers to give occasional oral lessons upon such topics in Nature Study as will have a tendency to interest students in agriculture, horticulture, economic entomology, the care of domestic animals and household economy.

Resolved, That we believe that the preparation and use of properly prepared leaflets upon subjects relating to agriculture, as suggested in the Governor's address, would prove to be of great interest to our children in public schools and of great value to the agricultural interests of the State.

The general principles on which the leaflets will be prepared and used may be summarized as follows:

First. No attempt will be made to issue the leaflets in the order in which they are to be used by the teacher. It is manifestly undesirable, if not impossible, to do this.

Second. The leaflets for the most part will be prepared by members of the Purdue faculty, but assistance will be sought from others, and occasional selections from books and magazines may be expected.

Third. No specific indication will be made as to the length of time each subject should occupy the attention of the pupils. Some of the subjects may properly occupy four weeks and some but a single week. This must depend chiefly upon the ingenuity of the teacher and upon the interest manifested by the pupils. Furthermore, some of the leaflets treat of subjects that should occupy the attention of the pupils for a brief time during the summer, and also for a brief time during the winter, as for example, the leaflet on "The Care of Domestic Animals."

Fourth. Teachers should at all times strive to induce the pupils to see and hear and think for themselves; in short, to become original investigators.

Fifth. It would be well for teachers to organize observation clubs and take the pupils on occasional rambles through the country.

Sixth. The pupils should be encouraged to make reports, to write essays and descriptions, and to illustrate on the blackboard and in their drawing books.

Seventh. The method of presentation should be oral so far as possible. Habits of correct expression should be cultivated, and the children should be encouraged to ask questions. A query box might possibly be used to advantage.

Eighth. Teachers should endeavor to interest parents in the enterprise, and should conduct the work in such a way as to secure their earnest co-operation. They should be careful not to require an undue outlay of time or money.

Ninth. It is suggested that flower and fruit festivals, in their proper season, at which small prizes could be offered, might be helpful. The co-operation of the county agricultural society and other similar organizations might be secured with advantage.

Tenth. Since the leaflets are to be used by teachers of varying experience and under widely differing conditions in respect to progress of pupils, no uniform method of treatment will be employed. Some of them will be in the form of directions to teachers, others in the form of directions to pupils, others again, in the form of oral object lessons, and still others will be in the form of stories; and, since they are prepared by a number of different people, no attempt will be made to present them with any uniformity in style of composition.

It is important to observe that very much of the Nature Study by the children must be done out of doors, and in the spring and summer, but many of the schools will not be in session at that time of the year.

Such of the leaflets therefore as especially relate to spring and summer work on the part of the children should be translated into oral lessons and given by the teachers of such schools during the winter term. It is quite apparent the leaflets can often be used in this way with but few slight changes in phraseology. Thus instead of taking the children on an excursion in May to observe spring birds the teachers can re-phrase the leaflet on that subject, and use it as a basis for a conversation with the children, instructing them how to become good observers as they go about and requesting them to report the results of their observations at the beginning of the next term. These oral lessons should bring out, as much as possible, the previous information of the children.

Some of the leaflets, however, which seem especially to relate to objects which can be observed only in the spring, may serve as models upon which the teacher can construct exercises adapted to use in the fall by substituting subjects of study which can be readily found in the later months of the year.

To emphasize what has already been said in the Letter of Transmittal it may be repeated that the chief purpose of these leaflets is to suggest *methods* to the teachers rather than to give them information, and that the most successful results will be obtained when teachers are able to supplement these lessons by those of their own construction.

JAMES H. SMART,
President Purdue University.

No. 1.

# LEAFLET

## ON NATURE STUDY.

DESIGNED FOR THE USE OF TEACHERS OF PUBLIC SCHOOLS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## INTRODUCTION TO NATURE STUDY.

BY PROF. STANLEY COULTER.

The purpose of these leaflets is to aid the teachers to bring the children of rural districts into close sympathy with nature, to cultivate the habit of accurate observation, and to give them such information concerning these matters as will be not merely of present interest and use, but which will serve to give added power and usefulness to them in after years, whether they remain upon the farm or enter some other life work. It is further the purpose to show how the truths gathered from these observed facts may be made to be of service in enabling them to do familiar things in a better way, or may even serve to suggest entirely new ways of forcing nature to contribute to our prosperity and comfort.

Teachers in our ungraded schools are already overcrowded with work, and it is a part of the purpose of these leaflets to suggest to them how, not by added work, but by work of different character they may secure much more perfect and enduring results. Nature work of the highest type can not be given from data drawn from books however skillfully prepared, the data must be drawn from nature itself. So each of these leaflets has as its real center some broad underlying principle, capable of almost endless illustration and expansion. If this is grasped, it will give new methods of interpretation of nature and its phenomena, which will enable the teacher to use to the objects nearest to his hand as the material for nature study.

Each leaflet is merely a suggestion as to how certain familiar objects may be successfully and profitably used in this work. No one of these leaflets is a complete statement of all the truth known concerning the subject treated. They should therefore be regarded by the teacher merely as suggestions, indicating how such material may be used. Large numbers of similar exercises upon subjects suggested by the teacher, or, better still, by the pupils, should be introduced at every point. The real value of these leaflets will be found to lie in the method of treatment and interpretation, not in the detailed exercises with which each one closes.

It should be remembered that the primary purpose of nature work is to cultivate habits of accurate observation. It is evident that in young children the perceptive powers are most keenly alive. Everything is novel and interesting to them, and the purpose should be to direct this interest in such a way as to bring to them added knowledge and become a mental habit. The objects used in nature work should be those objects which surround the child, and so these leaflets treat of familiar things which can be readily observed in almost any region.

Children love to do things. As they watch the processes of nature about them they see various changes brought about by varying conditions. These are usually so complex in nature as not to be of ready interpretation. So far as the subjects admit, there is added to each leaflet suggested experimental work which is within the grasp of the pupils and which may serve to enforce the facts observed. These experiments should as a rule be conducted by the pupil, although the teacher should see that the required conditions are met. These experiments may be advantageously extended in ways self-suggestive to the live teacher, if care be taken that conditions are not too complicated for ready comprehension.

While it may be necessary for the teacher occasionally to secure suitable material for the demonstration of a specific point, the children should from the first be taught to provide their own material. It is fairly easy to have suitable material provided by showing an example of such object. If for example material illustrating the opposite arrangement of leaves upon the stem, with the successive pairs of leaves in different planes is desired, a twig of maple could be shown and the children asked to bring in branches in which the leaves were arranged in the same manner. Nothing should be said as to the character of the arrangement, the eye of the pupil being the sole guide as to the material to be collected. It is plain that a similar method might be employed in almost any form of work undertaken. If children collect their own material they will develop habits of accurate observation much more rapidly and at the same time will have a much keener interest in the work. It cannot be too strongly insisted that about the surest way to defeat the object of nature work is to tell the child what he is to see. Yet this is at the same time the teacher's most common error. Unless the child is trained to observe and to rely upon the observations thus made, nature work in the lower grades is meaningless.

The work should not be entirely formal or systematic, and indeed it would be impossible to formulate any definite work either as to character or amount which should be assigned to the different grades. The children should be encouraged to observe those things that present themselves and these will vary from day to day. At one time it may be a flight of birds, at another a strange stone, at another a hail storm, or the opening of a flower, whatever it may be it should be used as matter for comment and farther observation. The children should be encouraged to extend their observations so as to include as wide a range of objects and phenomena as is self-suggestive. Yet the work should not be left to the chance material which may attract the child. It would be well to suggest objects to observe from time to time, which will serve for the basis of some work which all have had opportunity to consider. Experience has shown also that such suggestions add much to the interest of the work and serve to give a new purpose and meaning to the field work or short excursions which should form a part of nature work. It would perhaps be well to spend the half of each exercise upon some previously suggested subject and the other half as an observation club in which the pupils should be encouraged to report and question concerning things which may have attracted their notice since the last exercise. Encourage this especially, even though you are not familiar with the objects or phenomena, for you are only an older pupil in nature work, and if you are sufficiently quiet and observant you may learn much of nature through the keen eyes of your pupils.

The value of true nature work can scarcely be over-estimated. Habits of accurate observation soon lead to a correct perception of relations, and this, when applied to the affairs of mature life, conditions success. But in the period of school life it leads to correct notions concerning the relations of living forms to each other, of their relation to the inanimate world, of the influence of surroundings upon life forms, in such a way as to make nature self-interpretative, and her every manifestation educative. Such a knowledge of nature adds directly and largely not merely to the happiness but to the power of its possessor. Knowing nature and her processes, knowing life and its phenomena, he can so direct and control them as to produce the greatest results with the least expenditure of energy. It will make its possessors more expert in their management of cattle and poultry and bees, more skillful in their gardening and culture of small fruits, more successful in the larger operations of the farm. The applications of nature work touch every interest of rural life directly and constantly.

These leaflets will therefore be so directed as to apply to the various interests relating to agriculture, horticulture, the care of domestic animals and household economy. This will of course involve leaflets upon economic botany, economic entomology, soils, and other subjects having a bearing upon these broader topics.

It is suggested that at least one hour a week be assigned for work of this character, and further, that in the case of very young children no exercise exceed twenty minutes in length. If the teacher is successful in presenting nature work it will be through honest effort. The more popular literature bearing upon the subjects treated should be read by the teacher, so far as opportunity offers, in preparation for the work. Excellent material bearing upon these subjects may be found in the science books recommended by the State Reading Circle.

The fact that the objects which suggest themselves for nature study are so variant, and the added fact that they vary from day to day, with the season and with the region, renders it an evident impossibility to issue a series of leaflets which shall either by number or by date of publication, indicate the order of the presentation of natural objects. These leaflets, then, do not suggest an order of presentation, but are meant simply as helps to the earnest, ambitious teacher, when in his nature work he meets the subjects of which they treat. As their purpose is to help the teacher, their number will be largely controlled by their success or failure in accomplishing this end. It is further suggested that no time can be assigned in which the work outlined in any leaflet should be completed. The method given is meant to be the chief feature, and these methods should, in the hands of the teacher, be capable of application not merely to the subject treated but to a very wide range of related subjects.

FOR THE USE OF TEACHERS.

No. 2.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## THE STUDY OF THE FOLIAGE LEAF.

BY PROF. STANLEY COULTER.

The materials for "nature" study are the nearest and most conspicuous natural objects. These materials necessarily differ with the locality, with the seasons, even from day to day. It will be found, however, that in almost every locality the greater part of these studies will be connected with plant forms. The reasons for this are very apparent. Plants are *living* things and life appeals to the child. The material for the studies is convenient and abundant. Plants have a fixed position, allowing the effect of varying conditions to be readily seen and understood. The life cycle is so short that all of its phases may be observed in a single school year. Beyond this it is to be remembered that plants stand as the visible sign of the agricultural capacity of any region, giving us direct report of the character of its soil and climate; that they are intermediaries between unorganized matter and animal forms, and that they have profound economic importance not merely in furnishing food-stuffs, but also in some of their forms, in absolutely conditioning public health. It is, however, because of their abundance and relative ease of preservation in any desired condition, that plant forms must naturally furnish the material for a large part of nature studies.

The flowering plants are evidently the most conspicuous plant forms in any region, and of these the foliage leaf is the most conspicuous part. From the earliest spring when it begins to unfold its blade of delicate green, until it falls clothed in autumnal brilliance, it is the dominating feature of the plant. For this reason, this leaflet is intended to suggest how the foliage leaf may be used as an object for nature study in such a way, that all work done will have a definite purpose and an equally definite value.

Foliage leaves are so variant in general appearance, in position, in size and general outline, that it seems necessary to determine what characters are common to *all* such organs. The following general characters will be found to apply to all foliage leaves however diverse they may be in appearance.

1. The foliage leaf is a lateral organ of the *stem*. It is found upon no other part of the plant body.
2. The foliage leaf is, *characteristically green*, due to the presence of chlorophyll which is developed only in the presence of sunlight.
3. The foliage leaf is an *expanded organ*, giving the greatest possible surface exposure to light and atmospheric conditions. Other parts of the plants are mass structures, not surfaces.

It is very evident from these common characters, that the *foliage leaf is an organ adapted for the light relation.* The value of this conception of the foliage leaf in nature studies can scarcely be over-estimated. Its application readily and clearly explains peculiarities of form, of position, of lobing, and the great mass of adaptations characteristic of plants growing under differing conditions. It explains in a general way plant outlines, and will be found to render clear many apparently puzzling conditions.

Before illustrating the above points specifically, it will be well to consider briefly the work of the leaf. This work may be grouped under four heads.

1. *Transpiration*, or the interchanges of moisture between the interior of the plant and the external air. The result of transpiration, which is after all apparently little else than evaporation, is to aid in the transfer to the leaves of the nutrient water taken from the soil by the roots.
2. *Respiration*, or breathing. Those gaseous interchanges between the plant and the air through which oxygen is taken up by the plant and carbon dioxide returned to the air.
3. *Carbon fixation*, or those processes through which, under the influence of light, carbon dioxide taken from the air is broken down, the carbon being retained and built into the tissues of the plant, while a portion at least of the oxygen is returned to the air.

4. *Photo-syntax*, or those processes through which, under the influence of the light, the crude food materials derived from soil and air are transformed into substances suited to the needs of the plant.

While for the purposes of this leaflet, only one of these uses, that of transpiration, will be considered, the others have been given to show how essential the light relation is to the foliage leaf if it accomplish its assigned work. The foliage leaf then is not merely an ornamental appendage to the plant, its various peculiarities being considered as the result of chance, but a working organ intimately concerned with the most important duties in the individual life of the plant.

Let us now examine some of the ways in which this light relation is secured. One of the forms, often seen, especially in the early spring, is that known as the "rosette" arrangement. The foliage leaves are apparently arranged radially, lying flat upon the ground, and in the absence of the stem, seeming at first glance quite unlike organs for light relation. Common plants with this arrangment are the mullein and plantain. If the leaves in this arrangement are without leaf stalks, it will be found that in almost every case they are broader at the apex than at the base, a form which in definitional botanies is known as spatulate. The successive circles of leaves as they arise from the center are progressively shorter, the broader portions at the apex fitting into the spaces left between the narrowed bases of the leaves of the preceding circle. If the whole rosette be looked at from above it will be seen that scarcely any portion of the lower leaves is shaded by those above, each leaf, by its peculiar form and the regularly diminishing size of the leaves of succeeding circles, being brought into the most perfect light condition.

In the case of the plaintain, where leaf-stalks are present, the same condition is brought about by the progressive shortening of the leaf-stalk from the lower to the upper circles of leaves. It is very evident then that the "rosette" arrangement is a device for securing the light relation on the part of plants with reduced stems.

**Material for Illustration:**

*Common plantain*, earlier leaves of *mullein*, *shepherd's purse*, *dandelion*

Taking the cases where leaves are found upon a well developed stem, the most casual examination will show device after device for securing proper light relations. So evident are they, that they need not be mentioned in detail, almost every species of plant furnishing its own solution to the problem. If an ordinary erect stem is looked at from above it will be seen that the leaves are arranged in a series of fairly distinct ranks. The number of these ranks is important, since it has a direct relation to leaf form. The greater the number of ranks the narrower the leaves. The smaller the number of ranks the broader the leaves. Facts evidently explained by our conception of the leaf as the organ of light relation.

Thus far it has been assumed that the leaf-bearing stem has been erect. If by any chance, or by the necessities of growth it should change from the erect to the horizontal position, it is evident that to secure proper light relations the leaf position must also change. Comparisons of leaf positions upon erect and horizontal stems taken from the same plant will prove of great value in emphasizing the fact that above all other things the leaf must have light exposure.

MATERIAL FOR ILLUSTRATION:

> **Erect and horizontal stems of** *elm*, *maple*, *linn*, *oak*, *apple*, *peach*, *cherry*, *catnip*, *wild pinks*, *honeysuckle* **or of** *any* **plant that may be growing near at hand.**

I have considered as yet only cases in which the leaves were entire, or with unbroken margins, since these furnished the simplest illustrations. In the case of lobed or dissected leaves, the conditions are somewhat different. In the simpler forms of lobed leaves, the lobing is evidently a device to prevent the shading of underlying leaves. If you recall the ordinary ivy with its sharply angled leaves, almost geometrical in their regularity, this fact will be evident. If a growing tip of this plant, as it clings to the wall, be carefully flattened down it will be seen that the leaves fit into each other so accurately by means of these angles, that on the one hand there is scarcely any perceptible shading, and on the other there is scarcely any space unoccupied by the leaf. Such accurate fitting of leaves when brought to a common plane, produce what is known as leaf "mosaics," which simply serve to again prove that the leaf is the organ of light relation. Where the leaves are much dissected, as in the case of the common rag-weed, there is the same arrangement in ranks, the same arrangement of leaves in different planes as in the case of the entire leaf, but as a rule no marked diminution in the size of the leaves as we pass from the base to the top of the plant, the constant shifting of the parts of the dissected leaf, and the possible play of light through the openings between the leaf parts, being sufficient to prevent any portion of the underlying leaf from being continuously shaded.

MATERIAL FOR ILLUSTRATION:

*Ivy, geranium, star cucumber, begonia, common mallow, rag-weed* **or any plant with lobed or dissected leaves.**

It will be seen then that leaf form largely determines the outline of the plant taken as a whole. Let us return to the mullein for a moment. It will be remembered that the leaves are entire, the lower ones being the largest and standing nearly at right angles to the stem. As the summit is approached the leaves become gradually smaller and at the same time more closely appressed to the stem, until at the extreme summit they are much reduced and nearly parallel to the stem. This arrangement, so evidently for the purpose of preventing shading of lower leaves, serves to give to the whole plant a general pyramidal outline, a form characteristic of simple plants with *entire* leaves. In the case of the rag-weed, on the other hand, since there is no diminution in size of the upper leaves, the general outline of the plant is *cylindrical*, a form characteristic of plants with divided or dissected leaves.

It is evident that in genuine nature work the foliage leaf is to be studied from a new view point. It is not to be used as a frame upon which to hang definitions as to form and margin, apex and blade, but is to be considered as a working organ charged with important duties which can only be successfully performed in the presence of the light. In this view all peculiarities of position and form and structure are but devices for enabling the leaf to properly accomplish its work. The main question in every case concerning the foliage leaf is, "How is the light relation secured?"

Before considering specifically how the view of the foliage leaf as the organ of light relation serves to explain many so-called adaptations to meet special conditions, it is necessary to touch very briefly upon the relation of plants to the soil. It is evident that by far the greater part of the food of the plant is derived from the soil. It is also plain from our knowledge of the structure of the plant, that this food must be taken up in the form of a watery solution. It follows, therefore, that the amount of water in the soil has a very important bearing upon the food supply of the plant, and serves, perhaps, more than any other one factor to determine its structural features. Indeed this matter of the available water of the soil is of such great import that it determines largely not merely the external form of the plant, but also modifies in a marked way its minute structure.

Based upon this dependence of plants upon and their relation to water, the plants of any given region may be separated into three groups, each showing adaptive arrangements to fit it for its place in nature.

1. Water-loving plants, or those plants which live either wholly or partly in water, or else grow in very wet soil, where the water percentage is 80 or above. This is an extreme form of vegetation, and the number of species of plants in this class in Indiana is relatively small. Technically such plants are known as *Hydrophytes.*
2. Dry soil or desert plants, at the opposite extreme from the water-loving plants. These plants grow in dry soil and atmosphere, the water content of the soil being below 10 per cent. at its minimum. Such plants are known as *Xerophytes.*
3. Intermediate plants, or those adapted to medium conditions of moisture in air and soil. Such plants are known as *Mesophytes,* and constitute the larger portion of our native flora.

While these differing soil conditions modify the structure of the entire plant, we wish at this time to consider only their effect upon the leaf. It is plain that when a plant lives in an extremely dry soil, that the water lost by transpiration can be replaced with extreme difficulty, and that if no check were placed upon transpiration the available water in the soil would soon be exhausted and the plant would die. On the other hand, when plants live in the water or in a soil rich in water, the losses from transpiration, however great, can be easily replaced. As the foliage leaf is the chief organ of transpiration, the most evident adaptations to control the process occur in it.

Let us consider in what ways transpiration may be checked, and then see if by an application of these facts, the foliage leaf will not tell to us the story of the water capacity of the soil.

1. Transpiration may be checked by reducing the *size* of the foliage leaf. Much less water will be evaporated in a given time from a vessel with ten square inches of exposed surface than from one with a surface exposure of one hundred square inches. So, much less transpiration will take place from a small leaf than from a large one. Think of the leaves of the waterlily, of the splatter dock, of the skunk cabbage, indeed of any water or marsh plant with which you are familiar, and compare them as to size, with leaves of the golden rods or the mullein or any familiar plant living in a dry soil. You will see at once a marked contrast. In tropical regions where water is abundant both in soil and air, the foliage leaves are very large, but as we come into the temperate regions the leaves are reduced in size until finally in desert or arctic regions they are so reduced that they almost lose the semblance of foliage leaves.

2. Transpiration may be checked by reducing the *number* of leaves. If you can recall any plant, say a wild rose, and compare one growing in moist soil with one growing in dry soil, you will at once see how often nature makes use of this device to prevent damage by excessive transpiration and to fit the plant to meet its conditions. And in this way also, the leaf tells us of the water content of the soil. You know farmers and gardeners say that in wet weather their plants all *run to leaf*, which only means that no check need be placed upon transpiration.

3. Transpiration may be checked by *thickening the outer wall* of the leaf. If you compare a leaf of a plant growing in dry soil with that of one growing in very moist soil, the former will in almost every case have the thicker and tougher outer covering. This is one of nature's favorite devices for checking transpiration, and you can scarcely examine a leaf taken from a plant growing in dry soil which will not show it and at the same time tell to you the character of the soil as to its water capacity.

4. Transpiration may be checked by the leaves having *a covering of hairs*. This also is of frequent occurrence in nature. The common mullein is a familiar example of this method of controlling transpiration. This of course is not the only use of hairs, as may be shown in some future leaflet, but it is one of their important uses.

There are other methods of checking transpiration, but we are only concerned with those which are readily apparent and can be used in nature work.

If we compare then the foliage leaves of plants growing under dry conditions with those of water-loving plants, the following facts are apparent:

1. The leaves are relatively small.
2. The leaves are often fewer in number.
3. The outer covering of the leaf is thicker.
4. The leaves are often clothed with hairs, which in water-loving plants are almost always wanting.

The intermediate plants show almost all conceivable variations between these extremes and are extremely sensitive to the slightest changes in soil and air moisture, recording these changes in corresponding leaf modifications. The differences in many cases in plants of the same species growing under differing conditions is so marked as to have led to the formation of distinct species, when the plant was merely trying to tell us the story of the soil.

It is not wise, in these studies, to press the work upon a single feature too far. Continued application is an acquirement of age. The endeavor has been to call attention to a few points which may suggest to the teacher how to use the foliage leaf in nature work.

Similar studies, using some other one of the leaf functions as a basis, will doubtless suggest themselves to the teacher, as this work progresses. Some of these may be treated in future leaflets should this one prove to be helpful to the teachers of the State.

The teacher in the country school has here the greatest advantage over the teacher in the city. God's laboratories are infinitely more complete and more suggestive than man's, and earnest, honest work in these lines will develop in the pupil habits of observation which will not only be of temporary value but will be a permanent possession.

## METHODS OF PRESENTATION.

1. *Develop general characters of leaf.* (*p. 2.*)

This may be done by bringing in abundant material representing different plant forms. Some of the plants should be entire, showing root as well as stem. Have the pupils tell what part of the plant is stem, what part is leaf and what part root. This develops easily and naturally the *position* of the leaf. The *color* of the leaf can now be considered and this followed by the leaf as a *flat organ* or *surface.* Tell the pupil to bring to the school any plants in which the leaves are *not* upon the stem, are *not* green and are *not* expanded surfaces. Such exceptions will be found, but so rarely, that the general characters given will be seen to be the rule.

2. *Arrangement of leaves to prevent shading.*

(a) Take some simple case, as the maple, the elm, the mulberry, or indeed almost any form with simple and entire leaves, being careful to select *erect* stems. The specimens should be fresh, or the wilting of the leaves may obscure the real relations. Ask if the successive leaves as you pass from base to top of the twig are *directly* above each other. Does this arrangement prevent the shading of the lower leaves by those above? By abundant material of these simple forms, have the child see the different ways in which this shading is prevented.

In most cases it may be necessary to suggest to the child to look at the specimen from above and not from the side.

(b) Take horizontal stems of the forms studied under (a), and have the child report upon the very apparent differences in arrangement. Ask why this difference occurs. If the answer does not suggest itself to the children, repeat the work under (a) and (b), using different forms. Be careful not to suggest the explanation, but allow the pupil to work it out, even though it seem to take a long time.

(c) Take the earlier leaves of the *mullein*, the *plantain*, the *shepherd's purse* or the *dandelion*. Work out first the "rosette" arrangement. Then lead up to various arrangements for preventing shading. In the hands of the skillful teacher, this should not be a difficult task.

(d) The case of lobed and dissected leaves had perhaps better be illustrated by the teacher. The common ivy, star cucumber, or any convenient plant with lobed or angled leaves will be found suitable.

3. *The general form of the plant as determined by the leaf.*

(a) To show pyramidal form of simple plants with *entire* leaves, take the common mullein, the shepherd's purse, or any plant growing in your region having entire leaves. Have lines drawn from the tip of top leaf to the tip of bottom leaf. What is the shape of resulting figure?

(b) To show cylindrical form of plants with dissected leaves, take the rag-weed, or any form easily obtained, and proceed as in (a). In both cases plants of as many kinds as possible should be examined in order that the plant form as determined by the leaf may be seen to be the rule and not merely a chance outline. Plants in which branching does not occur or in which it is very simple should be chosen, as branches complicate the plant outline and render this point more difficult to work out satisfactorily.

4. *The leaf as indicating differing soil conditions.*

(a) Select any water or marsh plants with entire or nearly entire leaves. Suitable forms are waterlily, splatter dock, arrow leaf, skunk cabbage, or marsh marigold. Have them examined with reference to size, toughness and thickness of outer covering of leaf, and presence or absence of hairs.

(b) Select forms of plants loving dry ground, such as the goldenrods, mustards, some of the smart-weeds, indeed any form growing in dry soil, whether its name is known or not. Examine as to same points as in (a). Compare conditions found in (a) with those in (b).

(c) Take some single form, such as the wild rose, which you find growing in moist soil, intermediate soil, and dry soil. Note changes in leaf size, leaf number, character of outer covering and presence or absence of hairs, in specimens growing in these different conditions.

5. *Experimental Work.*

1. *To show necessity of light for the development of leaf green.*

(a) Take two plants, equally vigorous, and place them in pots. Keep one in the sunlight, the other in the dark. Let all other conditions be identical. At the end of a week or ten days what differences are noticeable in the plants?

(b) Shade a portion of a vigorously growing leaf by covering with a piece of pasteboard. The pasteboard may be held in place by pins passed vertically through it and the leaf, the small wounds made by the pins not producing any injurious effects. At the end of two or three days remove pasteboard and note results. Expose the previously covered portion to the action of light for a few days and note results. In the case of young children interest may be added by cutting the shading pasteboard into various patterns.

2. *To show that leaf green is necessary to the growth of the plant.*

Continue experiment one (a) for two or three weeks. Note differences in size and vigor of plants.

3. *To show effect of soil moisture upon plants.*

Take vigorous seedlings of Indian corn, beans, peas or any rapidly growing plant and place in pots. Subject one plant to drought by withholding moisture from it, give to the other abundant water, being careful, however, not to drown the plant. Note the results at the end of one, two, three and four weeks.

These suggestions are made not as laboratory directions, but merely as indications to the honest teacher, of methods by which information may be secured from nature itself without the intervention of text books. Suggestions which it is hoped will lead the teacher to find new meaning in that very common thing, the foliage leaf, and through this to give him the power to advance to a clearer and fuller interpretation of the life about him.

FOR THE USE OF TEACHERS.

No. 3.

# LEAFLET

## On Nature Study.

Designed for the Use of Teachers of Public Schools.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## THE FLOWER AS AN OBJECT FOR NATURE STUDY.

By Prof. Stanley Coulter.

In this study let us remember that the beauty of the flower is but an incident, that the *work* of the flower is the essential thing. Every living organism, whether plant or animal, has two supreme functions. One is the *maintenance of the individual life of the organism*, and this is secured by the varied processes concerned in nutrition. The other is the *maintenance of the species or kind*, and this is secured by the reproductive processes. To the flower, in a very large degree, is committed the work of perpetuating the species, and if this fact is kept in mind it will serve to make clear much of what follows:

Before we consider the work of the flower, let us examine the flower itself very briefly. Let us take for example the apple-blossom or spring-beauty. It will be readily seen in these cases that the flower consists of four circles of parts. An outer and lower circle, which is green in color, known as the *calyx*, the separate parts being called *sepals*. Immediately within and slightly above the calyx, a second circle, usually some other color than green. This is the *corolla*, and its separate parts are *petals*. Within the corolla a third circle of parts very unlike either sepals or petals in form, the individual members of which are known as the *stamens*. If you examine closely you will find the stamen to consist of two parts, a thread-like or ribbon-like lower portion, the *filament,* which bears at its summit a box-like part known as the *anther.* Within the anther are developed small bodies, rounded or angular in shape, and usually yellow or brown in color, which are called the *pollen grains.* When the pollen grains are fully ripened the anther bursts open and the pollen is set free. When you walk through a field of rag-weed in the late summer the yellow powder that covers your shoes is the pollen of the plant. Do not forget this pollen, for it is very important, as we will find later. In the center of the flower a fourth circle of parts, often appearing as a single organ, the *pistils.* Here again we must examine the part somewhat in detail. In most cases the pistil is found to be made up of three parts; a swollen, rounded base called the *ovary,* a more or less expanded summit known as the *stigma,* and a part connecting stigma and ovary known as the *style* If the ovary be cut across it will be found to contain a number of small, round bodies, usually colorless, which are known as the *ovules.* These ovules are the bodies which, after fertilization, become the seeds. Now, the ovules can only be fertilized through the agency of the pollen grains. If I wished to state the matter scientificially I would say that fertilization occurred when the protoplasmic contents of the pollen grain united with the protoplasmic contents of the ovule, but for our purpose perhaps the first statement will do. It is easily seen, then, that pollen grains and ovules are the parts of the flower essential to reproduction, or, in other words, to the formation of the seed. We then have to seek the significance of the calyx and the highly colored corolla, for they must in some way be associated with the work of the plant. Let us turn for a moment to some other flowers, those of the walnut tree, of the oak, or of grass. Examining these, we find calyx and corolla absent or much reduced, although stamens and pistils are readily made out. It is very clear, then, that calyx and corolla can be and frequently are dispensed with by the flower.

After this somewhat lengthy prelude, let us see what the facts it contains teach. Evidently the pollen, when liberated from the anther, must in some way reach the pistil, and, having reached the pistil, its protoplasmic contents must reach the ovule, which is completely enclosed in the ovary. With this latter part of the process we are not concerned in nature-study, but the former is of very great interest. It is plain, if we examine any large number of flowers, that the relative positions of stamens and pistils are such that gravity will not insure the falling of the pollen grain upon the stigma. We must find some means, then, by which the pollen grain is transferred to the stigma. This mechanical transfer of the pollen grain to the stigma constitutes what is known as *pollination*. *Cross pollination* is said to occur when the pollen of one flower is carried to the stigma of another flower of the same kind. Without discussing the matter, we find that in nature cross-pollination occurs in a large majority of plants, and that by many devices *self* or *close pollination* is prevented.

Cross-pollination is effected in a large measure through two agencies, *the wind* and *insects.*

If we examine wind-pollinated flowers, we find the following conditions to exist:

1. Calyx and corolla absent or greatly reduced.
2. Absence (ordinarily) of fragrance.
3. Absence of nectar or honey.
4. The development of an immense quantity of pollen.

The reasons for these correlations are very evident. The wind is an insensate agent; it "bloweth where it listeth," and its direction is not changed by brilliance of color, delicacy of odor or presence of nectar. So nature wastes no energy in the development of useless structures, and all the force thus saved is turned to the production of large quantities of pollen grains. This great amount of pollen is necessary because of the uncertainty of any large portion of it finding its way to stigmas ready to receive it; and so these large quantities stand merely as the index of the difficulty of the perpetuation of species in wind-pollinated plants.

In insect-pollinated flowers, however, we have a sentient agency, the insect, and as we examine the flowers we find the following correlations:

1. Development of color.
2. Development of fragrance.
3. Development of nectar.
4. Extremely varied forms.
5. A reduced amount of pollen.

It is scarcely necessary to speak in detail of these correlations. Color and fragrance serve largely, doubtless, to enable the insects to readily find the plants which produce their favorite food. We must remember that insects do not visit flowers because the flowers are beautiful or fragrant, but because they want food, the color and fragrance standing merely as the indication of the presence of food. The food, however, is so placed that the insect securing it bears away upon its body greater or less quantities of pollen. As it visits another flower of the same kind, this pollen is brushed off by the stigma, and pollination results. The devices for insuring that the pollen be thus borne away by the insect, and that it be deposited upon the stigma, are very numerous and very wonderful. Some of them are so intricate as to seem almost incredible unless we remember how jealously nature guards the type.

It sometimes happens that particular plants can only be pollinated by particular insects, a fact which largely explains many irregularities in flower forms. For example, the common red clover can only be pollinated through the agency of the bumble-bee. If the bumble-bees in any given region were completely exterminated, the red clover would fail to set seed and would, in a very short time, become extinct. In many cases where the red clover blooms very early farmers do not expect the first flowers to set seed, because, as they say, "the flowers blossomed before bee-time." Because of the purposeful movements of the insect from flower to flower in search of food, pollination is much more certainly assured than in the case of wind-pollinated flowers, and there is a corresponding reduction in the amount of the pollen.

We here begin to see how tangled is the web of life, how closely interdependent are life forms. The plant furnishing food for the insect, the insect in its turn insuring the perpetuation of the plant form. The more we study nature, the closer and more wide-reaching will these relations be found, until we see that the fullest study of a single form would in the end include all living organisms.

But, whether the pollinating agent is wind or insect, it would be possible in many cases that self-pollination would occur did not special devices for its prevention intervene. The more apparent of these are the following:

1. Stamens in one flower and pistils in another, though upon the same plant.
2. Stamens in the flowers of one plant, pistils in those of another.
3. Pollen maturing before the stigma is in condition to receive it, or the reverse.

It is very evident that any one of these conditions will effectually prevent self-pollination. The existence of these conditions is easily made out by an examination of the flowers, although the last may need a word of explanation. The maturing of the pollen is evidenced by the bursting of the anther for its escape, and the subsequent drooping of the filaments. The indication of the stigma being in a condition to receive the pollen is ordinarily the development, upon a more or less definitely marked region, of hairs or a mucilaginous substance which will serve to retain the pollen which falls upon it.

The questions in the study of the flower in nature-work that should always be in mind are these:

1. Is the flower self-pollinated or cross-pollinated?

2. If cross-pollinated, is the agency the wind or insects?

3. If by insects, what forms of insects visit the particular flower under examination?

4. What devices are present for preventing self-pollination?

It will be seen that in this leaflet I have called attention to the matter of pollination alone. Other suggestions could be made as to the use of the flower as an object for nature-study, but a somewhat extended experience has convinced me that, with this point as the center, the interest in the flower is keener and of longer continuance. The study of form and color weary after a time, because of their almost infinite variety. The study of a definite purpose accomplished by means of various adaptations is of abiding interest. If you and your pupils have the clear-cut conception that the flower has a definite and vital work to perform, and will honestly attempt to work out the various means by which this end is secured, every flower will be to you material for nature-study, and you will find your work increase in interest from day to day.

## METHODS OF PRESENTATION.

1. Select fairly large and simple flowers for the study of the four circles which go to make up the complete flower. Abundant material should be secured and the variety of forms should be as great as possible. Any or all of the following forms will be found suitable:

Any of the *buttercups*, *marsh marigolds*, *violets*, *water cress*, *larkspur*, *common wild yellow poppy*, *peas*, *beans*, *locust*, *apple*, *peach*, *cherry*, *strawberry*, *dog-tooth violet*, or any form near the school and accessible to the children. Work out the different circles repeatedly, using different plants until they are clearly understood. Make out the different parts of stamen and pistil.

*Do not have the flower torn to pieces*, except when looking for the ovules.

2. Take flowers of *maple*, *oak*, *hickory*, *beech* or *any grass* and compare with flowers studied under No. 1. Points for comparison will readily suggest themselves to the teacher.

3. To study prevention of self-pollination by separation of stamens and pistils, use flowers of *sassafras*, *spice bush*, any of the *spurges*, *oak*, *walnut* or *willow*. Many others will be found, if careful examination is made.

4. To study ripening of pollen and stigma at different times, use *crocus* (cultivated), *common plantain.* It will be of great interest to the pupils if they are allowed to work out points under Nos. 3 and 4 for themselves. The material should be distributed, with only one question—"Does any device exist for the prevention of self-pollination?"

5. While drawing is not nature-work, it is an accessory to it, and should be used wherever practicable, but never to the extent of obscuring the real center of the work, which is the study of nature. The drawing in nature-study is chiefly to be used as a convenient method of making notes.

**Experimental:**

*To show insect agency in pollination.*

When peas or beans are in blossom, cover some bunches of flowers with mosquito netting in such a way as to exclude insects, yet admit light. Note results from day to day.

Try the same experiment upon apple, peach or strawberry blossoms, and note results.

If possible to have access to a field of red clover, enclose some flower-heads *before opening* in mosquito netting, to prevent insect visitation. Compare "netted" flowers with those that were left "unnetted," as to setting of seed.

These suggestions as to methods and experiments are only meant to serve as hints to the busy teacher. If fuller details are desired by any teacher into whose hands this leaflet falls, they will be cheerfully given upon addressing the author.

Finally, it must be remembered that in all this work the essential feature is contact with the forms studied in their natural relations. It is the living plant that is to be studied. The scholars should be encouraged to collect their own material, to report upon facts they have observed, and be made to feel that it is their work to find new and interesting facts in nature about them.

FOR THE USE OF TEACHERS.

No. 4.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

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PREPARED BY THE

FACULTY OF PURDUE UNIVERSITY.

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# THE CARE OF DOMESTIC ANIMALS.

BY PROF. C S. PLUMB.

The purpose of this little leaflet is to aid in training the powers of observation of children, by studying the animal life of their daily surroundings at home. Enough suggestions are given to the teacher in this to enable one to discuss several phases of such life with the children, and inspire them with an ambition to become more familiar with the daily needs and welfare of farm animals.

Once upon a time, over a century ago, there lived in England a little boy by the name of Robert Bakewell. He lived with his parents in a stone house and helped take care of the horses, cattle, sheep and swine on the farm. He showed an unusual interest in all of the live stock, and was with them much of his time. As he grew in years, so his interest in farm animals increased. He was rather a reticent fellow and kept his thoughts to himself. But he was a great thinker and observer. He saw that the people about him had many animals that were unworthy of their keeping. The stock grew slowly, ate much expensive food, were of ill shape and were not profitable to their owners. And so after giving this

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NOTE TO THE TEACHER.

You will notice that part of the leaflet is printed leaded, or with the lines far apart, and a part of it not leaded. The teacher should use his discretion in the use of the closely-lined matter. In most cases it will be necessary to simplify it to meet the comprehension of the children. The leaded matter may be read to the children or presented orally just as it is. It, however, admits of unlimited amplification and discussion. In presenting it, the previous knowledge and experience of the children should be drawn upon so far as possible. It is suggested that this leaflet affords material enough for a great many lessons, and that part of it should be used in the summer and part in the winter.

matter much thought, Robert Bakewell began the work of improving the farm animals of his locality, in the county of Leicester. Horses, cattle and sheep he resolved to improve to a higher standard of excellence. His neighbors laughed at him, but he was not diverted from his self-assumed task. For years he worked at his problems, and finally he placed before the admiring world the improved English cart horse, Long-Horn cattle and Leicester sheep. Then Bakewell was honored, even beyond the shores of Britain, and in later days he became known as "the father of improved live stock husbandry."

What led to Bakewell's success?

A natural love for animals The faculty of observation. An ambition to improve that which he thought was inferior. The use of better methods. Persistency of purpose.

Are not all these qualities found to some degree in you? Do not the boys and girls of the farm, more often than not, love the animals with which they come in contact? How can this love be turned to account as a means of education in one direction, and animal betterment in another?

Let us see! Robert Bakewell, as one engaged in caring for and improving farm animals, believed in three things:

(1) Stabling or shelter;
(2) Proper feeding and watering; and
(3) Gentle treatment.

Have you ever thought what a highly developed being the improved farm animal of to-day is? Did he not once run wild and independent? Has not the will of man greatly improved the horse, ox, cow and pig since the days when they roamed wild? Seventy-five years ago the fastest horses could hardly race a mile in three minutes. Do you know what the fastest record is to day? Where cattle run wild they produce only enough milk to raise their calves on. How much milk has the best cow you have ever heard of given in a year? In some parts of the country, where the pigs run wild and have no care, they are so thin and have such long legs that they call them "razor backs," and they can almost outrun the fastest dogs. How do the best looking pigs that you see on our farms and at our Fairs look, compared with a "razor back"?

Yes, it is true, the farm animal of to-day is an artificial one, composed of either nerves, muscle, meat or wool, and over which man has a wonderful power, if he but knew it Once shelter and care would have been an injury; now is more frequently a necessity. And so you should know the real necessity of giving farm animals the care that humanity and economy make desirable.

Would it not be well to look into the necessity of these things? Suppose we consider some phases of the lives of farm animals that we might give attention to, and thereby add to the comfort of dumb beasts, while adding to our own knowledge of life.

*Stabling or Shelter.* All animals require protection from the changes of weather or other conditions to a greater or less extent. In the severe cold of winter or the heat of summer, what do most animals naturally do? Do they seek for shelter? Is it for this reason in part that sheds or barns are erected? How do cattle look as they stand in the corn-fields or barnyard on a cold, cloudy day in January, with a strong wind blowing? On the great prairies cattle seek the protection of groves or windbreaks, where other shelter is not provided. In the cooler northern part of the country, in winter, as in Indiana, for example, the humane and wise man provides comfortable barns or warm sheds in which his stock may be housed.

Is this important? Let us see.

Some years ago the writer conducted an experiment at the Indiana Experiment Station at Purdue, to see if shelter was desirable for animals in winter. Six cows were used. Three of these were given shelter from all kinds of disagreeable weather, while three were kept out, exposed to all sorts of conditions during the day, the only shelter provided being a small shed open on two sides. This experiment showed several things. First, that the exposed cows produced less milk each day than the sheltered. Second, the exposed cows lost in weight, while those given shelter gained Third, the exposed cows ate more food than the sheltered ones. Fourth, from the financial side, the sheltered cows showed nearly $13 00 more to their credit than did the exposed ones.

The animal body is something like the boiler of an engine. The food is the fuel which creates the energy to make the body go. If this body is exposed to severe cold, then more food or fuel is necessary to keep the system up, and so the cost for food is increased.

Another thing should never be lost sight of, and that is that it is cruel to expose animals to intense cold without for hours at a time. Even in summer, when there is no breeze and the heat is excessive, all kinds of farm stock will suffer if they can not secure shelter of some kind from the sun's rays.

Suppose that we make some observations on the subject of shelter. Turn one of the horses or cows out of doors in cold winter weather, and note how it affects the appearance and the appetite. When it is stormy in winter, if possible compare the condition of wool and skin of a flock of sheep out of doors with those kept in shelter. Ask the man who buys and sells wool what kind of a fleece is most valuable, the one from sheep running in the rain and snow or the one kept in the dry shed? In summer place some pigs in a field exposed to the sun, where they can get no shelter, and compare their appearance and comfort with those lying in the shade. In warm weather, when flies are biting badly, begin to weigh the milk of four cows morning and night. Now turn two of these into the pasture and keep two in a darkened stable, and see what is the influence on the milk yield and comfort of the different animals.

*Food and Feeding.* All true lovers of animals enjoy watching them eat. In the great zoölogical gardens crowds assemble to see the lions eat and to feed the monkeys peanuts and candy. There is a sense of pleasure in watching our farm animals with hearty appetite eating their grain in the manger. The most successful feeders study the appetites of their stock, and enjoy giving changes of diet and noting the relish shown by the animal in eating of it.

Of the foods fed, horses prefer oats or corn. Cattle and sheep relish both of these, as well as bran and oil meal, while pigs enjoy corn or shorts or middlings best. In fact a large share of the pigs grown in the United States are fed on corn or its products.

All classes of stock, however, enjoy and need herbage in some form, either dry or green. Horses are usually fed timothy hay, and cattle clover and corn fodder, green or dry while sheep need clover or some kind of fine grass, as, for example, Kentucky blue grass. This last is the best pasture grass we have, though for pigs nothing is better than green clover.

Now, that we know what foods are used, how shall the animals be fed? Shall they be fed at any regular hours? Is there a good and a bad way to feed? Suppose we say, that the best way to feed horses is to give them water first, then some grain, and last, hay. Is that right? Is that the way you do at home? I think horses should be watered before eating. That is, so they will not wash their food down before they have ground it up well in the stomach. But suppose you ask a few men you know, who have horses, when they give them water, and report on this subject.

Cattle are usually fed their grain first, and then the hay, or coarse fodder, or pasture. Horses and cattle must be fed morning, noon and night, although grain is not usually fed cattle at noon. Much, however, depends upon circumstances, for horses that are hard worked, or cattle that are being fattened, or heavily milked, require more nutriment than do others. Sheep and pigs should be fed at morning and night, but if being fattened, it is best to feed them three times a day.

It is important that all kinds of stock be fed only such an amount as will be entirely eaten, and with a relish, especially the grain. With some coarse hays or clover there always is necessarily some woody material left uneaten.

Here is a good chance to make some observations. What do the live stock you are acquainted with eat? How much is fed them of this or that? At what hours of day are they fed? Do you know how fast they grow? There are sheep and pigs on many farms, where simple feeding experiments might be conducted. Let us take two lambs about the same size, and feed one corn meal and the other ground oats, and see which will grow the best. We should have scales, and the lambs should be weighed occasionally, say once a week, and an accurate record kept of the growth, as well as of the amount of food eaten each week. Then, in a few weeks, it will be interesting to report on the gain in weight, how many pounds of grain were eaten, its value, and which cost the most. Will it not be easy to feed the calves the skim milk for a few weeks, weighing or measuring what they drink of it, and then report on the amount of such food a calf needs each day to grow well? Can you not show how much each 100 pounds of skim milk is worth, when fed to calves or pigs? Feed them the milk, weighing what you give daily, and keeping a record of the weights of the pigs or calves. How much grain do some cows eat daily, that make large amounts of milk? Will such a cow give less milk if she is fed less grain?

*Watering.* Few people realize how important it is that farm animals should be watered properly. In winter they suffer most, from having to drink from icy pools or troughs, so that if they get enough to satisfy thirst they are frequently chilled all through. With cold air all about the exterior of the body, and ice-water within, the temperature of the body is reduced, and then more food (fuel) is required in the furnace to warm up the body to the necessary point again.

Do you think animals prefer warmed water in winter? Mr. Gurler, in his book "American Dairying," tells of a case where some young heifers jumped into a water trough to get where the water was coming warm from a pipe. He says his cows when given water slightly warmed keep in better condition and give more milk. I have seen cows go to a stream of water flowing along icy shores, and drink, and then stand humped up and shivering as though suffering from ague. They were chilled through.

A cow will easily drink fifty pounds a day of water at a temperature of 60 degrees, but if at 35 degrees, she will not drink all she needs, and will turn away chilled, yet thirsty. Do you know how a cow looks containing fifty pounds of ice-water.

Teach the necessity of giving the farm stock water that is pure and clean, and which in winter has the chill removed from it. Filthy water usually carries disease germs, and may cause serious sickness. Thousands, yes millions, of pigs have died from disease through drinking water that was contaminated with cholera germs. The sheep and pig need as pure water to drink as the horse or cow, and they require plenty of it at all times.

Would you not be interested to learn something about this important subject? How much will our farm animals drink at a time? A bucket of water on the scales may be weighed before and after drinking. Will more warm water be drunk than cold? Place a pail of very cold and one of very slightly warm water before the horse on a cold winter day and see which he will drink first. How much water does a sheep drink at a time? How much water will a horse drink in a week? Will a horse that is working hard drink more than one standing in the stable?

How much more water will a large horse drink than a small one? Do you know of any men who have heaters in their water troughs in winter, so that their stock may have warm water? If so, ask them how they like these heaters.

*Gentleness* is a most important thing to observe when among animals, if one desires to secure the best results in handling them. The man who has the pigs under his feet whenever he goes into the lot where they are, by his quietness and gentleness has taught them that he is their friend. Such a person usually knows how to feed profitably and raise stock successfully. The man who sits by the nervous cow and quietly soothes her with a gentle voice while milking, instead of using harsh measures, secures more milk and enjoys the company of the beast more than would the man who would "teach her a lesson." No dumb animal was ever improved in disposition, or made more profitable to the owner, by the adoption of brutal or unnecessarily severe measures. The most successful feeders of stock are invariably gentle in handling their animals. The man who succeeds in getting the greatest speed out of a horse on the race-track is the one who rules by love, not fear.

No. 5.

# LEAFLET

## ON NATURE STUDY.

DESIGNED FOR THE USE OF TEACHERS OF PUBLIC SCHOOLS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## A CHILDREN'S GARDEN.

BY L. H. BAILEY,
Professor of Horticulture in Cornell University.

[Reprinted from a Cornell Leaflet by permission.]

We want every school child in the State to grow a few plants this summer. We want everyone of them to learn something of why and how plants grow, and the best and surest way to learn is to grow the plants and to watch them carefully. We want everyone to become interested in everything that lives and grows. It does not matter so very much just what kinds of plants one grows, as it does that he grows something and grows it the best that he knows how. We want the children to grow these plants for the love of it,—that is, for the fun of it,—and so we propose that they grow flowers; for when one grows pumpkins and potatoes, and such things, he is usually thinking of how much money he is going to make at the end of the season. Yet, we should like some rivalry in the matter in every school, and we therefore propose that a kind of fair be held at the school house next September, soon after school begins, so that each child may show the flowers which he has grown. What a jolly time that will be!

Now, we must not try to grow too many things or to do too much. Therefore, we propose that you grow sweet peas and China asters. They are both easy to grow, and the seeds are cheap. Each one has many colors, and everybody likes them. Now let us tell you just how we would grow them.

1. *The place.*—Never put them—or any other flowers—in the middle of the lawn,—that is, not out in the center of the yard. They do not look well there, and the grass roots run under them and steal the food and moisture. I am sure that you would not like to see a picture hung

up on a fence-post. It has no background, and it looks out of place. The picture does not mean anything when hung in such a spot. In the same way, a flower bed does not mean anything when set out in the center of a lawn. We must have a background for it, if possible,—a wall upon which to hang it. So we will put the flower bed just in front of some bushes or near the back fence, or alongside the smoke-house, or along the walk at the side of the house or in the back yard. The flowers will not only look better in such places, but it will not matter so much if we make a failure of our flower bed; there are always risks to run, for the old hen may scratch up the seeds, the cow may break into the yard some summer night, or some bug may eat the plants up.

Perhaps some of the children may live so near to the school house that they can grow their plants upon the school grounds, and so have sweet peas and asters where there are usually docks and smartweeds. Grow them alongside the fence, or against the school house if there is a place where the eaves will not drip on them.

2. *How to make the bed.*—Spade the ground up deep. Take out all the roots of docks and thistles and other weeds. Shake the dirt all out of the sods and throw the grass away. You may need a little manure in the soil, especially if the land is either very hard or very loose and sandy. But the manure must be very fine and well mixed into the soil. It is easy, however, to make sweet pea soil so rich that the plants will run to vine and not bloom well.

Make the bed long and narrow, but not narrower than three feet. If it is narrower than this, the grass roots will be apt to run under it and suck up the moisture. If the bed can be got at on both sides, it may be as wide as five feet.

Sow the seeds in little rows crosswise the bed. The plants can then be weeded and hoed easily from either side. If the rows are marked by little sticks, or if a strong mark is left in the earth, you can break the crust between the rows (with a rake) before the plants are up. The rows ought to be four or five inches further apart than the width of a narrow rake.

3. *How to water the plants.*—I wonder if you have a watering-pot? If you have, put it where you cannot find it, for we are going to water this garden with a rake! We want you to learn, in this little garden, the first great lesson in farming,—how to save the water in the soil. If you learn that much this summer, you will know more than many old farmers do. You know that the soil is moist in the spring when you plant the seeds. Where does this moisture go to? It dries up,—goes off into the air. If we could cover up the soil with something, we

should prevent the moisture from drying up. Let us cover it with a layer of loose, dry earth! We will make this covering by raking the bed every few days,—once every week anyway, and oftener than that if the top of the soil becomes hard and crusty, as it does after a rain. Instead of pouring water on the bed, therefore, we will keep the moisture in the bed.

If, however, the soil becomes so dry in spite of you that the plants do not thrive, then water the bed. Do not *sprinkle* it, but *water* it. Wet it clear through at evening. Then in the morning, when the surface begins to get dry, begin the raking again to keep the water from getting away. Sprinkling the plants every day or two is one of the surest ways to spoil them.

4. *When and how to sow.*—The sweet peas should be put in just as soon as the ground can be dug, even before frosts are passed. Yet, good results can be had if the seeds are put in as late as the 10th of May. In the sweet pea garden at Cornell last year, we sowed the seeds on the 20th of April. This was about right. The year before, we sowed them on the 30th. If sown very early, they are likely to bloom better, but they may be gone before the middle of September. The blooming can be much prolonged if the flowers are cut as soon as they begin to fade.

Plant sweet peas deep,—two to three or sometimes even four inches. When the plants are a few inches high, pull out a part of them so that they will not stand nearer together than six inches in the row. It is a good plan to sow sweet peas in double rows,—that is, put two rows only five or six inches apart,—and stick the brush or place the chicken-wire support between them.

China asters may be sown from the middle of May to the first of June. In one large test at Cornell, we sowed them the 4th of June, and had good success, but this is rather later than we would advise. The China asters are autumn flowers, and they should be in their prime in September and early October.

Sow the aster seed shallow,—not more than a half inch deep. The tall kinds of asters should have at least a foot between the plants in the row, and the dwarf kinds six to eight inches.

Sometimes China asters have rusty or yellow spots on the undersides of their leaves. This is a fungous disease. If it appears, have your father make some ammoniacal carbonate of copper solution and then spray them with it; or Bordeaux mixture will do just as well or better, only that it discolors the leaves and flowers.

5. *What varieties to choose.*—In the first place, do not plant too much. A garden which looks very small when the pussy willows come

out and the frogs begin to peep, is pretty big in the hot days of July. A garden four feet wide and twenty feet long, half sweet peas and half asters, is about as big as most boys and girls will take care of.

In the next place, do not get too many varieties. Four or five kinds each of peas and asters will be enough. Buy the named varieties,—that is, those of known colors,—not the mixed packets. If you are very fond of reds, then choose the reddest kinds; but it is well to put in at least three colors. The varieties which please you may not please me or your neighbor, so that I cannot advise you what to get, but I will give you some lists which may help you.

Amongst all the sweet peas grown at Cornell last year, the following seemed to be best on our grounds:

| | |
|---|---|
| Dark purple. | *Waverly.* |
| | *Duke of Clarence.* |
| Striped purple. | *Gray Friar.* |
| | *Juanita.* |
| | *Senator.* |
| Lavender. | *Countess of Radnor.* |
| | *Dorothy Tennant* |
| | *Lottie Eckford.* |
| White. | *The Bride.* |
| | *Emily Henderson.* |
| | *Queen of England, Alba Magnifica.* |
| Primrose. | *Mrs. Eckford.* |
| White flushed with pink. | *Blushing Beauty* |
| | *Katherine Tracy.* |
| | *Eliza Eckford.* |
| Striped or flaked pink. | *Ramona.* |
| | *Mrs. Joseph Chamberlain.* |
| Orange-pink. | *Lady Penzance.* |
| | *Meteor.* |
| Rose-pink. | *Her Majesty.* |
| | *Splendor.* |
| | *Apple Blossom.* |
| | *Boreatton.* |
| Rose pink shaded with orange. | *Firefly.* |
| | *Princess Victoria.* |

At another place or in another season, these varieties might not have given us the most satisfaction; but these names suggest some of the colors, if one does not happen to have a seedsman's catalogue handy.

Of China asters, the Comet type—in various colors—will probably give the most satisfaction. They are mostly large-growing kinds. Other excellent kinds are the Perfection and Peony-flowered, Semple or Branching, Chrysanthemum-flowered, Washington, Victoria, and, for early, Queen of the Market. Odd varieties are Crown, German Quilled, Victoria Needle and Lilliput. Very dwarf kinds are Dwarf Bouquet or Dwarf German, and Shakespeare.

FOR THE USE OF TEACHERS.

No. 6.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## A CHAT ABOUT BUGS.

BY PROF. STANLEY COULTER.

I believe in using pencil and paper, so I want you to have them near you while you are reading this leaflet. The first thing I want you to do is to make a list of all the animals that you know live about your home. I do not mean domestic animals, such as sheep and pigs and dogs, but wild animals, such as squirrels and rabbits. Write the names in a column on the left side of the page. Now opposite each name tell where the animal lives, whether in trees or caves or under ground, and also tell what kind of food it eats.

After you have done this make a similar list of the birds that live about your home.

Now try to make a list of the bugs or insects that you know live about your home, being sure to tell where they live and what kind of food they eat. You cannot tell so much about them as about the animals and birds, can you? Of course, every boy and girl is interested in animals and birds, they love to watch them and are constantly trying to find out more about them, but I find very few boys and girls or even grown-up people who are interested in what they call "bugs." Now, I do not think "bugs" a very nice name, but we can afford to let that pass because we know just what kind of animal we mean when we use the term. I was talking the other day about insects to some people, and when I got through one of them said: "I never knew there was anything interesting about bugs before." It was just because of that remark that I am writing this leaflet. Have you any idea how many different kinds of insects there are in the world? Well, there are hundreds of thousands. There are at least four times as many different kinds of animals of this kind as of all the other kinds put together. Have you studied arithmetic yet? If you have you will understand what I mean when I say that four-fifths of all the kinds of animal life by number belong in the family in which the bugs are found. So you see that they ought to interest us because they are so numerous. Did you ever hear of insects darkening the sun? They do sometimes, for they fly in such great swarms that they hide the sun just as it would be hidden by a heavy cloud. Do you think they could ever stop one of the great trains that you see rushing past on the railroad? They have done it, just because of their countless numbers. In Indiana we do not often see such vast numbers at a single time, but don't you remember sometimes how you have driven through clouds of gnats, or how in the evening the fireflies have made the meadow gleam like the lights of a distant city? If you watch this summer you will be surprised to find how many times you will see great swarms of bugs. Sometimes it will be in the morning, sometimes in the middle of the day, sometimes in the evening. When you see them, if you have time, watch them and see if you can find out what becomes of them.

Of this vast number of bugs or insects some are very helpful to man, while others give him a great deal of trouble and often cause him to lose his crops or harvested grain. Some of these insects help man, because if it were not for their love of honey many plants would not set seed, and that would mean that, after a while, that plant would entirely disappear. If all of the bumblebees in the world should be killed the red clover would also be destroyed, for red clover can only set seed when visited by bumblebees. Others of these bugs help man because they eat the harmful ones, or destroy their eggs or young, while others, such as the honey bee, furnish him with food.

A good deal of the harm done by insects is to growing crops. They attack it at all times. Sometimes just as the seed has burst open and is sending out its tender stem and roots, sometimes they wait until the leaves unfold and eat them, and sometimes they leave the plant untouched until the fruit is ripening and eat that. After the farmer puts his grain in the granary it is not safe, for some of the bugs known as weevils may find it and eat it, just as if it had been put carefully away for them. Try to find out how many kinds of bugs eat the tender, young seedlings. How many kinds eat the leaves? How many kinds eat the grain or fruit? Watch the growing corn and cabbages and potatoes and tomatoes, and do not forget the currant bushes and grapes and fruit trees. Sometimes you will have to look closely, for these dangerous insects are often so colored and marked as to almost exactly imitate the part of the plant upon which they feed.

Then insects injure man because of their attacks upon domestic animals. Did you think a fly could keep cattle out of a country? There are some regions, especially in South Africa, where there is splendid grass and plenty of water, but no cattle. The reason is that in those regions there lives a fly known as the tsetze fly, which actually worries the cattle to death. I cannot stop to tell you about the way in which this is done, but perhaps if your father will tell you something about the bot fly and the way it troubles cattle you can work it out for yourself. Then others of these insects are hurtful because they destroy those that help us. Do you know any one that keeps bees? If you do, ask him to tell you about the bee-moth and other insects that spoil the hives.

You see from what I have said that our bugs are of two kinds, those that eat vegetable food and those that eat animal food. Try how many different kinds of insects you can find that eat plant food and how many that eat animal food. I suppose none of you think you would be afraid of a flesh-eating insect. It might do to be afraid of a bear or a lion, but no one would be afraid of an insect. Yet in some places these fierce, flesh-eating insects at times gather in great numbers and march in unbroken lines across the country in their search for new homes. Nothing can stop their march but fire or flood, and if a man should attempt to force his way through such an army he would be killed and eaten in a very short time.

Even the plant-eating insects do their work of destruction very rapidly. I have seen a forty-acre field of wheat entirely eaten in less than two hours. Some time when you have found out all you can about bugs with your eyes, I hope you will get a magnifying glass, and then you can see the curious mouth-parts of these dangerous insects. Some are like scissors and some like chisels and all are very strong and powerful.

When the bugs, which you have thought so uninteresting, have so much to do with the success or failure of the year's work, don't you think it would be wise to find out all you can about them? I am sure

I do, for I believe that if your fathers and mothers had known as much about bugs as you may, if you keep your eyes open, they would be very much richer than they are to-day.

A million dollars seems like a great deal of money, does it not? A great many splendid things could be done with that amount. But did you know that the farmers of Indiana lose more than a million of dollars every year because of insects? It is because I want you to try to save this vast sum of money that I am trying to interest you in what are known as bugs. I believe I have said enough to show that bugs are worth studying.

But did you ever think how wise some insects were? I know of some that build great domes as perfect as our best engineers can devise. When we think of the size of the insect, they are vastly larger than anything man has ever undertaken. Man has wood and iron and steel to help him, but these insects have only the earth, and yet their wonderful arches and domes stand strong and true. Sometimes these domes are 60 feet around and 25 feet high and are led into by a series of vaulted halls and passages that cover rods in every direction. Then some insects are too proud to work, and so have slaves, who do all their work; in some cases they compel the slaves to chew the food for them and place the prepared morsel in their mouth. To capture these slaves they march out in companies and regiments and brigades, under the command of officers, and wage a genuine war. They talk to each other by means of their "feelers" or antennae, as wise men call them, and send messages from one part of the army to another or back to the home nest. I could tell you many more wonderful things that they do. Do you want to know what strange kind of insects know so much? Well, they are the ants. If you can find an ant nest this summer far enough away from the house not to be a nuisance, do not destroy it, but watch it from day to day, an hour or two hours at a time, and you will come to the conclusion that I have, that an ant has more sense than the elephant, big as it is, and that it knows more than even the dog or horse. It is strange, is it not, that you and I have not been more interested in animals that did such wonderful things? There are other insects beside the ant that are very intelligent, but I cannot stop to tell about them here.

I was talking a little while ago about plant-eating and flesh-eating insects, but what would you think of insects that eat the hardest wood, or that thrive on carpets and furs? Of others that prefer stone, and others that will chew up iron? Yet there are insects that destroy stone pillars, eating their way straight into the hard mass, and there are those that eat into the hardest wood, making holes as true and smooth as you can make with a carpenter's gimlet. I believe you will want that magnifying glass pretty soon to examine those wonderful mouth parts.

Then some of these bugs can sew, making seams so perfect and drawing torn or cut edges together so carefully that you will need the magnifying glass again to find where they have been at work. Sometimes instead of simply mending, they cut patterns out of leaves with their scissor-like jaws and sew the pieces together to make the desired article. There are others that spin, some coarse, rough threads, but others the finest silk. Indeed, if I were to try to tell you of all the wonderful things bugs could do I would have to write a book instead of a leaflet. Squirrels and rabbits cannot do such things, nor can birds. So I think if you watch closely you will find in your study of bugs not only many useful things, but many very wonderful things.

But I believe the most wonderful thing is yet to be told. If you see a young lamb you know it is a lamb, and when it grows it only gets bigger, and though we call it a sheep, it has still the same shape and eats the same kind of food. A young pig is just like an old one, only smaller. But with our bugs this is not so. Most of them have three different forms, in each of which they spend part of their life. These forms look very unlike, they have very different habits and sometimes eat different food. Some time in the summer you may be fortunate enough to find some eggs which have been laid by a butterfly upon a leaf. If you mark the spot and watch carefully by and by you will see the eggs break open, and there will come out, not little butterflies, but ugly, worm-like looking things, with any number of legs and strong, big jaws, with which they immediately begin to devour the leaf upon which they were born. We call these caterpillars. Scientific men call them larvae. You can always tell a caterpillar from a worm, because a worm has no visible legs and no well-developed mouth parts. Now, remember that every caterpillar you see is only a "bug" in one stage of its life. Watch these caterpillars. Find a tomato "worm" and watch it from day to day. Does it eat much? Does it grow rapidly? Go to the currant bushes and watch the caterpillars there. Examine the tent caterpillars that grow in cherry and elm trees. Do they eat much? Do they grow rapidly? I believe you will come to the conclusion that about all a caterpillar has to do is to eat. Indeed, many insects are only destructive in the caterpillar stage. Do you know if the farmers in Indiana knew this and would destroy caterpillars, or better still, the eggs, they would save thousands of dollars each year? Did you ever hear of a "cut worm?" Go out into a cornfield where they are at work. You can tell because the young corn is cut off just below the ground as cleanly as if with a knife. Dig up one of the cut worms. Is it a worm at all?

But by and by, if you watch the caterpillar, it moves about less and eats less, and builds over itself a strange-looking outer covering. This outer covering varies in color with the material of which it is made. Sometimes it is earth, sometimes leaves, sometimes silk spun by the caterpillar. In this tightly fitting house the caterpillar lies, perfectly quiet, sometimes for a month, sometimes for two or three months and sometimes even for years. This is another stage of insect life, which is called the *pupa* stage.

At last movements show themselves within the case, it splits open along the side, and there comes out the butterfly. It looks nothing like the caterpillar and nothing like the pupa. It does not have to grow, for it is as large the moment it is born as when it dies. Did you ever watch these changes from the egg, through the various stages, to the perfect insect? It can be easily done. You can try it with the currant caterpillar or the tomato caterpillar, and if you feed them well in the caterpillar stage you will have little difficulty in the work.

But I only wanted to show you how much of interest there was in bugs, and more than that, how important it was that we should know more about them, and not to tell you in detail how to study them.

After you have studied bugs a little while and know more about their structure you will find that lobsters and crawfish and spiders belong in the same family, unlike as they seem to be to the butterflies and bees and grasshoppers. You will find that there are bugs that live in the water and others that live in the air; that some live underground and some upon other animals. Indeed, you will find that every possible place where animal life can exist contains members of this great family, and you will no longer wonder that their number is so vast.

No. 7.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## THE OBSERVATION CLUB, No. 1.

You will remember that in our talk last Friday I told you that we should try to-day to form a sort of observation club composed of those of us who think we would be interested in taking excursions about the country in order to find out all we can about the things which we see and hear every day, but about which, as I am sure you have already discovered, most of us know very little because we have not learned to use our eyes and ears as we should. I think from the talks we have already had you have begun to realize what a wonderful world this is; how full of beauty; and how many instructive lessons it has for us if we are but ready and willing to learn them.

I hope you have been thinking and talking over what was told you last week and are ready now to organize some such club and to elect your officers. It seems to me we ought to have a president who will look after the business of the club and preside at its meetings; also a secretary to keep our records, take care of our money, if we ever have any, and of our museum, if we are able to collect one.

I do not think we shall need any written constitution unless we should grow into a society of naturalists, as I hope we may when we have had more experience.

Since I have promised to direct your field expeditions and to give you what field lectures I can, you may call me, if you please, the director of the club.

**NOTE.—The children should then, in proper order, nominate and elect such officers as in the judgment of the teacher are desirable, with or without written rules for the government of the club.**

**Among the names which may be selected for the club the following are suggested: The Ramblers, The Naturalists, The Zig Zag Club.**

Now, in order to interest you still more in the work which this club is going to try to do, I want to tell you something about a famous man who started, and for a long time conducted, one of these observation clubs in England. This man, the Rev. Chas. Kingsley, was a great preacher—for a time in the Cathedral at Chester and afterwards in that beautiful Westminster Abbey, of which you have probably heard—He was a great lover of books, too, but a still greater lover of nature. In an address which he once made to the boys in Wellington he said a good many wise things, a few of which I will read to you. I want you to listen very carefully, for he tells you some things which will be useful to you as members of an observation club.

"The first thing for a boy to learn, after obedience and morality, is a habit of observation—a habit of using his eyes. They say knowledge is power, and so it is, but only the knowledge which you get by observation.

"The art of learning consists, first and foremost, in the art of observing.

"Everything which helps a boy's powers of observation, helps his power of learning; and I know from experience that nothing helps so much as the study of the world about you, and especially of natural history. To be accustomed to watch for curious objects, to know in a moment when you have come to anything new—which is observation. To be quick at seeing when things are like, and when unlike—which is classification. All that must, and I well know does, help to make a boy shrewd, earnest, accurate, ready for whatever may happen."

While Mr. Kingsley was Canon of Chester he thought he might do good to the working people by interesting them in nature study. So he occasionally gave them evening lectures. I want to read you now a part of his lecture on coal, from which you will see that he had very keen eyes, and, too, that he used very beautiful language.

In the course of his lecture he lifted a lump of coal from the table, and holding it up before his listeners, said:

"A diamond, nothing less. We may consider the coal upon the fire as a middle term of a series of which the first is the live wood, and the last a diamond; and indulge safely in the fancy that every diamond in the world has probably, at some remote epoch, formed part of a growing plant. A strange transformation, which will look to us more strange, more poetical, the more we look at it. The coal on the fire, the table at which I stand, what are they made of? Gas and sunbeams, with a small percentage of ash, or earthy salts, which need hardly be taken into account.

"'Gas and sunbeams.' Strange, but true. The life of the growing plant—and what that life is, who can tell?—laid hold of the gases in the air and in the soil, of the carbonic acid, the atmospheric air, the water, for that too is gas. It drank them in through its rootlets; it breathed them in through its leaf pores, that it might distil them into sap, and bud, and leaf, and wood. But it had to take in another element, without which the distillation and the shaping could never have taken place. It had to drink in the sunbeams, and absorbed them, buried them in itself—no longer as light and heat, but as invisible chemical force, locked up for ages in that woody fibre.

"So it is! Lord Lytton told us in a beautiful song, how 'the wind and the beam loved the rose.' But nature's poetry is more beautiful than man's. The wind and the beam love the rose—or rather the rose takes the wind and the beam, and builds up out of them, by her own inner life, her exquisite texture, hue, and fragrance. What next? The rose dies; the timber tree dies—decays down into vegetable fibre, is buried, and turned to coal; but the plant can not altogether undo its own work. Even in death and decay, it cannot set free the sunbeams imprisoned in its tissue. The sun force must stay, shut up age after age, invisible but strong; working at its own prison cells, transmuting them, or making them capable of being transmuted by man, into the manifold products of coal, coke, petroleum, mineral pitch, gases, coal tar, benzole, delicate aniline dyes, and what not, till its day of deliverance comes. Man digs it, throws it on the fire, a black, dead-seeming lump. A corner, an atom of it, warms till it reaches the igniting point; the temperature at which it is able to combine with oxygen. And then, like a dormant live thing, awaking after ages to the sense of its own powers, its own needs, the whole lump is seized, atom after atom, with an infectious hunger for that oxygen which it lost centuries since in the bottom of the earth. It drinks the oxygen in at every pore; and burns. And so the spell of ages is broken. The sun-force bursts its prison cells, and blazes with the free atmosphere as light and heat once more, returning in a moment into the same forms in which it entered the growing leaf a thousand centuries since. Strange it all is—yet true. But of nature, as of the heart of man, the old saying stands—that truth is stranger than fiction."

**NOTE.—If the children are too young to understand the language of this quotation, it should be omitted. The teacher might, however, translate it into simpler language and make it serve as an interesting object lesson. Should he do this and wish for further information on the subject it may be found in "The Fairy Land of Science," by Arabella Buckley, one of the books in the list adopted by the Indiana Reading Circle Board.**

But while Mr. Kingsley felt that he was helping the people by means of these lectures, he soon decided that he could do far more for them by establishing something in the way of an observation club, and so he offered to conduct excursions into the country and to give field lectures. He thought that perhaps there might be ten or fifteen people who would be willing to follow where he, with his botany box on his back and his geological hammer in his hand, would lead, but he often had a hundred or more.

This was the beginning of the famous Chester Scientific Society, one of the strongest societies of its kind in England, which now has nearly six hundred members, and enrolls as honorary members such men as Huxley, Tyndall, Lyell and other famous scientists.

In the lecture at Wellington, which I have already mentioned, Mr. Kingsley spoke of a very interesting story, which had, as he said, a great influence on his life. He said: "When we were little and good, a long time ago, we used to have a jolly old book called 'Evenings at Home,' in which was a great story called 'Eyes and No Eyes,' and that story was of more use to me than any dozen other stories I ever read. And when I read that story, I said to myself, I *will* be Mr. Eyes; I will *not* be Mr. No Eyes, and Mr. Eyes I have tried to be ever since; and Mr. Eyes I advise every one of you to be, if you wish to be happy and successful."

I will, if you like, read you the story to which Mr. Kingsley alluded. Although the scene is laid in England and the story speaks of some things which are not to be seen in this country, I think you can get from it some valuable lessons as to the use of your eyes and ears.

## EYES, AND NO EYES;

### OR, THE ART OF SEEING.

By Dr. Aikin and Mrs. Barbauld.

"Well, Robert, whither have you been walking this afternoon?" said Mr. Andrews to one of his pupils at the close of a holiday.

R.—I have been, sir, to Broom-heath, and so around by the windmill upon Camp-mount, and home, through the meadows, by the river side.

Mr. A.—Well, that's a pleasant round.

R.—I thought it very dull, sir; I scarcely met with a single person. I would rather by half have gone along the turnpike road.

Mr. A.—Why, if seeing men and horses were your object, you would, indeed, have been better entertained on the highroad. But did you see William?

R.—We set out together but he lagged behind in the lane, so I walked on and left him.

Mr. A.—That is a pity. He would have been company for you.

R.—O, he is so tedious, always stopping to look at this thing and that. I had rather walk alone. I dare say he has not got home yet.

Mr. A.—Here he comes. Well, William, where have you been?

W.—O, sir, the pleasantest walk! I went all over Broom-heath, and so up to the mill at the top of the hill, and then down among the green meadows, by the side of the river.

Mr. A.—Why, that is just the round that Robert has been taking, and he complains of its dullness, and prefers the highroad.

W.—I wonder at that. I am sure I hardly took a step that did not delight me, and I have brought home my handkerchief full of curiosities.

Mr. A.—Suppose, then, you give us some account of what amused you so much. I fancy it will be as new to Robert as to me.

W.—I will, sir. The lane leading to the heath, you know, is close and sandy; so I did not mind it much, but made the best of my way. However, I spied a curious thing enough in the hedge. It was an old crab tree, out of which grew a great bunch of something green, quite different from the tree itself. Here is a branch of it.

Mr. A.—Ah! this is mistletoe, a plant of great fame for the use made of it by the Druids of old in their religious rites and incantations. It bears a very slimy, white berry, of which birdlime may be made, whence its Latin name *Viscus*. It is one of those plants which do not grow in the ground by a root of their own, but fix themselves upon other plants; whence they have been humorously styled parasitical, as being hangers-on, or dependants. It was the mistletoe of the oak that the Druids particularly honored.

W.—A little further on, I saw a green woodpecker fly to a tree, and run up the trunk like a cat.

Mr. A.—That was to seek for insects in the bark, on which they live. They bore holes with their strong bills for that purpose, and do much damage to the trees by it.

W.—What beautiful birds they are!

Mr. A.—Yes; the woodpecker has been called, from its color and size, the English parrot.

W.—When I got upon the open heath, how charming it was! The air seemed so fresh, and the prospect on every side so free and unbounded! Then it was all covered with gay flowers, many of which I had never observed before. There were, at least, three kinds of heath

(I have got them in my handkerchief here), and gorse and broom, and bellflower and many others of all colors, that I will beg you presently to tell me the names of.

Mr. A.—That I will, readily.

W.—I saw, too, several birds that were new to me. There was a pretty grayish one, of the size of a lark, that was hopping about some great stones; and when he flew he showed a great deal of white about his tail.

Mr. A.—That was a wheat-ear. They are reckoned very delicious birds to eat, and frequent the open downs in Sussex, and some other counties in great numbers.

W.—There was a flock of lapwings upon a marshy part of the heath, that amused me much. As I came near them, some of them kept flying round and round, just over my head, and crying "*Pewet!*" so distinctly, one might almost fancy they spoke. I thought I should have caught one of them, for he flew as though one of his wings was broken, and often tumbled close to the ground; but as I came near, he always made a shift to get away.

Mr. A.—Ha! ha! You were finely taken in, then! This was all an artifice of the bird's to entice you away from its nest; for they build upon the bare ground, and their nests would easily be observed did they not draw off the attention of intruders by their loud cries and counterfeit lameness.

W.—I wish I had known that, for he led me a long chase, often over shoes in water. However, it was the cause of my falling in with an old man and a boy, who were cutting and piling up turf for fuel, and I had a good deal of talk with them about the manner of preparing the turf and the price it sells at. They gave me, too, a creature I never saw before—a young viper, which they had just killed, together with its dam. I have seen several common snakes, but this is thicker in proportion and of a darker color than they are.

Mr. A.—True. Vipers frequent those turfy, boggy grounds pretty much, and I have known several turf-cutters bitten by them.

W.—They are very venomous, are they not?

Mr. A.—Enough so to make their wounds painful and dangerous, though they seldom prove fatal.

W.—Well, I then took my course up to the windmill on the mount. I climbed up the steps of the mill in order to get a better view of the country around. What an extensive prospect! I counted fifteen church steeples; and I saw several gentlemen's houses peeping out from the midst of green woods and plantations; and I could trace the windings of the river all along the low grounds, till it was lost behind a ridge of hills. But, I'll tell you what I mean to do, sir, if you will give me leave.

Mr. A.—What is that?

W.—I will go again and take with me the county map, by which I shall probably be able to make out most of the places.

Mr. A.—You shall have it, and I will go with you, and take my pocket spying glass.

W.—I shall be very glad of that. Well—a thought struck me, that as the hill is called Camp-mount there might probably be some remains of ditches and mounds, with which I have read that camps were surrounded. And I really believe I discovered something of that sort running around one side of the mound.

Mr. A.—Very likely you might. I know antiquarians have described such remains as existing there, which some suppose to be Roman, others Danish. We will examine them further, when we go.

W.—From the hill, I went straight down to the meadows below, and walked on the side of a brook that runs into the river. It was all bordered with reeds and flags, and tall flowering plants, quite different from those I had seen on the heath. As I was getting down the bank, to reach one of them, I heard something plunge into the water near me. It was a large water rat, and I saw it swim over to the other side and go into its hole. There were a great many large dragon flies all about the stream. I caught one of the finest and have got him here in a leaf. But how I longed to catch a bird that I saw hovering over the water, and that every now and then darted down into it. It was all over a mixture of the most beautiful green and blue, with some orange color. It was somewhat less than a thrush, and had a large head and bill and a short tail.

Mr. A.—I can tell you what that bird was—a king-fisher, the celebrated halcyon of the ancients, about which so many tales are told. It lives on fish, which it catches in the manner you saw. It builds in holes in the banks, and is a shy, retired bird, never to be seen far from the stream where it inhabits.

W.—I must try to get another sight of him, for I never saw a bird that pleased me so much. Well, I followed this little brook till it entered the river, and then took the path that runs along the bank. On the opposite side I observed several little birds running along the shore, and making a piping noise. They were brown and white and about as big as a snipe.

Mr. A.—I suppose they were sand-pipers, one of the numerous family of birds that get their living by wading among the shallows, and picking up worms and insects.

W.—There were a great many swallows, too, sporting upon the surface of the water, that entertained me with their motions. Sometimes they dashed into the stream; sometimes they pursued one another so quickly, that the eye could scarcely follow them. In one place, where a high, steep sand bank rose directly above the river, I observed many of them go in and out of holes, with which the bank was bored full.

Mr. A.—Those were sand martins, the smallest of our species of swallows. They are of a mouse color above, and white beneath. They make their nests, and bring up their young in these holes, which run a great depth, and by their situation are secure from all plunderers.

W.—A little further, I saw a man in a boat, who was catching eels in an odd way. He had a long pole, with broad iron prongs at the end, just like Neptune's trident, only there were five instead of three. This he pushed straight down among the mud, in the deepest parts of the river, and fetched up the eels sticking between the prongs.

Mr. A.—I have seen this method. It is called spearing of eels.

W.—While I was looking at him, a heron came flying over my head, with his large, flapping wings. He alighted at the next turn of the river, and I crept softly behind the bank to watch his motions. He had waded into the water as far as his long legs would carry him, and was standing with his neck drawn in, looking intently on the stream. Presently he darted his long bill, as quick as lightning, into the water, and drew out a fish, which he swallowed. I saw him catch another in the same manner. He then took alarm at some noise I made, and flew away slowly to a wood at some distance, where he settled.

Mr. A.—Probably his nest was there, for herons build upon the loftiest trees they can find, and sometimes in society together, like rooks. Formerly, when these birds were valued for the amusement of hawking, many gentlemen had their *heronries*, and a few are still remaining.

W.—I think they are the largest wild birds we have.

Mr. A.—They are of great length and spread of wing, but their bodies are comparatively small.

W.—I then turned homeward, across the meadows, where I stopped awhile to look at a large flock of starlings, which kept flying about at no great distance. I could not tell at first what to make of them; for they arose altogether from the ground as thick as a swarm of bees, and formed themselves into a sort of black cloud, hovering over the field. After taking a short round they settled again, and presently arose again in the same manner. I dare say there were hundreds of them.

Mr. A.—Perhaps so; for in the fenny countries their flocks are so numerous as to break down whole acres of reeds by settling on them. This disposition of starlings to fly in close swarms was remarked even by Homer, who compares the foe, flying from one of his heroes, to a *cloud* of *stares* retiring dismayed at the approach of the hawk.

W.—After I had left the meadows, I crossed the cornfields in the way to our house, and passed close by a deep marl pit. Looking into it I saw in one of the sides a cluster of what I took to be shells; and upon going down I picked up a clod of marl, which was quite full of them; but how seashells could get there I cannot imagine.

Mr. A.—I do not wonder at your surprise, since many philosophers have been much perplexed to account for the same appearance. It is not uncommon to find great quantities of shells and relics of marine animals even in the bowels of high mountains, very remote from the sea. They are certainly proofs that the earth was once in a very different state from what it is at present; but in what manner, and how long ago these changes took place, can only be guessed at.

W.—I got to the high field next our house just as the sun was setting, and I stood looking at it till it was quite lost. What a glorious sight! The clouds were tinged purple and crimson, and yellow of all shades and hues, and the clear sky varied from blue to a fine green at the horizon. But how large the sun appears just as it sets! I think it seems twice as big as when it is overhead.

Mr. A.—It does so; and you may probably have observed the same apparent enlargement of the moon at its rising?

W.—I have; but, pray, what is the reason of this?

Mr. A.—It is an optical deception, depending upon principles which I can not well explain to you till you know more of that branch of science. But what a number of new ideas this afternoon's walk has afforded you! I do not wonder that you found it amusing; it has been very instructive, too. Did you see nothing of all these sights, Robert?

R.—I saw some of them, but I did not take particular notice of them.

Mr. A.—Why not?

R.—I don't know. I did not care about them, and I made the best of my way home.

Mr. A.—That would have been right if you had been sent with a message; but as you walked only for amusement, it would have been wiser to have sought out as many sources of it as possible. But so it is—one man walks through the world with his eyes open, and another with them shut; and upon this difference depends all the superiority of knowledge the one acquires above the other. I have known sailors, who have been in all quarters of the world, and could tell you nothing. * * * On the other hand, a Franklin could not cross the Channel without making some observations useful to mankind. While many a vacant, thoughtless youth is whirled throughout Europe without gaining a single idea worth crossing a street for, the observing eye and inquiring mind find matter of improvement and delight in every ramble in town or country. Do you, then, William, continue to make use of your eyes; and you, Robert, learn that eyes were given you to use."

I hope that as Mr. Kingsley says, you will try to be Mr. Eyes all of you, especially during the coming week, and that you will try to find out all that you can about the birds that you see day by day. Next Saturday we will take our first field excursion and the subject of our study will be "Our Spring Birds."

FOR THE USE OF TEACHERS.

No. 8.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## SPRING BIRDS.

BY MRS. JEANETTE D. RUBY.

I wonder why every boy that can borrow a gun goes out into the woods, and tries to kill birds. I sometimes think it is because boys, and even grown people for that matter, know so little about birds. When we become acquainted with our native birds and learn their habits and know what they eat, we find that nearly all of them are helpful to us, and that only a very few are ever harmful to us. Suppose you write down upon one slip of paper the ways in which birds help us, and on another the ways in which they harm us. Which list is the longer? Perhaps when you first think about it the second will be the longer; but keep the lists, and during the summer keep your eyes open and note down every good thing and every bad thing you see birds do. When the season is over, I believe you will care for the birds not merely because they are so beautiful, but also because they are so helpful. You think the owls are altogether bad, perhaps, but try to find out what they feed upon and see if it is true. Of course they may eat a chicken occasionally, but you know that the owls in your neighborhood do not eat enough chickens to keep them alive. You guard your chickens too carefully for that. What do you think they eat when they cannot get chicken? When you find out let me know whether you think that even the owls are altogether bad. You can watch the screech owl more easily than any other perhaps, because it is so very common and does not seem to be so much afraid of man as some of its relations.

But I am not going to talk about the good or the harm that birds do just now, that may come later, but I wanted to show you why I think you ought to study the birds about your home, and how I think you ought to study them. To-day, as it is late in March, let us go out into the woods and see how many different kinds of birds we can find and try to learn something about each of them. Of course we cannot learn all about them in a single trip like this, but we can begin, and then by watching them from day to day we can have them answer all the questions that we choose to ask.

Listen! That is the first note of our earliest arrival, the *blue-bird.* He has been called the "Darling of Spring," and that soft, pleasing warble can come from no other throat. Notice his different tones. What do they mean? Can you hear him warble half angrily, then coaxingly, then cheerily and confidently, and the next moment sadly and plaintively? You must learn these different notes, for they each have a meaning which you can find if you are in earnest in trying to learn all you can of bird life.

There he is, no one can mistake the blue-bird. I wonder if we will see his mate, for sometimes he comes a week in advance of her. Yes, there she is also, but not quite so gaily dressed. Why do you suppose her feathers are not so bright a blue as her mate's? Notice this summer how many different kinds of birds you can find in which the colors of the female are not so bright as those of the male. Suppose you do not ask anyone to tell you the reason, but see if you can work it out yourself. There must be some good reason for it, for everything in nature has its reason.

But there they fly to that knot-hole in yonder apple tree. Why do you suppose they are examining it so intently? Place a box in your garden and see whether they will choose that, or a hole in a rotten stump or tree for their home. But while they are so busy let us see if we can how they are dressed. Perhaps as the male bird is the more showy of the two we had better watch him. His coat is blue, no mistake about that, and some one has called it the azure blue of the spring sky. What is the color of his throat and breast? What is the color of his under parts? Are his eyes large or small? What is the color of his legs and beak? How long is he? Don't you see you will have to carry a note book with you so you can put down all you are learning?

I hope he will not meet with the sad fate of a blue-bird I found last August, who had been indulging in his favorite pastime of peeping in holes and crevices, and by some unlucky move got his leg entangled in a horse-hair which had been woven into a nest. His efforts to free himself were hopeless and there he perished. His form dried and embalmed by the summer's heat was yet hanging in September, the outspread wings and plumage nearly as brilliant as in life. Did you ever see any in winter? Note the time they first appear. Who has seen them feed their young? Let me tell you what I have seen.

Last summer, I saw a mother-bird capture a harvest-fly, and after bruising it awhile on the ground, she flew with it to a tree, and gave it to the young bird. It was a large morsel, and baby made a brave effort to swallow it, but did not succeed, so that mother took the fly again to the side-walk, and proceeded to bruise and break it more thoroughly. Then she again placed it in her baby's beak with an air which seemed to say, "There; try it now." He swallowed and choked, but the great fly was still too big for his tiny beak. The young bird fluttered and fluttered and moaned, "I'm stuck, I'm stuck;" and the anxious parent again seized the morsel, carried it to an iron railing, and came down on it with all the force of her beak, with never-tiring perseverance. She offered it to her young a third time, with the same result, except that this time he dropped it, and she was on the ground as soon as the fly, and taking it in her beak flew to a high board fence. Just then the father blue-bird appeared, and said very plainly and curtly, "Give me that bug." But she would not do it, and flew away, and I never found out whether baby blue-bird got any portion of the fly dainty.

Watch carefully this summer and see if you can find a blue-bird feeding its young. What kind of food do the young blue-birds eat? Do they never eat other kinds?

Let us go on through this old orchard. Just over that fence yonder we will strike the old wood-road. See the ferns in their first dress of tender green, wearing their droll little hoods; but we must not stop for them to-day, for our March visitors have come and are calling for us. There is the note I have been listening for. Did you ever hear a more charming song? How would you describe it? "One high note, three times repeated, and then a trill like a canary." This is a song we will hear frequently for, the *song-sparrow* never wearies of singing. There; James is beckoning us eagerly. I suspect he has found the nest in that clump of bushes, or under that pavement of board which is raised from the ground a couple of inches. Has he disturbed the birds? Something is the matter, for there they are with their wings raised in a way expressive of horror and dismay. Let us hurry. Oh, there is a black-snake. See the quick movement of its head. What is it trying to do? Seize the birds? Let us hide here behind this stump, and watch the battle. The birds are so busily trying to beat him off that they have no time to cry. Notice how they keep their wings uplifted. There, the snake struck at one of them, but the other is renewing the assault from behind. How the poor things are panting with the fright and the exertion. John, throw a stone at that snake. Well, that routed him and he has hidden under the fence. Too bad. The nest has been rifled and there are no eggs. I wish we had come a little sooner. Why did they not build their nests higher, so that snakes could not rob them?

Do the song-birds generally build high or low? Observe for yourself and tell me. Last May, a song-sparrow that had met with some such misfortune as this bird, built its nest in a thick mass of woodbine, against the side of my house, about fifteen feet from the ground. Would you not have thought that a safe place? But it was not, either a rat or an owl pillaged the nest one night. What did the mother-bird do? After a week's moping she built again. Where, do you suppose? A few yards from the house on a smooth piece of green grass. There was not a weed or shrub to conceal it. When I saw the nest on the bare ground almost at my feet, I felt sure that the cats would kill her. The desperate little bird sat there day after day, looking like a brown leaf pressed down in the short grass. As the weather grew hot, and the sun beat down on her, she fairly panted. It was no longer a question of keeping the eggs warm, but of keeping them from roasting. I have known male robins in similar cases to make sunshades of themselves. But there was no perch for her husband had he been disposed to shield his mate. Unwisely, I tried to help, and stuck a leafy twig beside the nest. It was a mark for some cat or other enemy, and probably this time the mother-bird was caught, for I never saw her again.

Whose eyes were keenest and who can best describe our little song-sparrows who were fighting the snake? Mary says, they wore black and brown coats, and had chestnut heads with small black stripes. Very good. Who can add to that? When they flapped their wings, Ruth says, she noticed their under parts were white streaked with brown. How many saw the dull red edging the wing feathers, and the little brown stripe behind the ear? Don't forget their long and nearly even brown tails. Were their bills and feet black like the blue-bird's? Some say "Yes," and some "No." They matched the rest of their very sober and tasty spring dress, being pale brown. Do you think you can call them by name when you meet them again?

How many know the robin? All? Suppose then you draw me a robin, and write a description of his plumage, and habits. Early in March he is with us to remain until fall. Let us sit down by this crooked, lazy little stream bordered with willow, while we do our drawing and writing. Very good. I would know that to be a bird, but whether robin or song-sparrow I could not tell. "Under part, dingy orange red, or chestnut brown." Right as far as it goes, but is that all you can tell?

Let me ask you a few questions: and how fortunate it is that that robin has come and perched himself on that limb not twenty feet away. But you must look quickly and keenly for he may fly away at any moment. What is the color of his throat? What the color of his eyelids? Has he any spot in front of his eye? If so, what is its color? What is the color of his back, and wings, and tail? Are they all alike or different? What is the color of his legs and beak? How long do you think he is? If you have all those questions answered you will see what I meant when I said you would have to see quickly and keenly. Now he is singing; and do you know what his song seems to say to me? It seems as if he were saying, "Spring is here—is here—is here. I'm so glad. I'm so glad." Does it sound like that to you? If it does not now, I am sure it will some time in your life, for whether it rains or shines, whether it is cold or hot, the robin never forgets to sing his glad song.

I hope some time you will find a robin's nest. If you do, be very careful not to disturb it, but if you can, find of what materials it is made. Find also if you can how many eggs it contains. What is their color? What is their size? In this work you will have to be able to think in *inches*. Can you do it? Make dots on a sheet of paper an inch apart. Then some three, five, seven and ten inches apart. Then take a ruler and measure and see how near right you are. If you are very much mistaken keep trying until an inch really means something to you.

Some persons think we ought to kill the robin because he eats our cherries, grapes, and other small fruits. They are very much mistaken. Fruit is a small part of the robin's diet. What do you think he eats before cherries are ripe? It is worms and insects, and by the havoc he makes among them he more than compensates for his occasional visits to our fruit trees. I once kept a couple of robins in a cage for a day or two and found that each one ate sixty-eight worms a day. The length of those worms which I patiently toiled all day to provide, was about fourteen feet.

If you really wish to study birds, place a shallow vessel of some sort, in your school or home yard, and keep it constantly filled with water. For several summers I have had an old-fashioned iron camp-kettle in my back yard under some peach trees. The birds soon found out that there was always fresh water there and a secluded spot in which to drink and bathe. Although few nested in the yard, the robins, blue-jays, red-headed woodpeckers, cat birds, sparrows and many others, came almost daily. Some must have come from quite a distance. I thus had a good chance to watch the industry of father robin, whose whole day was spent in putting worms in insatiable beaks at about the rate of about one in every three minutes. Watch the robins teaching their young to bathe. The father keeps a lookout for cats and other enemies, while the mother says as plain as bird can say to her children, "Jump in. Jump in. I'm here. I'm here." Sometimes the bluejay comes, and naughty, selfish fellow that he is, drives parents and babies both away, claiming the bathing place as his especial right. He was even very impudent to me. Several mornings in the hot summer weather, I forgot to fill the kettle with fresh water. The bluejay would come to the house and scold, and scold, until I came out, then flying low over my head, as I filled the kettle, he would rate me soundly for my neglect. I tried him on several occasions until I convinced myself that his actions were due to design, not accident.

Let us make a list of the birds we have seen to-day. We have seen three—blue-bird, song-sparrow, and robin. What bird has been with us off and on all winter? He has a shrill whistle like "wheeo—wheeo, wheeo." Everyone knows him. It is our naughty favorite, the handsome, saucy, mischievous bluejay. He is a vain fellow, and you have a chance to make many good sketches of him as he sits coquettishly turning his splendidly crested head from side to side. All the birds know his trick of stealing through the trees in May or June in quest of eggs. Just watch the robins hustle him out of the tree that holds their nests crying, "Thief, thief," at the top of their voices. Did you ever hear him sing? It is said that he can sing as sweetly as a mocking-bird, but his usual notes are harsh and ill-tempered and only occasionally musical and sweet. Some people say he is a murderer, that he is a regular cold-blooded assassin, killing the fledglings of other birds, but the careful studies made by the Agricultural Department at Washington seem to prove that much of his bad reputation is undeserved. Find out all you can of his habits, where he builds his nest and how. How can you tell him from a bue-bird, for he too has a blue coat and black bill and legs? Are there any markings on his wings or throat or head, by which you may always know him?

Now let us stop for to-day and take another trip together late in April, but do not let us forget to watch the birds every day until then.

The morning is the best time to study birds, so let us start early for the woods this bright April day. This field so green with its covering of young wheat is just the place to find one of our familiar birds, the meadow lark. So two of you have seen him at the same time. One has seen him walking between the rows of wheat and the other perched on the top of a rail fence. Now as you have found him you may answer our questions about him. What is the color of his back and of his wings? Is it a solid color or is it speckled? What is the color of his breast? Has he any queerly shaped mark upon it? Suppose you describe it. What is the color of his legs and beak? How long do you think he is? Is he larger or smaller than the robin? How did he move when on the ground, did he walk or hop? As you are studying birds this spring, suppose you make a list of the birds that walk and another list of the birds that hop when moving about on the ground. At the end of the season see which list is the longer. Let us watch the bird upon the fence and perhaps we can see him when he sings. It will not take us very long, for the meadow-lark like the robin is almost always singing. Listen to his song and see how he throws back his dear little head in true operatic style. What do you think he says? Some people who love the meadow-lark think it is, "*I see you, you can't see me.*" Whatever it is, he evidently thinks this is a beautiful world and is telling us so.

Go over into the meadow and see if you can find the meadow-lark's nest. It ought to be on the ground, concealed by some of the long grass. But what is that gorgeous bird, with his crimson epaulets bordered with buff that we have disturbed so that it is flying away? You all know him, because he is our very common red-shouldered blackbird. Do you hear what he is saying as he flies away? Listen closely so that you can recognize him by his call after this. He is a very great friend of the meadow-lark at this season of the year, and usually chooses the same meadow for his nesting place. But we must go on or we will not reach the woods. Here is a nest which I almost stumbled on in the grass. Yes, it is the meadow-lark's nest, and in it are four eggs. What color are they. Don't disturb it, for we want to see some baby larks in the weeks to come, and hear some more lark songs next spring.

What is that rattling drum-call? Look! There is the drummer, high up on that telegraph pole, and very conspicuous he is, with his glossy black and white plumage, and brilliant red head and neck. How does he beat that long, rolling rattle, the regular woodpecker drum-call? Does the sound come from the bird or the wood? Did you ever notice a red-headed woodpecker make a soundless call on a fence stake where the decaying wood allowed of the full entrance of his beak? There he goes to that hickory tree. Notice the rapid, spasmodic motion of his head. Don't you think he is a pretty good athlete, to hurl his head and beak back and forth like that? Let us count how many strokes to the second. How many did you make it? Notice his legs. Have you seen any bird this Spring with as short ones? Can you tell me why his tail feathers are tipped with stiff points? Watch him and you will see. There, he's going to strike a hard blow with his bill. See him brace the points of his tail feathers against the tree and, rising to the full length of his short, powerful legs, and drawing back his body, head and neck, dash his bill home with a force of weight and muscle which is knocking off good-sized pieces from the hard hickory tree. What is he after? Some worm or insect whose retreat he has discovered. You think he must hurt the tree, do you? Suppose you watch him closely this summer and see whether he works on living or dead trees.

But he has a relative known by his yellow vest, sometimes called the "yellow-bellied sap-sucker," who does injure fruit and shade trees by stripping off the bark and boring holes. Our red-headed friend does not confine himself to insects alone. He eats nuts, fruits, and is very fond of corn, wheat and melons, but he eats so many insects that he earns all that he takes from the orchard and field. He is not a very satisfactory article for a sketch. Five seconds is about as long as he remains in one position, but we must learn to do some things in a hurry. Let us see if we can draw an outline of his form. It is pretty easy to make something that everybody knows is meant for a bird, but it is not nearly so easy to make a sketch that every one will know was meant for a particular bird. But this is one of the things that it will pay you to keep on trying, and after a while you will be surprised to find how well you can draw. But, while he is before us, let us write his color description. Put it in this order: Head and neck, back, breast, wings. Where are the white bands—on his body or on the wings, or both?

If we had as sharp eyes as he has, not much would escape us. See! Starting from the topmost branch of that tall tree he is flying fifty yards straight to an insect near the ground. Look at him catch that fly on the wing. How many different kinds of woodpeckers do you suppose we have in our woods? Find out their names. There are six or seven you will certainly see, and perhaps you will be fortunate enough to meet two or three more. The red-head has numerous relatives—thirty alone that are good American citizens, and about two hundred foreign relatives. Wouldn't you like to see the king of them all, who lives in the South and only rarely visits us? He must be worth seeing, with his grand scarlet crown, and great ivory white bill. How much larger do you suppose he is than this one we have been watching? The length with his ivory bill is twenty-one inches, while this one can not be more than ten. To see such a king and queen in vigorous galloping flight through the woods must be a sight worth seeing. His dress is very much like our red-head's. Indeed all the woodpeckers have a bit of red about their heads, and that makes them so conspicuous that cruel women like to wear them on their hats. I think the bird knows it, for he has been a little shy of late, keeping in the woods and up in the tree-tops, instead of along the old weed-grown, worm-eaten fences.

Would you call the woodpecker a musician? Well, if the drummer is a musician, he is one. He can also call, squawk, squeal and splutter. There is another woodpecker. That is the one I spoke about a little while ago—the "yellow-bellied sap-sucker." Why is he called a sap-sucker? Follow him into the woods and you will find out. See how many holes he has drilled—a regular band of them about the trunk of that sugar maple tree. What is he drinking so eagerly? Sap, of course. Robert, climb that tree, and count the holes he has made. Sixteen! think of that. Sometimes a sap-sucker will stay for hours at a single tree, sipping the sap, and then waiting for it to collect again. How much of their time do you suppose they spend sap-drinking? Did you ever see one sitting on the edge of a sugar trough drinking of the ready tapped maple sap? It is a short step from sap-sipping to cherry-tasting. Don't you think you would stop drilling into the hard green wood for food, when you could find a superior flavor stored up in a cherry, apple or grape?

The poor woodpeckers have to suffer for their kinsman's sins, but the yellow vest, and the crimson cap, enclosed by a half moon of black, and a border of yellowish white, ought to enable any one to know the bird of bad morals from his more virtuous relations.

Let us go into that thicket of haw and crab-apple. Last year it was the favorite haunt of the brown thrush, or the brown thrasher, as he is sometimes called. We are fortunate, for there is our bird in his snuff-colored coat and dappled vest. I believe he is the very same bird that I found here last year. Is he not a picture to remember, sitting on the topmost branch of that tree, with the morning sun bringing out the red tints in his brown coat. Listen to that shower of song, so full-toned, loud and clear. Such ecstatic trills and quavers; and Nature has been his only teacher, but there is none above her. Does he sing all the year round? In the South he now and then sings a low, dreamy, lulling song at night. Let us separate and examine every foot of ground quietly and closely for the nest, being careful not to frighten the birds. But here is the nest. Why do you suppose the male bird is no nearer his mate? To throw us off the track, and distract our attention from his treasures? Is this the nest, this straggling mass of twigs, roots, bark and leaf stems on the flat projection of that fence-rail? Is it ever on the ground? See how artfully it is concealed. It is the last place I would have thought of looking, and when you do look, you can see nothing but a mass of green leaves. What delicately pretty eggs. How many are there? "Four. But one is different—a dirty, speckled looking egg—not like those pale-green ones flecked with brown." Let me see it. It's a cow-bird's egg. "What is a cow-bird?" You have certainly seen them in the cow pasture, as black as crows, but much smaller and with an evil, thievish eye. It is a bird of low principles. What do I mean by that? It makes some other bird hatch its eggs. I have caught it in the act of carrying off wren's eggs; and, of course, it had left an egg of its own in the wren's nest. Is it not a shame that our lovely brown thrush, devoid of a single vice, will have to rear this ugly little foundling, who has taken the place of at least one nestling? It will be much larger than the others, and, if it is like its kind, will be very selfish and claim everything in sight, pushing the baby thrashers aside.

Suppose we sit down on the bank of this stream and rest a while. What was that splash? Ah! A kingfisher after his prey. There he mounts to his perch in that branch of sycamore overhanging the water, with a fish in his beak. How will he kill it? Watch him and see. There, he is beating it on the limb of the tree until the spines of its fins are crushed. Is he choking? No, but certainly his eating is not very enjoyable, judging by his gulping, stretching of neck, jerking of wings and contortion of body. What advantage is it to him that he is all ashy-blue and purple and silver-gray and white, instead of bright scarlet? Do you suppose a minnow looking up through the dancing water can tell that sky-blue and silvery creature poised above him from the sky and clouds? If he could, the kingfisher would often go hungry. Why is he called the "belted kingfisher"? Where does he nest? I expect we would find his nest over there in a hole in that dry, sandy bank, for the kingfisher is one of our burrowing birds. There is an interesting legend about him, and the poets have sung about him under his other name, the "Halcyon." See if you can find out what they tell of him. Write a color description of him as you did of the other birds.

But let us go back to the school yard and see if we can discover what birds have found a vessel of water we placed there for their use. What is that slender, quick-moving bird? The cat-bird, you all say. What a strange name. Irritate him and see if you can not find how he got that name. But if we find out more about him we will have to follow him over into that secluded corner of the pasture. Now listen to his song. Did you ever hear anything finer? It is one of the best in the world. Does it resemble the song of any of the birds that we have met in our walks? Think carefully and listen carefully before you answer.

Now, listen to the cat-bird talk, the soft "chuck" and "mew" in all tones. I wish he would give us his wonderful whisper song. There, his mate has seen us. She says, "Sing lower—lower—lower." Now we can hardly hear him, and we are not more than ten feet distant, but we can see him and get his description for our picture gallery of spring birds. Note the color of his back, breast and head. See if you can see a patch of chestnut-brown anywhere about him. He seems very happy now. See him sit and swing and sing on the willows by yonder little brook. Don't you think him handsome? His beauty does not make him a favorite, however. What is the cause of that? Well, like the human family, his unsocial habits and the way he has of skulking off by himself have excited a prejudice against him which is not unfounded, for I caught a cat-bird last summer perched upon the rim of a pewee's nest, hastily devouring the eggs. I was so vexed with her that I killed her on the spot, but I regretted it heartily when I found that she had a well-constructed nest of her own in a tree not far from the house, and five lovely deep greenish-blue eggs in it.

But here we are near the corner where we must separate.

How many birds have we met and described in our walks? Name them, if you can. Have we met others? "Many of them." How many do you suppose can be seen in the State of Indiana alone? Over three hundred different species, and of these about one hundred and fifty make their homes here. During the summer you will have the opportunity to visit many bird homes and find out how feathered babies are taught and cared for and disciplined. Let us see whose note-book will have the best sketches and the most accurate descriptions of birds seen and observed.

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## NOTE TO THE TEACHER.

This leaflet is the result of original observations combined with adaptations from John Burroughs, Maurice Thompson and John B. Grant.

It is intended to be used by the teacher simply as indicating the manner in which children may be interested and directed in the study of birds about them; and also the use which the teacher may make of the many valuable and instructive books upon the subject in the way of adapting them to the child's needs.

This, of course, is an imaginary excursion. The real excursion should have more of the activity of the children in it and its incidents will of necessity be altogether different. It should be remembered that the time at which the birds spoken of in this paper will appear will depend somewhat upon the advancement of the season and also upon the latitude. In order to see the most of them at their best, two or three excursions at least should be taken.

FOR THE USE OF TEACHERS.

No. 9.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## A COUNTRY SCHOOL GARDEN.

BY PROF. STANLEY COULTER.

Have you ever thought how much of your time is spent at school? Suppose you take a pencil and work it out. Seven months, or twenty-eight weeks, or one hundred and forty days. And you are there just about eight hours each day. Do you not think you would work better and be happier if the school yard and school room were made pretty and attractive? I know you would, for I have watched children at work for many years, and know just how much cheerful surroundings help them.

What kind of school yard have you? I have seen hundreds of schools in the country, and nearly as many in towns, where the school yard was so bare and ugly that I wondered how either the teacher or scholars could possibly do good work. Now, if your school yard is of this sort, suppose, when school opens, you all join together to make it more pleasant. Of course you will want plenty of room in which to play, and that part you need only keep free from litter and rubbish. Then, of course, you must have walks, so that there is only left the odd corners of the school yard for you to care for; and it is about these odd corners that I want to talk. But, before I do, I want to say something about walks. I visited a school not long ago where there was no sign of a walk, and had to wade through the mud to reach the front door. Of course, I carried a good deal of mud into the school room, and it dried on the floor and soon became dust, which very soon filled the air and made it unfit to breathe. For dirt and disease are very closely related, you know. All this, because there was no walk. But just outside the school-house yard was a great gravel bank, and, if the boys had thought to bring a wheelbarrow and some shovels to school, they could have made a good walk in a very short time. If you have not walks, you can make them in nearly every region, with very little trouble. It will pay you to do so, for the school room will be kept cleaner, the air will be purer, and you will find that you can do more work and better work.

But, about those odd corners: Did you ever notice how nature tries to cover over the bare spots? Over logs and unsightly stumps she trails delicate vines; in among the rocks she sets out ferns, and in every possible corner and crevice she plants flowers. Now, I want you to take a hint from nature, and, indeed, get her to help you to make the school yard beautiful.

If you have any stones in the yard, pile them up in a loose heap. Go out into the nearest woods and get some of the rich, black earth that you will find about decaying logs, and with it fill the spaces between the rocks. When the ferns are just beginning to appear in the spring, dig some up very carefully, so that you may not injure the roots and plant them in your rock pile. Be sure to leave some of the "home" earth about the roots, and water the ferns frequently, because you know they love moisture. Then, if you notice the places from which you dig the ferns, you will also see that they love shade. Of course, this means that your rock pile must not be put in a place where it will catch the full light and heat of the sun. If you do this, it will not be very long before your unsightly rock pile is a beautiful fernery, and one of the odd corners is filled. Watch the ferns as they grow and see how the delicate fronds unroll themselves. Probably there are ten or twelve different kinds of ferns in your neighborhood. Try to get them all to grow in your fernery. A little later in the season, after the fern leaves are fully opened, if you watch the underside of the leaf carefully, you will see little round bodies which at first are green but afterwards become brown. These are the spores of the fern, and from these spores new fern plants will be developed. Now, you will not find this very hard work; indeed, I think you will soon come to enjoy your fernery very much.

Are there any stumps or bare fences or sheds about the school yard? I think that there must be, unless your school yard is unlike most of those I have seen. Suppose, about such places, you plant morning glories or the wild cucumber. Perhaps you do not know what the wild cucumber is; if not, the morning glory will do very well, and you can get morning glory seeds almost anywhere. Dig up the earth where you want to plant the seeds, and, having broken it up very finely, mix with it some of the rich black earth of which I have already spoken. Do not plant the seeds very deep, certainly not over half an inch. In a few days the morning glories will begin to come up, but the two leaves which first appear do not look at all like the later leaves. Now put a small stick in the ground near the young morning glory and, tying a string to it, stretch the string up to the top of the stump or fence which you want to cover. This string is to support the stem, which is too weak to carry its load of leaves without some such help. The vine grows very rapidly, and it will not be long until the stump or fence is completely covered. Watch the stem from day to day as it twines itself about the string. Does it always twine in the same direction? Is this direction from right to left, or from left to right? Suppose you put some of the sticks to which the strings are tied, a foot or more away from the young morning glory, and watch the plants every day. Does the young stem ever go in any other direction than towards it support? How do you suppose it finds is way to the string? Watch other vines which climb by twining, and see if they behave in the same way? Do you think the plant can see? If not, how does it know where the support is to be found?

You will also see that the flowers are visited by many insects. What do they come for? Are their visits of any use to the plants? See if you can find how many kinds of insects visit the flowers.

The morning glory can stand more sunlight and heat than the ferns and does not need as wet a soil. Indeed, it will grow freely and vigorously in almost any place if you prepare the bed as I have said. If you are trying to cover the side or end of a shed with the vines, be sure you dig your bed far enough away from the building to escape the drip from the eaves. If you do not, the soil is liable to be washed away from the seeds before they germinate, or else to be packed so tightly by the beat of the rain that the plant can not get any air. As a plant is a living thing, it breathes, and if air is cut off it dies just as an animal would die under similar conditions. With these morning glories, then, you see you can cover many unsightly objects very rapidly.

Then, in the other odd corners, I would make flower beds, in which I would plant some of our beautiful wild flowers. These beds ought to be dug up to a depth of at least a foot and the earth broken up very completely, and then thoroughly mixed with rich earth. If the original soil is very gravelly, or a heavy clay, some of it ought to be thrown away and replaced with good earth. If you are very much in earnest about making the school yard more beautiful you will not have much trouble in having the beds dug up in the first place. After that you will want to do all the rest of the work yourself. Now, what shall we plant in these beds? I think I would take one small bed and fill it with violets. Did you know that there are ten or eleven different kinds of violets in Indiana? Probably five or six of them will be found growing in your neighborhood. If you decide upon a bed of violets, go out into the woods and study the violets in their homes. Do you find them most frequently in the sun or in shady places? When you have answered this you can settle the location for your violet bed. Do you find violets most vigorous in dry soil or in wet soil? When you answer this question you will know something about the amount of water you must give them if you want them to do well. Now, dig up your violets very carefully, keeping a good deal of the home earth about their roots, and replant them in the bed which you have made. You will find that they grow well and blossom all through the spring and summer. In this bed you should have blue violets and yellow violets and white violets; violets in which the leaves seem to come directly out of the ground and those in which the leaves arise from the stem, for all of these forms doubtless grow in your neighborhood. As the plants grow you can watch them every day, and if you do, you will find they will tell you much of the story of their life

Then, in another bed, I think I would put some phlox or "wild sweet William," as it is called. You know it, of course, for the phlox is very abundant all over the State, and its pink to red flowers are very beautiful. There are several different kinds of phlox in the State and you will probably find two or three of them in your neighborhood. Of course, before you plant them in their new home, you should know whether they live in sunny or shady places, and whether in wet or dry soils, for you want to keep the new conditions as much like the old ones as is possible. If you do this, you will have little difficulty in securing good results.

The other beds I would make "mixed" beds, putting in them almost any pretty flower that I could find. I would put in spring beauties, and blood-root, and the yellow crow-foot, and anemones, and wild geraniums; indeed, anything that was attractive in appearance. You will be surprised to find how soon this mixed bed becomes very beautiful. By watching carefully during the first season you can find what flowers have a long blooming season and what ones blossom for only a few days. The second season those that are unsuited to the situation because of this or any other reason can be omitted and only those which are satisfactory used. I am not going to tell you which ones are the best, for I want you to find out for yourself.

I have written this as if the leaflet would come to you in the early spring, and as if you were going immediately to work to make your school yard more beautiful. But it may come to you in the fall, and if it does, you will have to start with other flowers. I would make one bed of the splendid yellow golden rods, and we have twenty-seven different kinds of them in the State. Then I would have a bed of asters, of which we have very many, and very beautiful kinds. You know they range in color from white, through blue to deepest purple. As there are thirty-one different kinds of asters in the State, you ought to be able to get twelve or fifteen different kinds for your bed. Both the golden rods and asters are very hardy, bloom freely and keep their beauty for a long time.

Then off in one corner I would have some wild sunflowers. Indeed, in the fall you will have no trouble at all in finding plenty of flowers with which to work. Of course, if you are trying to make your school yard beautiful you will keep out weeds, such as the burdock and plantain and thistles, not merely because they are not attractive, but because they use the food and water in the soil which you want to go to the other plants.

I believe it is worth your while to try what I have suggested. If you succeed you will have to study plants in their homes and in this way will find out a great deal about plant life which may afterwards prove of great value to you. Then if you succeed you will begin to have a real pride in the appearance of your school grounds, and when that happens you will find you are also very much interested in your school work. Of course, it means work, but we must always work for anything that is worth having.

No. 10.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## A TALK ABOUT TREES.

BY PROF. STANLEY COULTER.

Have you ever thought in how many ways wood was used? Suppose you take a pencil and paper and make a list of all the different articles that are made of wood. You will find you will need a pretty large piece of paper before you are through. Of course, you will put down as the first thing houses and buildings of various kinds, and then, perhaps, you will put down the furniture. If you go out into the kitchen you will find other things made of wood, and if you go to the barn or tool house you will find still others. When you travel on the railroad you will find the rails rest on wooden ties, and that the telegraph wires are held in place by wooden poles. If you live near a river, the steamers and skiffs and wharf boats will be found to be largely of wood. The merchant gets his goods in wooden boxes, and the miller packs his flour in wooden barrels. But I am not going to tell you how many things are made from wood, for I want you to make as long a list as you can yourself. I think it would be interesting for you, though, to have your teacher tell you how paper is made from wood, because perhaps you do not live where you can see how it is done.

It is because the trees are so useful to us that I think all of us ought to learn all that we can about them. So in this leaflet I am going to talk to you about trees. Do you know how many different kinds of trees grow in Indiana? It has taken me a good many years to find out, and as you will not be able to find them all near your home I will tell you. There are 109 different kinds. Some of these are found all over the State, and some are found only in a few places. Some are very large, and their wood very valuable, while others are small, and their wood of no particular use. It is only the plentiful and useful kinds that I am going to talk about. The forests in Indiana are nearly always *mixed*. That is, if you go into any forest or grove you will find a great many different kinds of trees. That is not always the case. If you were to go with me down into the mountains of Tennessee I could show you some forests covering thousands of acres, in which almost all of the trees were chestnuts, and other forests equally large in which nearly all of them were pines. But it is not so in Indiana, and for this reason Indiana is a good place to study trees.

Now, let us go out into the school yard, or to the nearest woods and see how many different kinds of trees we can find. In most cases, unless you live in the southern counties of the State, you will find that very many of the trees are *oaks*. If you live in the southern counties perhaps the *beech tree* will outnumber the oaks. Do you know an oak tree when you see it?

The trees are usually quite thick and tall. The bark is quite rough, being broken up into irregular shapes by cracks of considerable depth. In some cases the bark is light colored, in others it is dark in color. See if you can find oak trees with light-colored bark and dark-colored bark. Do most of the oak trees where you live have light-colored bark or dark-colored bark? Sometimes we think the bark of a tree is worthless, but this is not always true. The bark of oak trees was once very largely used in making leather, and all the corks that we use are made from the bark of the cork oak. Look at the leaf. Do you see how the leaf stalk holds a single green part? When this is the case the leaf is said to be a simple leaf. All oaks have simple leaves. If you look at the leaf stalk you will see that it seems to run right through the center of the leaf to its tip, dividing the green part into two parts, which are almost exactly alike. Do you see how branches seem to go from this mid-vein, as you may call it, to different parts of the leaf? See if these branches or veinlets come from the same point on the mid-vein or if they start from different points. Do these veinlets run clear to the edge of the leaf? Look carefully and see just how they end.

If we look at the edge of the leaf we find it is always notched or lobed, sometimes very deeply, at other times only slightly, but the margin of an oak leaf is *never* entire. Now look carefully and see if the veinlets, which we have just examined, have anything to do with this lobing or notching of the leaf. I think it will help you to remember the things we have been talking about if you will place an oak leaf on a sheet of paper and with a sharp pencil draw its outline. When this is done fill in the mid-veins and the veinlets. See how many different kinds of oak leaves you can find in the woods about the school house or your home.

Did you ever see the flower of an oak tree? Watch this spring, and almost at the same time the leaves begin to unfold you will see long, slender spikes hanging down from various parts of the branches. These spikes are yellowish or greenish in color, and if you examine them closely you will find they are made up of a large number of flowers. Of course, the flowers of the oak tree do not look very much like those of the roses or pinks, but still they are flowers. At what date do the leaves of the oaks open? At what date do the flowers appear? Does the time of leafing and flowering differ in the different kinds of oaks? You may think I am asking you a great many questions, but the questions I have asked can be easily answered if you keep your eyes open.

Of course, you know that the fruit the oak tree bears is called an acorn. Now there are as many different kinds of acorns as there are different kinds of oak trees, and, if possible, you should find the acorn of every kind of oak tree you study. If this leaflet should come to you in the fall of the year, gather as many different kinds of acorns as you can and plant them in boxes or pots, so that you may see what young oak trees are like. If the leaflet comes to you in the spring, look carefully under the oak trees and see if you can find any of these seedlings, as they are called. Are their leaves like those of the full-grown tree? I am not going to say anything about acorns, because the next leaflet I write is going to be about "forest fruits," but before that comes to you I want you to know all you can about the different kinds of oak trees that grow in your neighborhood, and the kind of acorns that they bear.

I have talked a good deal about oaks for two reasons. The first is that, having taken so much time on one kind of trees, the others can be studied much more easily. The second is, that we have more different kinds of oaks than any other tree, and that they are perhaps the most valuable timber that now remains in our State in any great abundance. There are seventeen different kinds of oaks in Indiana. Almost all of them are of large size, and almost all of them are extensively used in manufacture. The wood is very firm and strong and is used for a great variety of purposes. See if you can find how oak wood is used where you live. When you do, will you not write and tell me, for that is what I have been trying to find for a long while?

I want you now to see if you can pick out a *maple* tree. Whether you live in the city or country you will be pretty sure to find one, for maples are very plentiful in the woods, and are more largely planted than any other form in city streets. If you compare the maple with the oak you will find it neither so thick nor so tall. The bark is thinner than in the oak, and not nearly so rough, but like the oak is light colored in some forms and dark colored in others. The branches of the maples spread in such a way as to give abundant shade and at the same time give to the tree a very beautiful shape.

Now pick a leaf of the maple and examine it carefully. As in the case of the oak you will find the leaf stalk bears a single green blade, or, in other words, that it is a simple leaf. But now look at the veinlets. Do they arise from the same point on the mid-vein or from different points? Measure the length and breadth of an oak leaf, and then the length and breadth of a maple leaf. Does this difference in the way in which the veinlets arise have any relation to the *shape* of the leaf? Leaves in which the veinlets are arranged, as in the oaks, are said to be pinnately veined. Where the veinlets are arranged, as in the maple, they are said to be palmately veined. See how many different kinds of trees you can find in which the leaves are pinnately veined. How many in which they are palmately veined. In the maples, as in the oaks, you will find that the edge of the leaf is never entire, but is more or less deeply lobed. How many of these lobes are there in a maple leaf? Does the distribution of the large veinlets bear any relation to this lobing? Trace the outline of a maple leaf and fill in mid-vein and veinlets.

The flowers of the maple are more conspicuous than those of the oaks. Instead of being arranged in spikes they are arranged in clusters. They are sometimes yellowish in color, and sometimes a bright red. In the maples, which appear first, the flowers or leaves? At what date do they appear? The fruit of the maple is a strange looking, two-winged affair. Notice when the fruit is ripe how it is carried by the wind from beneath the shadow of the parent tree. When the fruit finally reaches the ground are the wings pointed upward or downward? Why is this so? Examine the seedlings of the maple. Compare the shape of the young leaves with those of the fully grown tree.

We have four kinds of maples in Indiana. The most abundant of these is the sugar maple, which is found in every county in the State.

The wood of all of the forms is very valuable for manufacturing purposes, while from the sugar maple we get our maple sugar and maple syrup. If there are any sugar maple orchards near where you live see if you can find out how maple sugar is made. At what season of the year is it made? How is the sap of which it is made secured without injury to the tree? Be sure to visit a "sugar camp" if there is one in your neighborhood and watch every process from the collection of sap to the time in which it is changed into syrup or sugar. If you do not live near a sugar maple orchard, have your teacher tell you how maple sugar is made.

I suppose every boy and girl in Indiana has eaten walnuts and hickory nuts, and many of you have gathered them in the fall, after the first heavy frosts have loosened them from the branches and brought them rattling to the ground. The walnuts and hickory nuts are very closely related to each other, being in the same family. If trees counted kin as we do, the walnuts and hickory nuts would be cousins. Look, now, for a walnut tree. See how thick and rough and dark colored the bark is, much darker than in the case of the dark-colored oaks or maples. If, however, the walnut tree is very young the bark will be somewhat lighter in color. The tree is tall and very straight, and is sometimes two or three feet in diameter. Pick a leaf of the walnut, being very careful that you get the entire leaf. Do you see how the leaf stalk, instead of bearing a single green part, as in the maples and oaks, bears many such parts, each looking like a perfect leaf? In the case of the walnut the number of these *leaflets*, as they are called, varies from fourteen to twenty-two. When a single leaf stalk bears more than one green part it is known as a compound leaf. All the trees in the great walnut family, and that means the walnuts and butternuts, and all of the different kinds of hickory nuts, have compound leaves. Are the leaflets in the walnut opposite each other, or is one slightly above the other? Do the leaves of the walnut unfold before those of the maple, or after? Do they appear before or after the leaves of the oak? Do the leaves appear before the flowers? At what date do the leaves and flowers appear? There, you see, is another long list of questions which you can easily answer if you watch the trees from day to day on your way to and from school. You will be surprised to find how many things you can learn about trees by watching them in this way.

Of course, you know the wood of the walnut tree is very valuable. In the fully grown, old trees the wood is very dark in color and takes a beautiful polish, and so it has been very largely used in making furniture, and for picture frames, and for finishing the inside of houses. Indeed, the wood was so much sought after that now scarcely any large walnut trees are left in the State, except in small groves about houses. The walnut trees in the woods are nearly all what is called "second growth," and the wood is not nearly so valuable, because it has not had time to develop the dark, rich color which makes walnut wood so handsome. If people who owned farms had cared for their walnut trees many of these large forms would have been still left, and their owners would be very much wealthier. But we are just as foolish about the trees that are left and are every day making ourselves and the State poorer by uselessly destroying them. Beside the ordinary walnut we have what is known as the white walnut, or butternut. While this tree is not so large as the other, it is a very valuable tree, and should be carefully protected. It looks so much like the other walnut that you can easily recognize it in the woods. You see, however, as you look at the bark that it is not nearly so rough and thick and that it is gray in color, instead of dark. Sometimes the gray color seems to run in a series of bands straight up the tree. Pick one of the compound leaves and count the number of leaflets. Are they arranged in the same way as in the other walnut? When do the leaves and flowers appear? But you know the list of questions I want you to answer, so I will not write them out.

From the walnuts you can easily find the hickory-nut trees, for their leaves look so much alike. In all of our hickory trees the bark is of a light gray color and in many cases seems to almost fall off the tree in long, slender strips. If you try to pull off one of these strips you will find it still very closely fastened to the tree. In one of our hickories the whole trunk is made shaggy by these strips of bark, and we call the tree the "shagbark," or "shellbark," hickory. Pick the compound leaf of a hickory tree and count the number of leaflets. How are the leaflets arranged? Do hickory trees have flowers? If so, when do they appear? We have seven different kinds of hickory trees in Indiana, all of them of large size and all giving us very valuable timber. The wood is very hard and strong and this fits it for very many uses, in which great strength is required. The handles of tools, such as axes and plows, wagon-tongues and spokes, and a thousand other things are made from hickory when it can be obtained. Every boy knows he can make a good bow from a straight-grained piece of hickory, and that which makes it good for a bow makes it suitable for the other uses of which I have spoken. All of these trees bear nuts which can be eaten, except in one case. The nut of the "pig-nut" hickory is too bitter for even nut-hungry boys and girls to eat. The best of all these hickories, not only in the value of its wood, but also in the quality of its nuts, is the "white," or "shellbark," hickory.

But I have written more than I ought to already, and I have only talked about a few trees. But what I hope you will do is this: During this year see how many kinds of trees you can learn to tell apart.

1. By the bark.
2. By their leaves.
3. By their fruit.

Never mind about the long scientific names, the common ones will do just as well. While you are watching them notice the following things. If I were you, I would put them in a book, so that I might not forget them:

1. When do the leaves appear?
2. When do the flowers appear?
3. How long do the flowers last?
4. When does the fruit ripen?
5. When do the leaves fall?

And then, I think, last of all, I would try to find the uses to which the wood of the different trees were put in the neighborhood in which I lived. If you do this, or even a part of it, you will know so much about trees at the end of the year that the woods and groves will have a very different meaning to you.

If in your work you come to any questions which you can not answer, if you will let us know about it we will try to help you.

No. 11.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

# A STUDY OF OUR INSECT ENEMIES.

## IN THREE FIFTEEN-MINUTE LESSONS.

BY PROF. JAMES TROOP.

### I.

No children have a better opportunity for studying the habits of insects than those of you who live in the country; and I suppose it is true that the most of you do know a great deal more about the ways of insects in general than your city cousins; but I wonder how many of you have any idea how many kinds of insects there are in the world? I do not suppose that any one knows exactly, but I think we would be safe in saying that fully four-fifths of all the animals in the world belong to this class. This is a good many, you say. Yes, indeed, it is a good many, but you will see when you get a little older that I have not stated it any too high.

In studying insects it has been found necessary to divide them into classes as a botanist classifies his flowers. The classification that has been adopted is based largely upon the wings of insects. Those having thin, membranous wings are put in one class; those having scale wings in another; and those having sheath wings in still another, and so on.

**NOTE TO TEACHER.—The time at which these various lessons should be given will depend somewhat upon the latitude and advancement of the season; but since it is desirable to give the lessons about the time the observations can be made it will be necessary to place them about three weeks apart.**

There are seven of these classes that are important, the names of which are pretty hard to remember, so I will have them written on the blackboard and you may copy them in your notebooks. Here they are:

1. **Hy-men-op-tera.** Having membranous wings. This is the class to which the bees and wasps belong.
2. **Lep-i-dop-tera.** Having scale wings. Here we find the moths and butterflies.
3. **Dip-tera.** Having two wings, including the common house fly and the mosquito.
4. **Co-le-op-tera.** Sheath-winged. To this belong the beetles, such as the May-beetle, or "June-bug," as it is sometimes called.
5. **Hem-ip-tera.** Half-winged. These are the true bugs. The black squash-bug and the green plant lice are good examples.
6. **Or-thop-tera.** Straight-winged. To this class belong the grasshoppers and crickets.
7. **Neu-rop-tera.** Lace-winged. Here we find the dragonflies or snake-feeders.

Now I want to ask a question. Have any of you discovered in these hard names any portion which is the same in all of them? Look closely at the names on the board. You will see that the latter part of each name is alike. This part is from a Greek word which means wings.

There is something with regard to the most of the insects which I wish to explain to you before we begin to study them. It is this: Most insects are found in four different forms. The first is the egg. When the egg hatches it produces a worm-like animal or caterpillar which eats and grows sometimes for days, sometimes for weeks sometimes even for months. This stage the scientists call the *larva*, and it is in this stage that the greater part of the insects do the most damage. Can you name some such insects? Yes—tent-caterpillars, currant-worms and cut-worms are insects that are most injurious at this time.

When it has eaten and grown enough it lies very still for a long time, often wrapping itself up in a covering called a cocoon. This is the *pupa* or *chrysalis* stage. After awhile this *pupa* bursts open its outer covering or cocoon and appears as a full-grown insect like the butterfly, or beetle, or common house fly. This last stage is called the *imago*. Can you name some insects that are most harmful when full grown? Yes—grasshoppers and some of the beetles.

**NOTE TO TEACHER.—If the children could be shown a large number of specimens of different insects, either mounted or alive, for the purposes of observation and classification it would greatly enhance the value of the lessons.**

Now we are ready for our talk, which to-day is to be about some of our insect enemies. Where shall I begin? With the mosquito? With the fly? I suppose we may call mosquitoes and flies our insect enemies, so I will speak of these for a few minutes.

Perhaps the mosquito and fly are as well known to us as any of the insect tribe, but I wonder how many of the boys and girls know all about the habits of these very familiar little insects? For instance, I speak of the mosquito as *she*. Did you know that Mr. Mosquito has much better manners than Mrs. Mosquito? Well, he has, for he never tries to worry or bite us as she does. He is a bashful fellow, and is always found hiding in some out-of-the-way place, such as swamps and woods, while his mate amuses herself by trying to sing us to sleep so that she may have a good chance to stab us with her little spear, and suck our blood.

In our study of these and other insects it will be quite desirable for us to have a small hand magnifying glass in order that we may see them to better advantage. For example, the spear or bill of the mosquito appears to the naked eye to be made up of a single straight piece, but with a good glass it will be seen to be made up of a number of long thread-like pieces which she can bring together, thus forming a tube through which she takes her food. Compare this with the beak of the house fly and note how they differ. Next examine their wings. How many does each one have? By this time you will very likely begin to think that these two insects are related to each other; and so they are.

How many know where the mosquito lays her eggs, and where the young live during their babyhood? Let us see. Did you ever know mosquitoes to be numerous where there were no ponds, or rain barrels, or other standing water? You did not? Very well, if you study them closely you will find that the old mosquito lays her eggs in little boat-shaped masses upon the water, and the little ones spend all their time in the water feeding upon decayed matter that is always to be found in such places. After a short time the young mosquito, which does not look at all like a mosquito, changes to a different form, and then it frequently comes to the top for air. If you disturb it, it will go wriggling down to the bottom again. What then would you call it? A wiggler? Yes, that is right. After a few days it comes to the top for the last time, the old skin splits open on the back and makes a nice little boat for the full-grown mosquito to stand in until it can stretch its wings and legs, when off it goes to search for food. All this that I have just told you can be readily seen, providing you have sharp eyes.

Let us see how the house fly differs from the mosquito in these respects. Do you think the fly lays her eggs in the water? No, she lays her eggs in cracks in the floor or in other out-of-the-way places where there is a good supply of food for her young. Here they live till they are full grown, when they change their form, as did the mosquito, but they take on a very different shape, looking somewhat like a small black bean. After a short time, one end of this little black case is forced off and out comes Mr. Fly.

I wish you to notice that these insects which we have called our enemies are not altogether bad. They help us while they are young by destroying various kinds of filth and decaying matter which, if left in the water, or upon the ground, or in our dwellings, would be very injurious to our health.

I think perhaps we have said enough about the fly and mosquito at this time to put you on the right track, so that during the summer with the aid of your glass you will be able to discover many more interesting things about them.

## II.

Spring will soon be here and with the first warm days the currant and gooseberry bushes will begin to send out their leaves and will take up another season's work of increasing their growth and producing a crop of fruit. If those of you who have them in your gardens will watch carefully you will probably find after a few days, down in the center of the bush, some leaves which have tiny holes through them, and yet there does not appear to be anything on them. But pick a leaf and look closely at the underside of it. There you will find a dozen or more little greenish worms with black dots all over their bodies. Where could they have come from? Look carefully along the ribs of the leaf on the underside and you will soon be able to answer this question.

But in order to find out what becomes of these worms when they are full grown, we must have a breeding cage. Such a cage is easily made. You have only to take a small box, about a foot in diameter each way, knock off the bottom board and replace it with cheese-cloth and then cover the top with glass so that you can see what is going on inside. When the worms are about three-fourths of an inch long, which will be when they are about three weeks old, put some fresh currant leaves in the breeding cage and on these place some of the worms. Give them fresh leaves every day as long as they will eat and watch carefully to see what becomes of them. I can tell you, but I think you can find out for yourselves, and if you watch carefully you will discover some very curious things. I want you to put down in your notebooks just how these worms eat, because later you may wish to compare their habits with those of some other worms of which I will tell you.

The parents of these little worms of which we have been speaking are very spry, so that you will probably not be able to catch the mother-fly in the act of laying her eggs, but if you could, you would see her use a little saw, which she carries in a convenient place, with which she cuts small holes in the veins of the leaves, and in these she places her eggs, just as you saw them when looking for the young worms. Now, what would you suggest as her family name? Saw-fly? Certainly; that is just what she is called.

Do you know what injuries these saw-flies do to our fruits? Ask your father and he will probably tell you that if they are left to themselves they will soon strip the currant and gooseberry bushes of their leaves.

So far we have spoken of but one kind of saw-fly, but there are a good many kinds, all more or less injurious to our cultivated plants, although they differ a good deal in their habits. For example, you may have a cherry tree with its bright green leaves just beginning to do the work which Nature intended they should, when you suddenly discover that something is the matter with them. Something has eaten away part of the leaf covering so as to make it appear spotted. Find out, if you can, what it is that has done this. Ah! There you have him—a sticky, slimy-looking fellow, eating away as contentedly as can be. He looks like a snail, you think. So he does. Do you notice, though, that he eats only the green part of the leaf and leaves the veins? But does this really hurt the tree, you ask. Let us see. I think you must have learned before this that the green portion of the leaf is called *chlorophyll*, and that without it the tree cannot digest its food, and this digestion is necessary in order that it may grow. Now, if you will watch your cherry tree for a few days you will see what will happen if these fellows are allowed to go on with their work unmolested. The leaves will die, and thus the tree, being deprived of its food, will stop growing.

Let us see if we cannot find some simple remedy that will rid us of this pest. I wonder if any of you know how insects breathe? You know that a dog breathes through his nose or his mouth, but these little creatures breathe through holes placed along the sides of their bodies. Now, you remember that these insects were covered with a sticky substance, so suppose we scatter some fine road dust over them and see what will happen. If you do this successfully you will close up all their breathing holes, and thus choke them to death.

But how about those rose bushes with their leaves stripped of their *chlorophyll?* Can you find any worms on them? If so, how do they compare with the others? Yes, they resemble the others in most respects, but they are not covered with a sticky substance.

Now, how do we know that these three insects all belong to the Saw-Fly family? If we could examine the female flies of each kind we would always find the little saw of which I have spoken tucked away ready for use. But that is too difficult a task. I think it will be easier for you to find out about the family by examining the young of these flies, or the *larvæ;* that is, those worms of which we have been talking.

Suppose you find a tent-caterpillar and count its feet. Sixteen, you say? That is correct. And the strange thing is that there is but one family among the insects that has more than sixteen feet; and that is the Saw-Fly family. Now count the feet of each of the three worms of which we have been talking. How many do you find? Twenty in each case, you say. Very well. Here you have the family of which I spoke.

## III.

At some convenient time visit the celery plants growing in the garden and see what you will find. I think it will be a peculiar striped worm, eating away at the plants. You have all seen him before, but who knows what becomes of him ? Visit the spot again in a few days and see what you find—a bright-colored object hung up by one end to a celery stalk, and around its shoulders it has placed a silken thread or band and fastened the ends to the celery plant also. Now, in order to be sure of it when it makes its next change, you had better take the stalk to which it is attached and place it in your breeding cage. If you watch it carefully you will observe another very curious result. It will have beautiful wings, and I wish you to take your books and make notes of their size, shape, and color, so that you will recognize others of the same kind.

This is also a good time to visit the cabbage and watch the small white butterflies as they fly from one plant to another, apparently just for the fun of the thing. Notice what the female is doing. Did you see her lay her egg? Where did she put it, upon the upper or lower side of the leaf? Now, note carefully when the eggs hatch, and how long it takes the worms to pass through their various changes. You observe that they finally turn into full-grown butterflies. Note down in your books the size of the body; shape and color of the wings; how they are folded when at rest; shape of the antennæ or feelers, and any other striking peculiarity you may notice.

Now, I will speak of only one or two more, and one of these is the Tomato Moth. I speak of it here in order to show you the difference between a moth and a butterfly.

Every farmer boy or girl knows a tomato worm, of course, and some of them are afraid to touch one for fear they will get pricked with the sharp horn sticking out of his back; but that was only put there to frighten timid people. It is not a dangerous weapon. I wonder how many of you know how long it takes this worm to become full grown, and where it goes after it stops eating? Did you know that it goes into the ground and remains there all winter? Well, it does; and so in order to follow it through its other two changes this year, it will be necessary to begin this spring. Go into the garden when they are plowing the last year's tomato ground, and you will probably find a number of brownish, oblong objects about an inch and a half in length, each having a queer little jug-handled arrangement at one end. They are apparently dead, but if you pinch one of them it will probably squirm a little, enough to let you know that it is alive, but that it has not yet awakened from its long winter's sleep. Now, place some moist soil in the bottom of the breeding cage and bury these again and wait until about the time your father's tomato plants are well grown, when you will be surprised some morning to find some beautiful large moths in your cage in place of the ugly-looking things you put there.

Now get your notebooks and observe how they differ in size of body, shape and color of their wings from the cabbage butterfly. How do they fold their wings when at rest? Are their antennæ of the same shape as those of the butterfly? Now I think you will be able to tell *some* of the differences at least between a *moth* and a *butterfly*.

But, someone asks, why don't we see these moths flying about in the daytime, like the butterflies? Sure enough. That is a peculiarity that we overlooked, because these moths have been kept in a cage all of this time. If you let them out you will see that they will go and hide themselves as quickly as possible until just at twilight, when you may see them, if you look sharply, flitting from flower to flower, sipping the sweet nectar from the deep flower tubes which the bees could not reach. Watch them and see how they remain poised over the flower while they poke their long tongues down into it. Can you think of any kind of bird that behaves in a like manner? The humming bird? Certainly; and these moths are sometimes mistaken for humming birds. So we will call them the *Humming Bird Moths.*

But I want to speak of one more before closing. You will remember that I asked you to make a note of how the currant-worms took their food. Now go into the garden and watch those large black squash bugs, as they are feeding away on the squash vines. Can you see where they have eaten the plants? You cannot? Well, the plant seems to be dying. What is the cause? You can't tell? Let me help you a little. Catch one of these bugs and look at its mouth under your magnifying glass. You see a straight beak. Can you tell me how this one differs from the currant-worm in its method of eating, and why the squash plants were withering? You will notice that it does not eat the leaf as the currant-worm did, but thrusts its beak into the plant and sucks its juice, thus causing it to wither and die.

Now, I think you will be able to see that the most of these insects about which we have been talking are able to do a great deal of injury during their lifetime, if we but let them alone. Sometimes whole gardens are destroyed and whole fields of grain are ruined in a single season. A single insect is very small and not able to do very much, but when many of them unite their forces they are able to accomplish great results.

They attack our wheat, our oats, our larger fruit trees and our smaller ones, as well as our garden crops—indeed almost everything that grows may be injured by insects. Sometimes this State loses a million or more of dollars' worth of agricultural products in a single year by their ravages. This, you think, is a very important matter, and so it is. Some of you may ask, is there no way to get rid of them? Yes, there are many things that you can do to prevent them from doing injury, but the methods are so difficult that I cannot explain them to you at this time. If your father is interested in the matter and wishes some information on this subject, you had better ask him to send a postal card to the Director of the Experiment Station, Lafayette, Ind., stating that he is a farmer and asking for bulletin No. 69. If he will do this he will receive a bulletin which will tell him how to prevent insects from doing so much damage.

The next time I shall talk about beneficial insects, or Our Insect Friends.

FOR THE USE OF TEACHERS.

No. 12.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## A TALK ABOUT WATER-DROPS.

By Prof. A. Wilmer Duff.

What is a water-drop? To experiment is to try for yourself, and as that is the surest way of learning anything, we shall begin with an experiment. Dip your finger into water and withdraw it, and you will be able to see the shape of the drop that forms at its end. It is round like a glass bead except just where it hangs to your finger, and if you watch it carefully you will see that, just when it gets free from your finger, it is nearly perfectly round. If you let it fall on a piece of glass it will form a circle. If you could see it while it is falling you would find that it is nearly a perfect sphere. If I let water from the end of a stick gather and form a drop, while the end is in a glass of paraffin oil, you will be able to see a much larger drop hanging from the stick and you will find that it is nearly quite round.

Such, too, is the shape of a rain-drop while it is falling. You may try this the next time it is raining by holding a sheet of paper so as to catch some of the drops. We can, however, learn still more from the drops formed at the end of the finger. Watch a few and you will see that each drop seems to have some difficulty in tearing itself away from the water that remains. The drop has to grow quite large and heavy before it can by its weight pull itself free. It is evident, then, that water holds together with considerable force. It is, in fact, this force which causes the drops to become round, for it makes the parti-

**NOTE.—This leaflet will furnish material for several short lessons.**

cles draw as closely together as possible. You can see another interesting example of the same thing if you hold the square end of a stick of sealing wax in a flame, for you will find that, as it becomes liquid, the sharp corners disappear and the whole end becomes round like the water-drop. This force which holds particles of liquid together is called cohesion.

Now, you all can tell me what will happen to a water-drop if it is left for some time where it falls. It will vanish. The first one which we allowed to drop on glass may already have done so. What has become of it? No one saw it going away, and if any one looked at it, he merely noticed that it seemed smaller each time he looked. But has it left nothing whatever behind? If you look closely enough you will probably discover that it has left a thin film or crust. Whatever this crust is, it must have been contained in the water-drop. You should see whether all kinds of water leave the same crust. Try, for instance, drops of spring water, river water, rain water, and also, if you can get them, a small piece of snow and a small lump of ice. We shall not, however, in this lesson, attempt to make a study of the crust that a drop leaves behind. Leaving it for another occasion, let us ask again what became of the water itself. Some of you will be able to tell me that it has become vapor or steam and is scattered in the air around us. It escaped in small particles that were invisible, and in this invisible form they are called water-vapor or steam. To this you may object that the steam formed by a boiling kettle is not invisible, but look closely and you will find that just where it issues from the spout it is invisible and only becomes visible a little farther on. It is true water-vapor that issues from the spout and what we see a little farther on is not water-vapor, but a little cloud of water-drops. Try putting a spirit flame beneath this cloud, and you will find that the drops are again turned into invisible vapor.

Thus we see that one way of turning water into vapor is to heat it, and that heat can overcome the force of cohesion, which holds the particles together. It would seem, however, that this is not the only way, for if we watch a little cloud from the kettle, we shall see that it gradually turns back again into invisible vapor, which spreads itself throughout the room. Sometimes, however, the cloud rises much higher than at other times, and it seems much less ready to turn into vapor. You will find that this is the case when the kettle has been steaming for a good while in the room and the doors have been closed. Now, this evidently means that vapor forms less readily when there is already a good deal of vapor in the room, and more readily when there is but little vapor in the air.

You may see the same thing on a much larger scale if you look at the puffs that come from a locomotive drawing a train. Sometimes there is very little smoke mixed with the steam, and the cloud that rises is like the cloud from the spout of the kettle. Look carefully and you will probably find that there is a space between the top of the smoke-stack and the cloud where nothing can be seen. Just above it is cooled by the air, and it shrinks into separate drops of water. If you could see inside the boiler you would find that the steam above the water is quite invisible water-vapor, and the same thing can be shown by boiling water in a thin glass flask such as chemists use. Notice the clouds thus formed by a locomotive, and you will observe that on some days they hang lazily in the air for quite a long time, and on other days they fade away quite rapidly. Observe what the days are like on which they disappear rapidly, and what the other days are like on which they disappear slowly.

It will help you to understand the matter if you will try some experiments to find how fast water will turn into invisible vapor. Turn a saucer upside down and you will see a shallow depression with a rim around it. Put the saucer with the bottom up somewhere out of doors where it will not be disturbed, and pour enough water in the hollow to fill it. Then find how long it takes the water to dry up. Do this on several days, and put down in a little note book the length of time it takes in each case. Note also in your book whether the day is cloudy or sunny, warm or cold, windy or still, and see if you can find any connection between these things. If you wish, you may use a wet rag hung from a clothes-line instead of the saucer. Always use the same rag and hang it up without wringing. Find as before how long it takes to dry.

We can now understand how real clouds are formed. Vapor is continually rising from the water on the surface of the earth, the process being greatly aided by the heat of the sun's rays. It is quite invisible until it rises high in the air. Now, people who have climbed high mountains and men who have gone up in balloons tell us that the air is much colder higher up than it is at the surface of the earth. We can understand, then, what happens to the invisible vapor when it rises high in the air. It is cooled and turned again into water-drops. These make up the cloud that we see far above us. If you watch the different clouds on a fine day, you will probably see some that look like large masses of cotton-wool. They are wavy or irregular above, but bounded by a sharp line below. The line marks the place at which the air becomes cold enough to turn the vapor into drops. If now a cold wind comes along and chills these clouds still more, the small drops will grow larger by more vapor turning into water, and finally they become large enough to fall rapidly as rain. You may sometimes, but not often, find that rain falls before any clouds are formed. This is due to a very cold wind suddenly blowing in and chilling the air a short distance above us, so that the vapor quickly turns into large drops, which fall as rain. You will find it interesting to note the direction from which the wind that brings rain usually comes. If you keep a list in your notebook you may soon become quite an authority on the weather.

After writing the last two sentences I remembered that it is sometimes very difficult to tell from what direction the wind really does come, and when the wind is very light you will probably find this difficulty. You may then try the method that sailors sometimes use when they wish to find from what direction a very faint wind is springing up. Wet one of your fingers and hold it up. Wait until it begins to dry, and you will feel one side of it much colder than the rest. That is the side of it on which the wind blows. You can detect the very slightest wind in this way. If you open the outside door of a warm room a couple of inches and hold a wet finger at the bottom of the opening, then at the top and then at points near the middle, you will be able to learn something very interesting about how air circulates.

But this experiment can teach us more than the direction of the wind. We learn from it that when water dries up from any surface it leaves the surface colder; that is, the vapor takes heat away with it. In fact, the heat is needed in all cases to turn the water into vapor. Try wetting one side of your face and then standing so as to face the wind, and then you will perhaps be able to explain why a little little wind is so very agreeable on a warm day. Is it because the wind itself is cool? There are some hot summer days when the wind does not seem to cool us at all. If you notice you will find these are days on which the air itself seems moist; some people describe the weather as "muggy." Can you explain why hot weather is so much more oppressive when the air is moist?

While speaking of the cold produced by water turning into vapor, let me suggest another experiment: Some hot summer day take two bottles of luke-warm water; wrap a wet towel around one and put them out in the shade where the wind will blow on them, and after the towel has nearly dried see if there is any difference between the two bottles as regards the taste of the water. You will then know how to get cool water on a hot day. If you find that on some days you cannot get this plan to work well, you should see if you can explain the cause.

But we have wandered somewhat from our subject, which was the fate of the water vapor that rises from the earth. We found that rain is one way in which it comes back, but that is not the only way. You will readily think of the dew that sparkles on the grass when the sun rises after a cold, starry night. Cold has a good deal to do with the formation of dew, but you may wonder why the stars are mentioned. With a little assistance you will find for yourself the explanation of dew and the connection between it and the stars, and you will then wonder why the explanation was never thought of until less than a hundred years ago. You must all have noticed what happens when a pitcher of cold water is left standing in a hot room. The outside of the pitcher soon becomes covered with moisture, which may even gather in drops and run down the sides. This is exactly the way in which dew is formed. The surface of the ground becomes cold at night and chills the air near it, and the vapor in the air then shrinks into drops.

I am going to ask you to notice on what nights dew is most plentiful. Before going to bed find out whether the night is cloudy or clear and whether there is much wind or very little. In the morning see whether there is much dew or little. We shall keep a record for a month, and at the end of that time you will be able to predict at night whether much dew will be seen in the morning, and you will be able to answer the question, "What have the stars to do with dew?" Take some care to notice, also, where there is most dew, on the earth, on grass, on stones or on metal articles, and whether there is more on the open grass or on grass under trees. You will also learn something interesting about the matter if you stretch a piece of muslin on four little stakes and notice how much dew is deposited under it. I must not, however, leave you with the idea that all dew comes from the air. Some part of the dew on a leaf actually comes from inside the leaf by means of small openings or pores.

But we have not yet mentioned all the ways by which vapor returns to the earth. We all know what snow is, although people who pass all their lives in the countries near the equator never see it. What is snow? Some still, cold day when the large flakes are just beginning to come down, catch some of them on the sleeve of your coat and look at them carefully. You will soon find that they are among the most beautiful things that you have ever seen. The flakes are all in the form of stars, shooting out rays on every side. Sometimes these rays are quite straight, but in many cases you will find that there are little raylets darting out from the main ray and giving it a most beautiful fern-like look. I am not going to tell you what these different snow stars are like. You can find out much more easily than I could tell you. You should draw pictures of as many as possible, and see how many different kinds of stars you can get. You will easily find half a dozen; others have found as many as a thousand. If you count the number of rays on each of the different stars you will find something very interesting about them. Perhaps the day on which you first try may not be a very good day for observing, for there may be too much wind and many stars may stick together or they may be too small. But persevere and you will find that some day you will get a good view of these snowy gems.

But we have not yet answered the question, "What is snow?" Snow flakes are not frozen water-drops, for if they were they would be round like water-drops. They consist of particles of water vapor which have been caught and fixed in position by some invisible power before they united to form water-drops. This power is not merely the coldness of the air, for that could not give the snow flakes their regular shape. The star-making power is something more than mere cold or even the cohesion which we spoke of before, but we shall not at the present time attempt to explain it. If you wish to find the effect of great cold alone on water vapor, fill a tumbler with a mixture of salt and snow and observe how the vapor particles from the air are deposited on the outside, owing to the intense cold produced by the freezing mixture. What you get here is much like the hoarfrost that takes the place of dew on very cold nights, and, in fact, hoarfrost is merely frozen water vapor which did not become liquid before freezing.

Perhaps you are somewhat surprised at the statement that vapor can turn into a kind of ice, such as snow or hoarfrost, without first becoming liquid water. Yet there is no doubt about it, and it is no more surprising than the other fact that snow or ice can turn into vapor without first becoming water. For instance, when there is very cold weather for two or three days together it is often found that the snow disappears, although the weather is quite too cold for it to melt. It has simply flown away particle by particle as vapor. You may have to wait a good while before you get a chance to observe this, but there is another way of noticing the same thing. The next time that clothes are put out to dry on a very cold day notice that the clothes can dry almost completely although it was certainly too cold for the ice on them to melt into water. You may say that it has melted into vapor.

Although snow does not consist of frozen water-drops, yet we are all familiar with frozen water-drops under the name of hail. These little ice balls come down sometimes in summer when the air does not seem cold enough to freeze water. But they must have been froezn somewhere before reaching the earth, and so we learn that there must be somewhere above us on a summer day places where the air is cold enough to produce ice. You can often see such a place, even on a hot summer day, if you wish. Look for a cloud that seems very high up, one that resembles hairs or feathers with their fibers curled. These clouds are sometimes called horse-tail clouds. They consist really of small pieces of ice instead of drops of water. When you see many of these clouds you may expect wind soon, or at least a change of weather. They are very high up, sometimes as much as ten miles. You must not, however, suppose that the hail actually comes from these clouds. It really is formed much nearer the surface of the earth by very cold currents of air. If the drops are first frozen into hail by cold air, and these frozen drops before reaching the earth have to pass through a thick layer of warm air, they are partly melted again, and we get what is called *sleet.*

We have said a good deal about water vapor shrinking as it is cooled until it becomes drops of water. What happens to water as it is cooled? Does it shrink? Try it for yourself in this way: Take a large glass bottle with a narrow neck. Fill it first with pretty warm water, merely to warm it up. Then pour this out and fill it with water that is nearly boiling. Tie a string around the neck just where the water stands, cork the bottle and put it where it can cool. Look at it as it cools, and notice that the level of the water falls steadily.

We thus see that water shrinks as it cools. Notice which part of the bottle is the colder and see if you can explain why. If the day is cold enough you may at last get the water down to the freezing point. You will find, however, that it does not go on shrinking right down to where it begins to freeze. A little expansion actually occurs before the freezing point is reached, but unless your bottle be very large and have a very narrow neck, you may not be able to see this. If you can get a small glass tube and pass it through the cork and then shove the cork hard into the bottle full of water you may make a very narrow neck for the bottle, and then you may be able to see this slight expansion of the water before it is quite down to the freezing point.

But what happens when the water actually begins to freeze? Leave the bottle of water out on a very cold night and see what has happened to it in the morning. You will find that the bottle has cracked, showing that when the water began to freeze it must have expanded in volume, and as the bottle couldn't expand also, the latter was shattered. So we see that while water vapor and water both shrink steadily as they cool, when water turns into ice it expands instead of shrinking, and therefore the ice must be less dense than the water. Now, any solid that is less dense than water will float on water, and so we see why ice always floats on water instead of sinking. Try this for yourself with a lump of ice and a tumbler of water. Try and judge how much of the ice is above the water and how much below. If you can judge very accurately you will find that there are about eleven times as much of it below as above.

How many different effects produced by this expansion of freezing water can you think of? There are some very important ones, indeed; but we must leave such questions as these for another leaflet.

No. 13.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## CLIMATE IN SOME OF ITS RELATIONS TO DAILY LIFE.

IN FOUR LESSONS.

BY PROF. H. A. HUSTON.

### I.

The weather is a continuous but very variable factor in our every-day life. We accept all kinds of weather as a matter of course and often underrate its influence on our affairs. Extremes of heat or cold, great storms and unusual phenomena attract passing attention. But the ordinary climatic conditions upon which so much of our comfort and welfare depends are practically unnoticed. Do you know what is the average temperature of the town in which you live? Do you know how much rain falls about you in a year, how it is distributed by months, and how it varies from year to year? The figures representing these facts are not exciting reading, yet the conditions that they record exert a most important influence on our health, our capacity to work, our ability to produce or obtain food and, in fact, on almost every act of our lives. Every one who has charge of workmen, students or invalids understand the ill effects of a dull or unseason-

**NOTE.--Some of the topics in this leaflet are difficult ones to present to very young people, but an attempt has been made to simplify the language as far as possible, and it is hoped that much of what is found here may profitably be presented by the skillful teacher to most of the children in the district schools.**

able day. These conditions are practically beyond our control, yet a careful observation of them, supplemented by a day's notice of what conditions to expect, will enable us to so adjust our affairs as to take advantage of favorable conditions and to reduce to a minimum the injury caused by the unfavorable ones.

## CLIMATE AND HEALTH.

Some people attribute all their ills to the weather. While this is, of course, an extreme view of matters, it is still true that a careful comparison of the weather and the health records for a long series of years shows that there is a well-defined relation between the prevalence and severity of certain diseases and the state of the weather. Rheumatism is one of the old weather prophets and pneumonia is a typical cold-weather disease, the dangers of which are intensified by sudden changes of temperature. Careful observation has shown that when the water in wells rises after a prolonged drouth there is a marked increase in diseases of the typhoid-fever class, owing to the germs being carried into the wells. In hot weather there is a great increase in the death rate of children, especially in the poorer quarters of large cities. Actual experiments have shown that this is in great measure due to disease germs carried in such food as milk. The hot, moist weather furnishes the most favorable conditions for the multiplication of the germs causing such diseases.

## CLIMATE AND COMMERCE.

It is difficult for one who has not been connected with a weather office to realize how great and how varied are the commercial interests that daily seek information regarding the weather conditions and how these interests are controlled by the information received. The shipper of perishable materials, such as fruit, vegetables and meat, knows what losses may be caused either by extreme hot or cold weather. Financial and humanitarian motives lead the shipper of live stock to scan the "probabilities" carefully. If a destructive hot wind occurs in the western part of the corn belt at a critical period in the growth of the crop, its effect is shown not only on the crop, but in every corn market in the world.

Railroads are most frequent users both of predictions and weather records, and reciprocate by rendering valuable aid in distributing predictions along their lines.

Great as are the financial benefits derived from an intelligent use of weather predictions, they appear insignificant when compared with the great saving of human life resulting from the system of storm warnings at lake and ocean ports.

October 8-14, 1882, a hurricane crossed Cuba, causing the loss of thousands of houses and cattle; 40 persons were killed. Its passage along the Atlantic coast was marked by violent gales and great damage to shipping, but urgent and timely storm warnings detained most vessels in port until the hurricane passed. Fifteen steamers and over 200 sailing vessels, representing a property value of from eight to ten million dollars, were held in New York harbor alone by timely notice of the violent storm. On the Labrador coast over 70 vessels were lost and about 100 men perished.

## II.

### CLIMATE AND CROPS.

The production of materials used for food and clothing employs the energies of the greater part of the earth's population. In no field of human activity is the influence of climate of such vital importance as in this. Not only do certain great groups of products require certain well-known conditions of climate, but in the zones adapted to the cultivation of these groups, what may appear to be only a slight departure from the average conditions may cause a disastrous failure of the most important crops, often accompanied by famine and pestilence in addition to the enormous financial losses. Such calamities are often viewed as dispensations of providence and thus beyond our control. Yet much may be done to reduce the ill effects of these visitations. If the last killing frost of spring be ten days later, or the first killing frost of the autumn be ten days earlier than the average, it may cause the loss of many millions of dollars.

A desert is bare not because it is infertile, but because of a lack of water. Some of the most productive lands in the world are portions of deserts to which water has been supplied by irrigation systems.

Drouth is the great cause of crop failure. In 1885 Indiana produced 45,000,000 more bushels of corn than in 1887, although more acres were planted in 1887. What was the cause of the enormous difference? During the months of June, July and August, 1885, 10.85 inches of rain fell; during the same months of 1887 7.20 inches fell, an average difference of less than one and a quarter inch per month for these three months, yet it made a difference in the value of a single crop of over $12,000,000.

## PROTECTIVE MEASURES.

A few simple observations will serve to illustrate the principles upon which the methods of combatting unfavorable conditions of climate in respect of crops are based. What can we do to reduce the effects of drouth? Our first observation is that only a part of the water falling on the land leaves it by the way of streams and rivers. The rest is *evaporated* from the surface of the soil or from plants. Can we do anything to reduce the loss from evaporation at the surface of the soil? Let us try a simple experiment. We will need a pair of scales, two tin buckets holding about four quarts each, a peck of loam and some water. The loam should be well mixed, free from stones and large lumps. Place the loam in a box which is not water-tight, cover it with water and allow the surplus water to drain off. Fill the buckets with this wet earth, placing an equal weight in each. The buckets of earth must be allowed to stand where they will be protected from rain and freely exposed to the air. The earth in one should be left undisturbed. So soon as the surface of the earth in the other is dry enough it should be stirred to a depth of about one inch, and this stirring should be repeated every few days in order to keep a layer of loose earth on the surface. Weigh the buckets of earth every few days and note the results. Why does one lose weight faster than the other? Let us see if this can be made clear to you by using a familiar fact as an illustration: How does the oil pass from the lamp reservoir to the flame? What would be the result if all except a few of the fibers of the wick were cut or if the top end of the wick should be made of material that did not readily permit the movement of the oil through it? When you have thought out the answers to these questions, you have the principle involved in the use of the mulch blanket of fine earth which is so valuable in conserving soil moisture and in carrying crops through prolonged periods of drouth. Frequent shallow cultivation is of great value in reducing the loss of water through evaporation from the surface of the soil.

Can we do anything to increase the water kept stored in the soil and to decrease the amount that is lost in streams? Do you not know of hillsides where heavy rains make gullies and the water carries the soil away? or of flat lands on which water stands until it "dries up?" Why is this? Because the water cannot enter the earth as fast as it falls. Often the washing does not begin as soon as the rain begins to fall; in this we may find the key to a solution of the matter. If the ground has been plowed five inches deep it may take up the water until this five-inch layer contains all it can hold. The water then passes very slowly from the plowed layer to the hard layer below. The excess runs off the surface and washes the hillside or stands on the surface of the flat land. Suppose the soil had been loosened to a depth of 15 inches, would it not have taken up three times as much water? If so, it would have taken up as much as falls in our heaviest rains, and no washing would have occurred. Three times as much water would have been stored in the soil for the use of the crops. If any one in your neighborhood subsoils his land, notice whether such land washes or dries out quickly. Subsoiling is performed with a special plow that follows the common plow. It loosens the subsoil, but does not bring it to the surface.

Some clay lands become puddled as soon as the rain wets the surface. After this the water enters such soils very slowly. Can a simple remedy be found for this? Procure some heavy clay, moisten it well with water and divide it into two equal parts. Work one part well and form it into a ball. Work well into the other part as much freshly slaked lime as will lie on a penny. Put both balls where they can dry out, and after a week break them and notice which breaks the more easily. If you are impatient you can get a quicker result by filling two clean bottles of equal size with muddy water from the roadside. To one bottle add a spoonful of lime water made by shaking an ounce of freshly slaked lime with a pint of water and allowing the coarser particles to subside. Allow the two bottles to stand a few hours and examine the deposits on the bottom of them. Notice the difference in the thickness of the layers and the appearance of the edges. Lime has the power of making the very fine clay particles group themselves in little flakes which do not stick closely to each other. When a few hundred pounds of freshly slaked fine lime are mixed with the surface soil of an acre of heavy clay the rain water enters it much more readily and the surface does not become puddled.

## III.

### PROTECTION FROM FROSTS.

In order to understand the theory of protection from frost we must keep in mind how dew and frost form. Water freezes at 32 degrees Fahrenheit. If some of the water vapor in the air deposits on plants or other objects which have a higher temperature than this the water forms in a shape which we call *dew*. But if the things on which the water deposits have a temperature below 32 degrees the water is deposited in the form of little crystals of ice, which we call *frost*.

We all know how garden plants are protected from frost by a simple covering of paper or cloth. Do we protect them in this way on a windy or cloudy night? The air under the protecting paper is not notably warmer than the air at the same height outside. What is the principle involved? In the early evening many objects, such as plants and things made of metal, lose heat faster than they receive it. It leaves in straight lines that point to the sky. These bodies lose heat faster than the air does; they therefore become cooler than the air above them. A frost may form on plants when the air four feet above them is at 40 degrees. If some body be placed between them and the clear sky the heat cannot readily pass off, and they remain at the temperature of the air. This body may be a paper, a layer of smoke or a cloudy sky.

But what is the frost? The air always contains some water in the form of invisible vapor. The amount is not the same at all times. One cubic foot of the air contains an average of about 1.3 grains of water in January and 6.5 grains in July. Heat perhaps has something to do with the amount of water vapor in the air? Yes; the temperature of the air determines the amount of water vapor it can contain. At our average January temperature (26.6 degrees) a cubic foot of air could not contain over 1.8 grains, and at our average July temperature (74.8 degrees) not over 9.3 grains of water vapor.

What happens when warm, moist air cools? Our air usually contains seven-tenths as much water vapor as it can hold. A cubic foot of air at 50 degrees would then contain about three grains. This is the total amount that air at 41 degrees can contain. If this air cools to 38 degrees it cannot hold all the water vapor. If the air be in contact with leaves or metals or other objects that lose their heat readily, the water from the air will condense on them, and we call it *dew*. If a cubic foot of the air at 50 degrees had contained but two grains of water vapor it could have cooled to 30 degrees before any of the water would have been deposited. But this is below the point at which water freezes. The vapor would then have been deposited in the form of minute ice crystals which we call *frost*. If a cubic foot of the air at 50 degrees had contained but one grain of water vapor it could have cooled to 11 degrees before any of the water would have been deposited. But plants would have frozen before any such temperature had been reached. Under these conditions the temperature would not usually fall to 11 degrees, and no ice particles would be deposited on the outside of the plants. This is the dreaded *black frost*.

The temperature at which dew or frost begins to be deposited is called the *dew point.* When water is converted into vapor a definite quantity of heat is absorbed. When the vapor condenses into water this heat reappears. Therefore, when dew begins to form, the temperature at the point where the dew is forming does not fall any more. Did you ever see a frozen dew-drop? Upon these principles is based the method of making local

FROST PREDICTIONS.

There is no simple way by which the quantity of water vapor in a cubic foot of air or the dew point can be directly found. But they may be found through the relation between the dryness of the air and the rate at which water is converted into vapor. In passing into vapor, heat is absorbed, and if the heat is taken from the water the temperature of the water will fall. Cooling a body by wrapping a wet cloth about it is a familiar example of this principle. Place the bulb of a thermometer in some water that has the same temperature as the room. Remove the thermometer, leaving the bulb wet, and notice the reading as the water evaporates from the bulb. If one end of a piece of old, clean muslin the size of a lamp-wick be tied around the bulb of the thermometer tube, entirely covering it, and the other end of the piece of muslin be placed in a cup of rain water (do not use well water) the water will be renewed about the bulb, and in about 15 minutes the reading will remain constant. Such an arrangement is called a "wet-bulb" thermometer. If the air contains all the vapor that it can hold at a given temperature there will be no evaporation from the muslin, and the wet-bulb and the dry-bulb instrument will read the same. Such air is already at the dew point. But if the air has less vapor in it than it can contain at the observed temperature, the water will evaporate from the muslin and cool the wet bulb. The temperature to which it will fall will depend upon the relative amount of vapor in the air. This in turn fixes the point at which dew or frost will form.

Now let us try to foretell whether there will be a frost or not. The instruments must be used at a distance from trees and buildings or if in cities, they should be used on roofs and exposed to free movement

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The common thermometers sold in shops generally read too high. Most of them are so bad as to be worthless. The errors range from 2 to 27 degrees. Thermometers made by Henry J. Green, of Brooklyn, N. Y., are always reliable. The form with a cylindrical bulb is the best. It is better to get two of them, one for the "wet bulb" work and one for the "dry" or "exposed" bulb. They may also serve as standards for checking other and cheaper thermometers.

of air. A rule which gives fairly accurate results when the temperature is at 50 degrees or below is to multiply the difference between the reading of the wet and dry bulb by 2.5 and subtract the product from the reading of the dry bulb. The number so obtained is the approximate degree to which the temperature will fall during the night unless the wind changes and blows from a moister quarter, or cloudiness intervenes. This is also the dew point. On a fine, clear day toward evening or after sunset, suppose we find the dry bulb reads 49 and the wet bulb 39. Then 10 times 2.5=25; 49—25=24. You may be sure that a frost will occur. If the readings are 49 and 45, we have 4×2.5=10; 49—10=39, and no frost will occur. If the readings are 49 and 42, we have 7×2.5=17.5; 49—17.5=31.5; a light frost will probably occur and tender plants should be protected. By the use of dew-point tables published by the Weather Bureau somewhat more exact results may be obtained. But either method gives results that may be of great value in protecting perishable crops.

## IV.

### THE WORK OF THE WEATHER BUREAU

The United States has the largest and best weather service in the world. Observations are taken at 8 a. m. and 8 p. m., Washington time, at over 100 regular and at several hundred volunteer stations. The observations taken furnish climatic records of very great value and are at once utilized for the purpose of predicting the weather conditions for the 36 hours following each observation, and issuing storm and frost warnings when necessary.

A description of the instruments and the methods of using them may be found in a pamphlet called "Instructions to Volunteer Observers," issued by the Weather Bureau.

The lesson for us is that the present magnificent system which saves thousands of lives and many million dollars worth of property every year is the outgrowth of careful observation of local phenomena. The foundation of our knowledge of American storms is said to be the observation of Franklin, that the severe coast storms in which the wind blew from the northeast reached Philadelphia before they did Boston. A further study of the matter developed the fact that while the wind moved from the northeast the storm itself moved toward the northeast. It was found that the winds in such storms did not blow in straight lines, but in spirals. At the common center of these there was an area in which the air pressure was low and the wind circled about this center moving in a direction contrary to that of the hands of a watch. If you will place a circle of card-board on the map of the United States in such a position that the western one-third of the disc rests on the State of South Carolina and the eastern two-thirds rest over the ocean, and then move the disc northeast parallel to the coast, at the same time rotating the disc so that its northern edge moves to the west, you will form a very good idea of the movement of such a storm center and the winds that circle about it. Such storms may be several hundred miles across. They are called cyclonic or low-area storms. Many of them move across the United States every year coming from west of the Mississippi River and generally moving a little north of east at the rate of 600 to 900 miles per day. East of the storm center the air is warm and moist, frequently rains fall, the winds are from the south and east and the barometer falls. After the storm center has passed, the weather clears, the air becomes dryer, the temperature falls, winds come from the north and west and the barometer rises. When such storms are accompanied by high winds they are called cyclones or hurricanes. We should distinguish sharply between *cyclones* and *tornadoes*. A cyclone is a great storm 200 miles or more wide and its path is often 2,000 miles long. A tornado is a local storm of great violence, 100 to 600 yards wide and from one to 50 miles long. It generally has a funnel-shaped cloud that rotates and moves forward in the same way as a low-area storm. The area of greatest violence moves forward from 20 to 50 miles per hour in nearly all cases from southwest to northeast. Tornadoes are associated with low-area storms. They are likely to occur 200 to 300 miles southeast of the low-area, at points where the air is both very warm and very moist. In the lower Missouri and the upper Mississippi valleys tornadoes occur more frequently than at any other point in the world. You can determine the direction of a low pressure area very readily. If you stand with the back squarely to the wind, the low area is always to your left. The experiment is easily tried and you can verify it by the observations of the weather bureau which are published in the large daily papers.

There is another kind of storm which is just the reverse of the low-area of cyclonic storm. In its center is an area of high pressure about which the winds rotate in the same direction as the hands of a watch. It is not a storm in the common meaning of the term since it is associated with clear, cool, dry weather. It is often called an anti-cyclone. Just as the low-area storm is often associated with the tornado, so the anti-cyclone is often associated with the *cold wave*. This term was coined by the Signal Service and means that the temperature will fall to at least 45 degrees and that the temperature at a given hour (as 3 p. m.) to-morrow will be at least 15 degrees lower than it is at the same hour to-day. Cold waves do not go with every anti-cyclone, for in July the temperature rarely falls to 45 degrees, but there never is a cold wave without an anti-cyclone. They originate in Canada just east of the Rocky Mountains and follow three general courses—one from west to east along the Great Lakes, another from Manitoba directly south to Texas, and a third in a southeasterly direction. This last course crosses Indiana.

The knowledge of the general movements of low and high areas is the basis of the prediction of weather conditions. Twice each day the forecast official receives telegrams giving the conditions at a large number of stations. These he enters on a map and after observing the changes since the last observation, he ventures to predict what will take place during the next 36 hours.

The movements of storm areas are influenced to a considerable extent by local conditions, such as the presence of lakes, river valleys and mountain ranges. The forecast official must know not only the laws governing the general movements of the storm areas, but he must also keep in mind all these local variations. He is the most successful forecaster who knows best the effect of these local conditions. These are learned only by constant observation of the things about him, and here we have another illustration of the fact that the soundest and most useful knowledge is that which we derive from a careful observation of the things with which we are daily brought in contact.

## LITERATURE.

The only suitable work for general reading for American students is "American Weather," by Gen. A. W. Greely. New York: Dodd, Mead & Co., $2.50.

FOR THE USE OF TEACHERS.

No. 14.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## THE GERMINATION OF SEEDS.

BY PROF. J. C. ARTHUR.

I brought in a handful of acorns from the woods some days ago, and threw them into a dish of water to rinse off the dirt. Being a warm day, although in February, I had taken a stroll to enjoy the springlike air and see what could be picked up of interest.

Under the trees, among the dead leaves I found quantities of acorns, some still in their scaly cups, just as they grew upon the trees, and more yet that had dropped out of the cups and now showed the large round scar where they had been attached. Most of the acorns were well covered with fallen leaves and snugly enough tucked away from cold winds and weather. Of course, every one knows that there is a plant inside of the acorn, because we all have been told that "great oaks from little acorns grow."

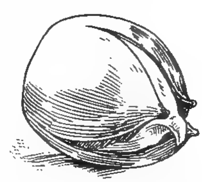

FIG. 1. A germinating acorn.

It was odd to see how much the color of the acorns made them look like the dead leaves, sticks and soil, in which they were partly buried. I thought if the squirrels had as much trouble to see them after they were uncovered as I did, they might sometimes go hungry, even with plenty of acorns right before them.

This made me think to taste of an acorn, just to see if it would be good to eat. So I cut one open and tasted ever so little of it, but didn't swallow any; for you may be sure that I was not going to eat it until some one who really knew told me it was all right. But the acorn I tasted was bitter, and I think even squirrels would not care to eat such bitter food if any other could be obtained. It may be all acorns do not taste the same. I mean to taste of the different kinds, and also watch the squirrels, when I go out next time.

While I was wondering if there were any animals that really liked bitter things to eat, I noticed one of the acorns had a small hole in the side of it, and at once suspected that there was a worm inside. Cutting it open, I found no worm, for it had already escaped, and had left behind only some brown stuff like wet sawdust, in the place of the kernel.

I now noticed for the first time that about half of the acorns I had thrown into the water when I came from the woods had sunk to the bottom and the others floated. (See Fig. 2). I cut into some of them and found that the ones that floated were quite brown and dead inside, and some had white worms in them; not exactly worms either, but larvæ that will probably change into some kind of insects. I intend to plant the rest of the floating acorns in a box of dirt, and tie a piece of mosquito netting over the top of the box. If I keep the box in a warm room, and do not have it too wet or too dry, the insects ought to come out after a time, and as they can not get away, I shall be able to see what they look like. There may be a good many kinds that like to eat acorns; we shall see.

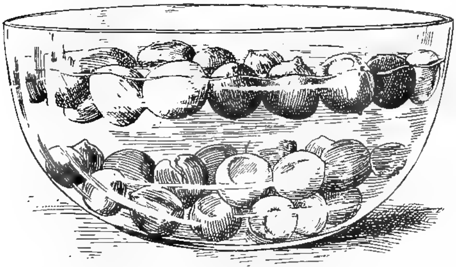

FIG. 2. A dish of acorns; the bad ones floating, and the good ones at the bottom.

The acorns that went to the bottom of the water I planted in a box of soil in a sunny window, and they are already coming up. The young oak as it comes through the ground is a rather curious plant. It is a slender stalk, without leaves at first, at least not true leaves, but with a number of small scales, set in pairs. The upper end is bent over as it comes from the ground, which is a way it has to protect the growing end from injury when pushing up through the rough soil. It is as if a boy should lift up a cellar door from beneath by putting his shoulder to it, so as not to injure his head. Potatoes when they are coming up through the ground do the same thing, and many other plants.

More curious things yet are going on under ground. Dig up some of the young plants and wash off the dirt. It was fortunate that I planted them in a deep box, for what long straight roots they have, ever so much longer than the stems. Some that have just started to grow show that the root comes out of the seed first, and grows straight down into the soil, with only very few small side roots. (See Fig. 3.)

The root always breaks out at the same end of the seed and the shell usually splits so as to make three points. Why three points, rather than any other number? It has been found out that when the acorn is very young, still in the flower (it may be you never saw oak flowers—look for them in the spring), there are three parts to it, and two plantlets, *embryos*, to each part, all too small to be seen except with a strong microscope. One embryo usually gets ahead of the others, and grows so fast that it fills up the whole acorn, and the other five perish for want of room. Sometimes two embryos grow; and by hunting long enough one might find an acorn with two kernels, that is, with two grown embryos. Even three might be found, and possibly more, even as many as six in one acorn; but that would be far more difficult than finding four-leaved clovers. If you come across two or three young oaks coming up together in the woods, dig down and see if they come from one acorn.

Now, pull off the three valves of the acorn shell and the kernel separates into two parts. It is not hard to see that these are really two very thick leaves on short, flat stalks, and that the stem grows from between them. The seed leaves are called *cotyledons,* and they are of all sizes and shapes in different sorts of seeds. When thickened they hold food for the young plant, until it can get well established with roots in the soil, and leaves spread out to the light. So what is food for squirrels and worms, and small boys and girls, is food for young oaks. Thus plants and animals evidently like the same kind of food, and thrive on it.

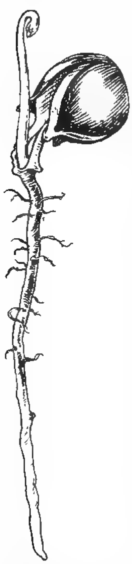

Fig. 3. An oak seedling before it has broken through the ground.

If some of the acorns are uncovered as soon as they start to grow, and the shell pulled off, the cotyledons will spread apart after a time and turn green. But they never look very much like ordinary leaves, for their greatest use is to hold the food for the little plant, stored up by the parent oak, and not to make new food.

I have noticed that the exposed cotyledons have not only turned green, but they are quite red in places. And I see that the young stems are decidedly red, too, now that one's attention is directed to the matter. Red is sometimes called a warm color, and such it is in very fact; for the stems and leaves retain more of the sun's heat when they are red. So that many young shoots in early spring, before settled warm weather arrives, are red to help them keep warm enough to grow well.

It is very interesting to start different kinds of seeds, and see how they behave in germination. Peas will be found to have many resemblances to acorns in their mode of growth. The two thick cotyledons normally stay underground, and there are scale leaves on the young stem before the true foliage leaves appear. Don't forget to compare the roots, the way the stem pushes through the soil, and the color. The pea has no hard shell, but it has a skin to protect it, which becomes soft when soaked. By looking in the acorn we shall find that the kernel really has a skin about it, only it is thin, brown and papery. Then if we remember that the pea grew in a pod that was dry and hard when ripe, we shall see that the acorn and the pea are more alike than appeared at first; even the half-dozen peas in a pod only show that more grew up than in the case of the acorn.

Plant some scarlet runner beans, and some common field beans. The first behave quite like peas, but the second carry their cotyledons up into the air, and turn them into quite fair foliage leaves, but not at all the shape of the leaves that follow. Try some pumpkin, tomato and onion seeds, and notice the different ways they adopt to establish the young plant. These seeds can be planted at any time during the year, while the germination of acorns can not be readily observed except during winter and spring.

In the case of corn there are differences that are not clear at first. The seed remains underground and acts as a source of food supply for the plantlet. The first leaves are short, as they are in the oak and pea, but enwrap the stem, and are placed singly, instead of in pairs. This leads us to suspect that there is only one cotyledon, and that it must be held fast in the seed. Let us try and separate it. The best we can do is to tear away the germ, but it has carried the roots and stem with it. This soft white germ is in fact the cotyledon. It does not have the stored food inside of it, as with the acorn, but outside of it, and so is grown fast to the storehouse, and sucks out the nutriment as the plantlet needs it for growth. If the seed is planted deep, the stem is very long from the cotyledon to the base of the first leaf, so as to bring the first leaves above ground. Roots are formed at this first joint after a time. We must not forget to look at the roots that spring from the seed and notice how very different they are from those of the acorn. Possibly some connection can be found between the disposition of the first roots of the seedlings and the rooting habits of corn and oaks when full grown. Who knows whether these plants have roots that go down deep into the earth or that spread out close beneath the surface of the ground?

If some seeds are grown between blotting paper or folds of cloth laid in a dish with just enough water to keep them moist, and another dish turned over for a cover to prevent the whole from drying out, some more important and curious things can be seen. The roots will be nearly covered with white, delicate root-hairs, that collapse and wholly disappear if kept in the open air for a time. At the tips of the roots and back a ways from the tips there are no root-hairs, this being the part that pushes through the soil; and there are none on the oldest parts of the roots, but for a very different reason. Some kinds of plants produce more and larger root-hairs than others; they are so small on the oak seedlings that I have to take a magnifying glass to see them. Examine roots growing in earth and notice how the hairs cling to the particles of the soil. It is the way the plant has of getting nourishment out of the ground. The root-hairs help to dissolve the solid particles, which they afterward absorb, together with moisture and any nutrient matters held in the soil water.

I have just tried growing some seeds in a covered dish fixed up with wet blotting paper, so that the seeds are kept damp enough, but the roots have to grow out into the moist air of the dish, and I have found out a number of strange things that I did not suspect before. When I go for acorns next time I intend to look for walnut, hickory, sycamore and other tree seeds, and also for various kinds of weed seeds, and it may be that I can find some little plantlets already started. It seems much easier to see all these curious things now that some of them have been pointed out, than when I brought in my first handful of acorns.

FOR THE USE OF TEACHERS.

No. 15.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## OUR INSECT FRIENDS.

BY PROF. JAMES TROOP.

In a former Leaflet you were told that fully four-fifths of all the animal life upon the globe belongs to the great tribe of insects. Now, do you not think that it would be very strange, indeed, if, among all of the many thousands of different kinds with which we are daily surrounded during the summer, there were not some which we could call our friends? Have you ever thought about it? Is it not true that you have been in the habit of thinking of every kind of insect as being your enemy? I suspect that you have sometimes called the honey bee hard names because it stung you when you got too near its hive or because you pinched it when it was quietly sipping the sweet nectar from a flower in the garden. And I imagine that you have thought of the bumble bee as a good-for-nothing old fellow when you knocked him off a clover blossom and then accidentally stepped upon him with your bare foot. In each case the bee was simply trying to protect itself against such harsh treatment. I suppose that you did not stop to think that the honey bee was working hard at that moment in storing up honey for your benefit, and that without the bumble bee your father's clover plants would not produce any seeds, and that without clover seed we should have no clover.

I think that you can see that our insect friends may do us good in many different ways. For example, some may give us something good to eat, while others may show their friendship by preventing our insect enemies from injuring us or our crops.

Let us see if we can not divide them into two classes. In one class we will put those that produce something we can eat, or wear, or that we can use in some other way. In the second class we will put those which help us by destroying our insect enemies.

Now, which ones shall we place in the first class? There are only a few, like the honey bee, the silkworm, the cochineal bug and perhaps the blister beetles.

The second class will not be very large either. Here we might name the lady bugs, a number of the larger ground beetles, and two or three families of little flies, which are commonly called parasites.

Now let us talk about some of the members of the first class for a little while. Let us take first the honey bee. How many kinds of material do we get from the honey bee? Two—honey and wax. Of course, every farmer's boy ought to know that. Now, where is the honey made? Do the bees gather it from flowers? A good many people think so, but let us see. The next time you find a clover blossom pull out a single flower and suck out the sweet substance which it contains. Is it honey? No, you say it does not have any of the peculiar honey taste about it. It is simply a sweet substance called nectar. It is not honey until it has been manufactured by the bees. This is such a difficult operation that I think you will have to wait till you get older before attempting to learn how it is done.

Now, can you tell where the bees get the wax? Do you think they gather that from plants also? A good many hundred years ago people thought that the bees used the little yellow balls, which we sometimes see clinging to their hind legs, for making wax, but now we know the little yellow balls are made of pollen which the bee gathers from flowers for the purpose of feeding its young and that the wax is secreted from their own bodies in much the same way as a cow secretes milk. The wax forms in little scales on the under side of their bodies and when they want to use it they pick it off with their feet and after mixing it in their mouths, they use it in building their combs and in making the little pockets in which they store the honey.

How many of you know how many kinds of bees there are in a hive? If your father keeps bees you have probably heard him talk of the "queen," the "workers" and the "drones." It is very easy to distinguish between these different kinds of bees if we observe them a little closely, but I doubt if many of you have done this because, as a rule, people do not care to get very near to bees, especially when they are at work. You need not feel afraid of them, however, for the bees are like our domestic animals; if we treat them kindly they will usually treat us in the same way.

This is especially true of the queen, who is the largest and most important bee in the hive. Of course, then, like other queens, she must have a larger and finer house to live in than those her subjects have. If you should examine the living room of the queen bee you would find that it is nearly four times as large as those of the other bees. It is about the size and shape of a peanut and is usually placed on the edge of the comb.

The queen is the mother bee and lays all the eggs. How many do you suppose she can lay in a day. One writer tells us that he had a queen bee that sometimes laid more than three thousand eggs in a single day, and that she continued to lay at intervals for more than five years. Of course, there are some seasons of the year when she does not lay so many, and other seasons when she stops laying altogether, but it does not take long for her family to become so large that the hive will no longer contain it. What do you suppose happens then? They prepare to found a new colony, or in other words, they "swarm." Have you never seen a cloud of bees come out of the hive and light upon some tree or bush near by, then after a while fly away? If the bee farmer has been watching them and is familiar with their habits he has a new home ready for them, but he sometimes has to use a good deal of ingenuity to get them to go into it. If he has not been prepared for their swarming they frequently get away from him altogether and fly off into the woods.

Now, why do you suppose they lighted on the first tree or bush? It was that they might be sure their queen was with them. A swarm will never permanently leave a hive without a queen bee. If they find that she is not with them, they will return to the old hive, wait for a time and then make another attempt.

But, you say, if the queen goes with the new colony, who is to govern the subjects she leaves behind? The workers have prepared for that. They would not allow her to leave them unless they had her successor ready to take her place. An egg has been laid in the queen's cell, and the young, larval queen has been fed upon what is called "Royal Jelly." This food is very much richer than that fed to the workers or the drone *larvæ*, and it is this that causes the difference in the size and structure of a queen. In case of an accident to their old queen, the bees have a curious way of getting a new one very quickly. The drones select three cells which contain *larvæ*, knock out the partition walls, kill two of the *larvæ* and feed the third on the Royal Jelly.

The "workers" are the most numerous as well as the most active class among the bees. How many should you think there were in a good, strong colony? The number varies, of course, but usually there are from 30,000 to 40,000, and each bee has its own particular work to do. If you could look into the hive when they are all busy you would find the young bees building the comb, feeding the *larvæ*, and doing general housework; those a little older would be secreting wax and helping their elders in shaping the pockets for storing the honey which these older bees bring in.

We have learned that the queens sometimes live four or five years,—now, how long do you suppose these workers live? It depends a good deal upon the time of the year at which they are hatched; if late in the fall, they will live until the next spring, but if during the busy season in summer, they work so hard that they wear themselves out and live only forty or fifty days.

And now there remains only our third class of bees—the "drones." These are the male bees. They are larger than the workers, but have no sting and are altogether very lazy, useless fellows. We might call them the "tramps" of the bee family. Sometimes the "workers" grow tired of feeding and caring for them; they will then kill them and throw them out of the hive.

How much honey do you suppose is made in one summer by a good hive of bees? The amount will depend very much, of course, as to whether or not there has been an abundance of flowers for the bees to work upon, but I know that a great many pounds, often twenty-five or thirty, have been taken from one hive, and that when swarms of bees have wandered off to live in a hollow tree the hollow has been found to be full of delicious honey. Different varieties of bees vary in their ability to produce honey. I presume your father would tell you that the Italian bees are the best kind to have, because they begin their work earlier in the morning and continue it later in the evening. Then, too, they have a longer tongue than the black bees and can get nectar from flowers which the black bees can not reach. Best of all, they are much more gentle and easy to handle.

I think, perhaps, the silkworm is next in interest of our insect friends. Not many of you will be able to see just how silk is made, so I will talk about it a little while. In the first place there is a beautiful large moth which lays the eggs which hatch into the *larvæ* or silkworms. These worms are then fed all the mulberry leaves that they can eat until they are full grown, when they spin a silken cocoon around themselves, completely shutting themselves in; then they change to the *pupæ* state and remain quiet for a few weeks.

Now, if you leave these *pupæ* long enough they will burst open their cocoons in much the same way that the mosquito does and thus many of the threads of silk will be broken, so at this time men take these cocoons and put them in an oven and bake them so as to kill the *pupæ*. Then the cocoons are placed in hot water and the silk is wound off and used for making thread, cloth, etc. If you will watch the large caterpillars, which feed upon the apple and cherry leaves next fall as they are getting ready for winter you may see just how the silk threads are made.

Can you think of anything else that we get from insects? Well, there are a number of insects which furnish us with dye stuffs. One of these belongs to the order *Hemiptera*, or true bugs. It feeds upon the cactus plant and is known as the cochineal bug. It secretes a coloring material from its body which is used in coloring candies and other things. They are very useful, but as they do not live in this climate, we will pass on to another one with which you are all acquainted. This is commonly called the blister-beetle. Members of this family are long, black and striped fellows, which we often find doing so much injury to the potatoes, beets, etc. You did not suppose that these insects were of any use, did you? Most people do not consider them so. Why do you suppose they are called blister-beetles? It is because they are used for making blister plasters. The beetles are killed, dried and then pulverized and the powder is made into paste and used by the doctors to produce blisters. In this way they become very useful in curing certain diseases.

Now, we come to the second class, which, I think, is the most friendly of all, because without its aid our crops would frequently be entirely ruined by the injurious insects. These are flesh-eaters and so are called *carniverous*, because they feed upon other insects. Some of these kill only as many as they want for their immediate use, while others place their eggs either upon or within the bodies of the *larvæ* of other insects and, as they hatch, the young feed upon them and so destroy them.

In this class we may place many of the beetles—those with the hard wing covers. Among these are the Tiger beetles. Of course, you all know what Tiger beetles are. Those long-legged, bright-colored beetles which run very swiftly, and nearly always go hunting in the hot portion of the day. There are a number of other kinds of ground beetles among our friends, but they hunt for their prey after night and hide during the day under stones and logs. Now, do any of you know where the young Tiger beetles live? They cannot run as fast as the full-grown beetle, so they have to adopt some other plan to catch their prey. It is very interesting, and you may see them this summer if you watch carefully. This is the way they do it. The *larva* digs a little well in the grassy sod just large enough to admit its body, then it gets down into it so that its head is just below the surface of the ground, and then waits—for what? For some unlucky insect to come crawling along over its hiding place, when, like a flash, up goes its head and its stout jaws are securely fastened into the body of its victim and it is dragged down into the well and devoured.

I wonder how many of you know the "Lady bugs." I hope that you all do, because they are among our very best friends. Some people who have not studied about insects suppose these little beetles to be injurious, but they are not. The next time you see some of these little spotted fellows crawling over the fruit trees or rose bushes just watch them closely and see what they are about. They will appear to be looking for something, and pretty soon you will see one pick up a green plant louse, suck its blood, toss the dry skin away, and then look for another. This they keep up day after day all summer. Thus they destroy an enormous number of plant lice, which, as you know, if left to themselves, would do a great deal of damage to the young plants. The young lady bugs are even greater eaters than the full-grown beetle. I wonder how much a wide-awake lady bug can save in this way each day. I cannot tell you, but I know that in a large market garden they may save many hundreds of dollars' worth of vegetables each year.

I wish now to speak to you for a moment of two families of the *Parasites.* What are parasites, I hear you ask. They are plants or animals that get their living by feeding upon some other plant or animal. For example, if your father keeps sheep, you have probably seen the sheep ticks which get on the little lambs and worry them so much. These are parasites, and your father will tell you how destructive they are to the lambs. But since these must be classed among our enemies, we will not talk about them now. The friendly parasites of which I wish to speak to you are two families of flies. They differ a great deal in size; some of them are quite large, while others are very small, but they all work in the same way, though in different insects. Would you like to know how they work?

If you will examine the oat plants carefully about the time they are nicely headed you will probably find a large number of plant lice busily sucking the juice out of the plants. It would not take them long to destroy the whole oat crop. Now, if you will watch carefully you will probably notice a little black fly very actively engaged about something. Look closely and you will see it apparently sting the plant louse. You will find that there are a great number of these little flies, and all hard at work. What are they doing? They are laying their eggs inside of the bodies of the plant lice and when these eggs hatch the young flies will feed upon the lice and soon eat them up. If you will look again in a week or ten days you will probably find that the lice have all disappeared and the oat crop has been saved.

One more familiar example. Go into the garden in August and September and examine the tomato worms. Some of the worms will be almost completely covered with little white objects that look like little eggs. Look at them more closely through your magnifying glass and you will see that they are little cocoons. Where did they come from? This worm has had a great many little eggs laid within its body; they have hatched and the young, having fed upon the worm until they were full grown, have come out and spun little silken cocoons upon the outside in order that the full-grown flies may get out easily when the proper time comes. The worm, which is very destructive to the tender plant, will soon die.

There is still one family of flies of which I wish to speak to you. The flies are very small, in fact, among the smallest of all known insects, but there are so many of them that the family is a very large one. As you will not be able to see them, I will tell you how they work. The female fly bores a tiny hole through the shell of the egg of some other insect and lays her egg inside of the other. When it hatches the young fly or *larvæ* feeds upon the other egg until it is full grown. In this way great numbers of injurious insects are destroyed while yet in the egg.

I think now you will understand why these little insects of which we have been speaking should be classed among our insect friends.

No. 16.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

# BUTTER MAKING FOR YOUNG PEOPLE.

BY PROF. C. S. PLUMB.

Each year, during the week of the State Fair at Indianapolis, one day is devoted to the children. This is known as "Children's Day," and every boy or girl who wishes, by the generosity of the Indiana State Board of Agriculture, on this day is allowed free admission to the State Fair grounds, where many interesting and instructive sights can be seen. Thousands of happy boys and girls crowd the grounds, and their bright faces are to be seen everywhere. They see and learn many things. If they go into the Dairy building and look around carefully, they see a very large refrigerator with glass sides, built into the room, in which are many tubs and packages of beautiful yellow butter. The State Board of Agriculture offers prizes to the people who will make the best butter and show it at the fair. This butter in the refrigerator was made to compete for the prizes offered, and it is supposed to be of unusually good quality. This butter is all carefully examined by an "expert judge," who critically studies it in every way. He grades it for its flavor, color, texture, the amount of salt in it, for its general appearance, and finally awards the prizes for the best butter.

Now, would it not be a good idea for the school children of Indiana to learn something of how nice butter is made, so that they might know how to make butter that they could show with pride at the county, or, if you can go, at the State Fair? Think how interested the people would all be in a show case filled with beautiful yellow butter made by school children. How proud the teacher of your district school would be to show her friends such an exhibition. No doubt the fair directors would be glad to encourage in some way such an exhibit. Did you ever think of what a difference there is in butter and its value in the market? Let us take a simple, every-day example.

Two women drive to town, each with some butter to sell. They go to the same store. One places pound prints, neatly wrapped in special butter paper, before the store-keeper. The other puts on the counter unshapely lumps, wrapped in none too clean white cloth. That in the paper, on being unwrapped, is seen to be of a beautiful yellow color, of firm texture, with a flavor of the most appetizing character. The other, removed from its cloth, is unattractively white, somewhat soft, and with a flavor that but few people enjoy.

One person receives 20 cents a pound for her product, the other 14. The store-keeper desires to buy the one of fine flavor and attractive to the eye, for such is always in demand. The other he can sell only as an inferior article, with a slow sale at that.

Why should there have been so much difference in these two lots of butter?

If you can learn how to make such butter as the woman received 20 cents a pound for, then you need not be ashamed to show it to your friends. You might, perhaps, make a creditable exhibit at the fair, among much older people than yourself. So we will consider some of the important things, a knowledge of which is so essential to success in the process of butter-making.

If we could examine a drop of milk under a powerful microscope we should see a quantity of very minute, roundish bodies of a pearly appearance, floating about in the fluid. These are so small that it takes from 15,000 to 25,000, placed side by side, to cover the length of an inch. These little particles are the fat of the milk, and from these butter is made. They are lighter than milk and so gradually float upward toward the top of it in the pan or can, where, mixed with a little of the milk at the top, they form cream.

Now, cream is really exceedingly rich milk. One hundred pounds of common milk may contain four pounds of butter, while 100 pounds of cream may have twenty.

Did you ever notice how different milk is as regards the amount of cream it contains? Here is a pretty chance to experiment. Get four bottles that are rather tall and made of clear white glass. Bottles six or eight inches long will do. Fill each of these up to within half an inch of its neck. Put in bottle No. 1 skim milk; in No. 2 the milk from a black and white cow; in No. 3 that from a red cow, and in No. 4 the milk of a Jersey cow. Place these bottles in a cold room or refrigerator and let them stand over night. The next day you will find each bottle contains a layer of cream on top of the bluish-white milk. Now, what is the difference in these milks in the amounts of cream they contain? Measure them and find out how much is cream and how much is milk in each bottle. This will show you how much milks differ in the amounts of cream they contain. It will also show you that it requires very careful skimming to get all the cream from the milk. If you have no such cows as the above to make an experiment with, then select three cows from among those that you do have at home, with which to make the experiment. They will do. Then report on the results.

If this cream we have been considering is placed in a churn and dashed and swashed about, the little particles of fat begin to hit together and stick to each other, so that if the conditions are right, in a little while they unite to form small pieces of butter about the size of a mustard seed or perhaps a grain of wheat. Then the fat or butter becomes visible to the eye, floating in the white buttermilk. This fat may then be taken from the milk and worked up into lumps, such as is sold in the stores.

Now, we wish to find out why one person makes good butter and another person poor butter.

Milk is the parent of butter. It is an interesting liquid, and is peculiar in that it absorbs or takes up bad odors. To illustrate this, get some fresh, warm milk and place in a box or room containing, say, cabbages or onions, and let it stand there an hour or so. Then place it in a clean, sweet-smelling room, and leave it till the following day. When you next examine it, smell and taste of it, and report upon its odor, or flavor. Does it taste like the milk you are accustomed to? After being in the sweet room for a day, does it lose the bad odor? No doubt you will have an interesting report to make, but it will surely also interest you and your schoolmates if you will try another experiment. At noon, if your father will consent, feed a cow a small amount of strong-smelling vegetables, such as cabbage, turnips or onions. At night, after she is milked, drink some of the milk and try its flavor. Also let some of it stand until it becomes cool, and then taste. Do you notice anything peculiar? You will be quite sure to, for such strong-smelling vegetables, when eaten by a cow a few hours before milking, will taint the milk. This will show you how sensitive milk is to odors, and that it will even absorb them before it is drawn from the cow. So we must be careful where we place milk, in order to keep it pure and sweet. We must also keep it in very clean, nice pans or cans, and the cow must be fed the sweetest and best of foods.

Butter is really a part of milk, and like it will absorb strong odors of any kind. This you can easily learn, if you will. Go to a store where the butter is kept in refrigerators or boxes that are not clean, and smell and taste of it. You will be surprised to find that butter tastes of so many different things. I am sure it will interest the teacher and children if you will report your discoveries in this butter box. You also can carry on a simple little experiment at home. Take one of the nice, sweet lumps of butter your mother has made and cut it into two parts. One part keep in a clean, sweet room or box. Place the rest in a box that has had some kerosene (coal oil) spilled on the inside of it, and keep it there over night. Now, every one will be interested to know if there is any difference in the flavor of the two halves of that lump of butter. You should be able to tell.

I am very sure that your various investigations will show that both milk and butter absorb strong odors, and so themselves become of bad quality, thus injuring their value. So does this not teach us that it is important to keep all milk and butter in a sweet air and in very clean vessels if we are to have agreeable tasting food of this kind, and wish to get the best prices for it?

After obtaining the cream from the milk, by skimming, it is necessary to churn it to secure the butter, and as has already been said, this is done by a dashing process. The vessel the cream is dashed about in is the churn, of which there are many different kinds. The best churns are usually of the simplest make.

Several things combine to make the operation of churning easy or difficult, and to produce good or poor butter. Among these may be mentioned—

**1st. The kind of churn.**
**2d. The kind of cream.**
**3d. The temperature of the cream.**
**4th. The temperature of the room.**
**5th. The washing of the butter.**
**6th. The salting and working of the butter.**

Let us briefly consider these points.

### 1st. THE KIND OF CHURN.

Generally speaking, a churn that contains a dasher or paddle will not make as good butter as will one that is free of such things. The dasher bruises or smears the butter, so as to injure what is called the "grain." These dashers are not really necessary, for cream dashed against the sides of the churn which contains no sticks or paddles will yield butter in a very few minutes. For this reason the best churns now made are barrels or boxes, without dashers, that either turn over and over or swing back and forth while churning.

Will it not be possible for you to get some information about churns? Visit some of the butter-makers in the neighborhood and learn what kind of churns they use, and see them in operation. Then compare the appearance of the butter made in the different churns. You may group all churns into two classes; first, those *with* dashers, and, second, those *without* them. Can't you make a few observations on these two points: First, which churn makes the best appearing butter; second, which churn is most easily kept clean? It will also be a good plan for you to see which is the easiest to churn with, one of the old dash churns or a box or barrel churn.

### 2d. THE KIND OF CREAM.

If your mother skims the cream from the top of the milk, and takes with it some of the sour, curdled milk, little hard, white lumps called "curds," will occur in the butter and so injure its looks. These lumps will also get rancid, and so spoil the flavor of the butter. The only way to prevent this is to strain the thick cream through a fine strainer, so that nothing but very smooth cream will pass into the churn.

Of course, from what has already been said, the cream must be kept where there are no bad odors, otherwise it will be seriously injured.

Another thing that affects the butter is the condition of the cream when churned, whether it be sweet or slightly sour or "acid," as it is called.

Here we have two nice opportunities for experimenting. In summer weather get your mother to allow several pans of milk to become sour and clabbered before skimming. Have her skim some of the thick top milk with the cream, as is so often done where milk is skimmed by hand. Now divide the cream into two parts. One lot churn just as it is, but the other pour through a wire strainer, so as to remove all lumps. What is the difference in the butter from these two lots of cream?

You can carry on an interesting experiment by taking two lots of cream, one of which is real sweet and the other slightly sour and churning them separately. Which do you find churns easiest, and which has the best flavor?

### 3d. THE TEMPERATURE OF CREAM.

Every person who has a dairy and churns should use a thermometer. Did you know that cream will churn much better at some temperatures than others? Nice thick cream will churn best at about 56 degrees. The only way you can find out when the cream is at the right temperature is to use a thermometer. You can buy floating bulb or dairy thermometers for 25 cents that will be very valuable, and any druggist can get them for you. The use of the thermometer for one day may more than pay for the cost of it.

Here is an experiment for you that will be worth something to your parents, perhaps, as well as to other people.

Take some fairly thick cream, put it into a deep pan or pail, and place in a tub or large pail of very cold water and cool it until your thermometer says it has a temperature of 56 degrees. Stir the cream in the can to make it cool rapidly and evenly. Then take some cream that is much thinner and churn it at the same temperature. Which does it take you the longest to churn? Now, supposing you get some thin cream and churn it at 62 degrees. How long does it take the butter to come at this temperature? If you study this question carefully, you will find that in summer it will be well to churn the cream at 56 degrees, because it will gradually warm up some in the churn, while in the winter it will be well to have it somewhat warmer, or about 60 degrees. The colder you can churn your cream and get butter the better the butter will be, and you will not lose so much fat in the buttermilk.

### 4th. TEMPERATURE OF THE ROOM.

If you place some cream at 56 degrees in the churn, and then agitate it in a room at 70 degrees, what will happen? After you have churned fifteen minutes take the temperature of your cream. You will be sure to find that it is warmer than when you put it in the churn. What does that mean? Does it not mean that the air of the room is warming up the churn and its contents? That is just it. Now, if the butter comes in this warmed-up cream, will it be nice and hard to handle, or somewhat soft and sticky? Can't you report on this? Would you advise churning in a room warmer than the temperature of your cream, or in a little colder one, if possible?

### 5th. WASHING THE BUTTER.

After the butter comes in the churn to about the size of wheat grains we stop churning and draw off the buttermilk. That leaves the butter in the bottom of the churn, sometimes like a mass of golden wheat grains. Now, each of these pieces of butter has just been bathed in buttermilk, and so it needs a bath of water to make it clean. If you do not believe this, do what I tell you. Take some butter from the churn without washing it and make a nice solid lump of it, and place it in the ice chest. Then wash the rest of the butter in the churn with clear cold water, twice, allowing the water to run off quite fully each time. Make a lump of butter from some of this and place alongside of the other unwashed butter, and keep it for a week or so, and note which keeps sweetest and of the best flavor.

### 6th. WORKING AND SALTING.

People take butter from the churn and put it in a bowl or on a butter-worker. Then nice dairy salt is scattered over it, usually about three-quarters of an ounce of salt to a pound of butter, and then the butter and salt are worked together. This working is for the purpose of mixing the salt with the butter, and also to get the water or milk out of it, and make it into hard, attractive lumps. Now, if the butter is rubbed or worked over too much, it looks greasy and does not have a nice "grain." Did you ever notice how some pieces of stone when broken have a ragged, glistening, broken surface? That surface shows the grain, and when butter is not worked too much, if a lump is broken in two, it will show a nice grain, much like the broken stone. So in working butter it should be firmly rolled or pressed with ladles or wooden sticks or rollers, but never rubbed with them. Rubbing destroys the grain, while the other process does not injure it, unless carried to excess.

If you know of a creamery that you can visit, ask your parents if they will not let you go there and watch them work the butter, so you can tell how it is done. Then go to some store where they sell plenty of butter, if you have an opportunity, and ask to see it. Look and see if you can tell which has been worked too much, and which is all right. Now, you will be able to understand some of the reasons why one woman received more for her butter than another. She knew how to make her butter properly.

Do you think this is an important subject? It certainly is. Indiana has about 500,000 milch cows. Each one of these cows makes about one hundred pounds of butter a year, or 50,000,000 pounds in all. In 1890 over 48,000,000 pounds were made in Indiana. Suppose this butter is like the poor stuff sold by the farmer's wife to the grocer. Then it would be worth $7,000,000. If, however, it were made as the woman made hers who got the highest price, because she made it the right way, it would be worth $10,000,000. Now, if the people of Indiana, by making a better quality of butter can increase their income from butter sales by $3,000,000 a year do you not think it would pay? It not only would pay us well in money, but our butter would get a better reputation, and so have an increased demand by consumers. And so, if you will use your influence to teach people how to make good butter it may be the means of making Indiana a great butter-producing State.

No. 17.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## ABOUT SPIDERS AND THEIR CURIOUS WAYS.

(Condensed from Morse's First Book of Zoölogy by the Editor of "School and Home.")

The spider is divided into two regions or parts. The hinder region is called the abdomen. The front part, to which the legs are attached, is called the *cephalo-thorax*. *Cephalo-thorax* means head-chest, and is thus called because the spider has its head and chest combined.

The spider has four pairs of legs, instead of three pairs of legs, as in the true insects. Projecting in front are a pair of jointed feelers called *palpi*. These look very much like legs, and in very young spiders can scarcely be distinguished from them.

The mouth is armed with a pair of jaws which are attached above the mouth and hang down in front, at the end of which are the poison fangs. With these they are enabled to secure and kill the flies and other insects upon which they feed.

Directly behind these jaws are two smaller jaws, which aid in crushing the food and arranging it for the mouth.

The spider has eight eyes, situated on the front part of the *cephalo-thorax*. They look like little black beads, and in large spiders can be easily seen without the aid of a magnifying glass.

The abdomen has little appendages at its hinder end called spinnerets, and from these the spider produces the thread with which it builds its nests and nets, the nets being commonly called spiders' webs.

Highly magnified, the spinnerets appear as blunt protuberances arranged together in pairs, and capable of being contracted or expanded. These spinnerets are covered with hundreds of jointed hairs which are perforated and through which the web-forming material escapes. This material is fluid and something like the white of an egg. Escaping from the body, through hundreds of these minute openings, the strands of this fluid dry almost instantly, and, uniting, form the delicate, yet comparatively strong, thread of the spider. Thus it will be seen that the thread of the spider is composed of hundreds of strands, which may be often separated just as the fibres of a rope may be pulled apart.

As the thread issues from the spinnerets the spider guides it with its hind pair of feet, and these are curiously adapted for the purpose not only of holding and guiding the thread, but also of enabling the spider to run rapidly across its nets without getting entangled, while other animals become helplessly ensnared in attempting the same thing.

The ends of the legs terminate in three claws, a pair of larger ones, generally notched like a comb, and a third one, like a spine, which acts as a thumb. Other notched spines or hairs also aid in securing a hold upon the web, and even if these fail to secure a footing, the leg itself is covered with long, stiff bristles, pointing downward, which are sure to catch in the web. The two large notched claws, as well as the other claw and spines, are highly polished, and consequently present no roughened surface to which the thread will adhere.

By observing the spiders which build their nets across the openings of windows and in other convenient places while at work, they may be seen to use their hind feet in apparently drawing out the thread, as it were, from the spinnerets. It will be observed that the thread issues in a broad band, and, when these spiders are sluggish, the thread may be caught on the end of a pencil by gently rubbing the spinnerets with it and then by withdrawing the pencil the thread may be reeled off.

The various kinds of nets are adapted to entrap the spider's food, which consists of flies and other insects.

Certain kinds of spiders do not build nets, but go in search of their prey by stealthily creeping up and pouncing upon it unawares.

It is a very interesting sight to watch the little black-and-white spider (so common on the sides of houses) slyly approach a fly which has alighted near it. If the spider is on the side of a window sill and a fly has alighted near it, the spider instantly turns around, facing the fly, cautiously and very slowly moves backward till it gets on the upper side of the window sill and out of sight, when it rapidly approaches, now and then peering over the edge of the sill, to see where the fly is, and, finally getting directly above the fly, it gathers its legs for a jump, securing its thread to the window sill at the same time, and then with a sudden spring seizes the fly in its jaws. Sometimes the insect is much larger than the spider, and flies away with the spider tightly clinging to it; the thread, however, holds fast, though sometimes run out to the length of a foot or more. Soon the poison of the spider takes effect and the fly gradually weakens and ceases its struggles, when the spider carries it off to some nook, there to devour it.

One of the most common spider nets is thus made: The spider first runs a few threads as a sort of framework, to which are to be afterward attached the radiating threads, that is, those which run from the center of the net to the sides. Having arranged these so near together that the spider can easily reach from one radiating thread to the other, the creature commences at the center of the net and runs a thread from one radiating thread to the other in a rapidly unwinding spiral till it reaches the outer edge of the net. This is to form a staging and also the better to hold the radiating threads in place. It then commences at the outside and going back over its last course carefully constructs the permanent mesh; and, as it comes to each radiating thread, it will be seen to attach to it the thread it is now making by simply pressing the spinnerets against it. As it goes around again and again, continually lessening the circle, it gathers up the thread which was first laid as a staging, and, rolling it up in little balls, drops it to the ground. This habit has led to the impression that the spider eats its web. The circular threads are glutinous, while the radiating threads are smooth, and this can be proved by throwing dust through the net, when the cross-threads will catch and hold the dust, while the radiating threads will remain clean. The actual center of the net is not the geometrical or true center, but a little above it. It may be observed, too, that the net does not stand vertical, but leans a little and the spider having completed the net, takes a position in the actual center of the net, head downward and on the inclining side of the net. With its legs outstretched and resting on the radiating lines, it can feel the slightest jar or agitation made by a struggling insect. The spider being above the true center of the net and on the inclining side, if the fly has become entangled below the center, it can instantly drop to the desired point suspended by the ever-ready thread which it makes, and, swinging to the net, it almost instantly catches the fly.

Besides the nets made by spiders to ensnare insects, some species have the power of running out a long thread which answers the purpose of a balloon in raising them from the ground and carrying them floating a long distance in the air. In constructing this buoyant means of transportation, the spider does it at peculiar times of the day, and in peculiar positions. Selecting some place where the heated air is rising from the ground or from the side of a fence, it turns up its abdomen and allows the rising current of air to carry upward the thread which is being made, and when this thread is of sufficient length for its buoyancy to overcome the weight of the spider, it floats away with the spider hanging below.

The spider also constructs cases to hold her eggs and lines them warmly with the finest web. These nests vary greatly in appearance. A common variety, somewhat oval in shape, may be found suspended in barns and sheds.

The young spider comes from the egg resembling in form the parent spider, except that the legs are much shorter in proportion to his relative size, and the *palpi* appear so large that they look like another pair of legs, as they then are in fact, but they afterward become modified to feelers.

As the young spider grows it sheds its skin at short intervals of time till it has reached adult size.

The mother spider, generally so timid, overcomes her fear during the time she has the care of her eggs, and with many spiders the egg-cases are directly cared for by the mother, she oftentimes carrying them about with her or holding on to them and showing the greatest solicitude for their safety. Some species of spiders carry their young on their backs and move about with them.

The spider has no power of throwing or ejecting its thread to distant objects, as many suppose. When threads are seen stretching from one tree to another, the spider has caused the thread to issue from the spinnerets, and the wind has then caught it and borne it along till finally it gets entangled with some object and in this way the spider is enabled to cross from one point to another.

These creatures are not so dangerous as many suppose and but very few authenticated cases are known of man having been bitten by these animals; though the larger spiders at the South and in California, as the tarantula, for example, can inflict a dangerous wound.

No. 18.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

# THE WORK OF WATER.

BY PROF. A. W. DUFF.

One of the busiest of all busy things is water. It is always working, usually doing useful work, but sometimes causing great damage. It carries more freight than all the railways; it breaks up more soil than all the ploughs; it cuts more rock than all the quarrymen; it soars higher than the highest mountain, and digs deeper than the deepest mine. It is the most active thing in the world.

The next time it is raining see what becomes of the raindrops that fall on a sloping road. First, they make small imprints in the dust; then they join to form pools; these pools overflow and streams start down the road; these streams unite to form larger streams, and near the foot of the slope you have a small brook, which has dug out a regular channel for itself. If you follow it far enough you will probably find that it joins other brooks and becomes a large stream and flows into a river which finally reaches the sea.

NOTE.—The material of this paper will suggest subjects for several lessons. Although the primary purpose is to teach children to observe for themselves, the explanation of some of the phenomena referred to would be difficult if attention were not called to operations of Nature beyond the ordinary range of observation. Hence, this leaflet departs somewhat from the principle laid down in the Introduction to Nature Study as found in Leaflet No. 1.

But if this were all, we could hardly describe water as an active worker; it might be better described as a mere busybody. You will be able to discover which it is if you fill a glass jar with water from the nearest brook or river, and let it stand for a few hours. You will find that the water becomes much clearer, and that a layer of muddy matter forms at the bottom. Dip off all of the water you can without disturbing the mud, and then leave the jar in the sun until the rest of the water dries up, and you will find that you have a crust like clay at the bottom. Now, evidently, the mud did not come down in the rain, for if you test some pure rainwater in the same way nothing whatever will settle to the bottom. Hence, the mud must have been taken from the ground over which the water passes. Thus every stream carries off some of the materials which it meets in its course.

Now, what becomes of all the mud that the streams thus carry off? Much of it, no doubt, settles to the bottom of the river. But the river itself is always taking up more from its banks. Hence it is clear that the river must always be carrying earth to its mouth where it empties it into the ocean. If you examine a map of the mouth of a large river, such as the Mississippi, you will observe that it has a very curious form, as if the river had dragged the land out into the sea; and so, in fact, it has, for it has built up banks of mud from the material it has carried from far inland. Part of its burden it carries still further than the banks at its mouth, bearing it even for some distance out into the ocean.

The quantity of mud thus carried out to sea by the Mississippi is enormous. It amounts to 400,000,000 tons every year. Thus the rivers are ever busy transporting the mountains into the sea.

But is this work useful? Much of it certainly is. Those of you who live near a river with very low banks will probably think of one very useful form that it takes. In the springtime the river often overflows the bottom lands near it and deposits on them some of the soil which it has taken from elsewhere, thus greatly increasing their fertility. Many rivers were formerly much larger and deeper than at present and the very fertile land found along their banks was formed by deposits of soil in the way mentioned. This, evidently, is very useful work.

But rivers are not content to carry off mud only. They can even pick up pebbles when they are running swiftly. The gravel which you find along the banks is evidence of this. In countries that are more mountainous and where the streams move more swiftly, rapid torrents can even carry off stones that weigh many pounds, and in some places they have been known to partly roll and partly carry rocks weighing many hundreds of pounds. This may seem almost incredible when you think of the weight of large stones, but water by no means finds the stones as heavy as you do. Take a stone weighing several pounds and hold it under water and notice how much lighter it seems. If you have a spring balance you may amuse yourself by weighing the stone while it is in air and then while it is in water. If while it is in air it weighs twice as much as an equal bulk of water it will lose half its weight when you weigh it in water; if three times as much it will lose one-third of its weight in water, and so on. And so you may discover about what the density of the stone is. These experiments will help you to understand how water can carry off pebbles which it has dislodged.

You must remember, however, that it is only very swift streams that can carry even pebbles to any distance. You will discover how mud or very fine sand is carried farther than coarse sand, and coarse sand farther than pebbles if you take a handful of gravel and throw it into a glass of water. You will notice that the stones fall to the bottom at once, while the coarse sand falls in a more leisurely fashion, and the very small particles that make up mud may take hours to settle down to the bottom. In the same way the river soon drops the stones that it may have taken up, while it may carry the coarse sand some distance, and the fine sand and mud is carried to great distances.

Examine the part of the bed of a river that is exposed when the river is very low. You will find that where the current has been very strong there may be a gravel bank. At other places, where two currents meet, you may find a ridge of sand which the water has dropped where it is partly stopped by the opposing currents. But wherever the flow has been very gentle you will find the channel covered with fine mud.

Now we have already seen the good work accomplished by the mud carried by the river. But the pebbles also play an important part in the work of the river. As they are shoved along near the bottom and sides they naturally tear up the ground and so set more earth and mud in motion, and these, too, are carried along by the stream. Evidently this means that the pebbles help the river to scour out its bed, and thus make a wider and deeper channel. If you have grasped this you really know how most rivers come to exist. Where you now see a mighty river with a deep, wide bed there was once but a small stream, and the stones carried along enabled it to scoop out a deeper and wider channel and so the process has gone on until you have the present river, with its great, wide, deep bed. Have you ever seen a picture of the Colorado river? At certain places it runs for long distances at the bottom of an enormously deep channel in the solid rock, the sides being at some points more than a mile high. How was this gigantic furrow ploughed? Simply by the water itself, with the assistance of the stones and sand it carried along.

Yet this is still only a very small account of the industry of water. It carries mud and small stones down stream with it for hundreds of miles, but what is more surprising still, it was water that actually made the mud and pebbles. To explain this we must refer for a moment to the way in which water turns to ice and ice to water. If you have not yet tried the experiment of freezing water in a bottle on a cold night you should do so and you will learn that when water freezes it expands in volume and occupies a larger space. This explains why ice floats on water, for in becoming ice it increases in volume and becomes therefore less dense, and so can float on the heavier water. You will no doubt know cases in which the expansion of freezing water does much damage. Water pipes and jugs that are full of water must burst when the water in them freezes. We say it is due to frost, but this merely means that it is due to the freezing water.

Now all of the rain that falls does not run off in streams. Much of it sinks into the soil and even into such rocks as sandstone and limestone. Sandstone is a very coarse kind of stone and contains quite large spaces or pores between the separate grains of sand which make up the stone, and limestone is full of cracks, into which the water trickles. Suppose, now, cold weather comes and part of the water freezes. In freezing it must expand, and in expanding it shoves the parts of the rock apart and so produces cracks which grow larger every time the water freezes in them. If you notice the rocks exposed in a quarry you will find that they are split up by great fissures, and these large cracks enable the quarryman to divide the rocks up into large blocks. At an exposed surface of the rocks layers are actually peeled off by this action of freezing water, and fall from the rest. But the water is not content to leave even the pieces that thus fall off. In the same way it splits up these pieces into still smaller pieces until it at last reduces them to fine grains of sand or mud, just as if they had been crushed in a mortar. Thus rocks are turned into soil by the action of water. Frost, then, is one of the farmer's greatest friends. It helps to make the soil for him and also loosens the ground so that the roots and fibres of plants can readily enter. Observe the surface of a cultivated field after a frost. You will find that it is now a layer of fine mud and in some cases you will see that the small stones have been partly pushed out of their beds.

From all this we see that while water is continually carrying earth and small stones from higher to lower levels and so tending to leave the rocks bare, it is at the same time breaking up the surface of those rocks and so forming fresh soil. If all the soil on a piece of land were scraped off so as to leave the bare rocks exposed, these rocks would in course of time become covered with fresh soil, due to the action of the water that comes down as rain in tearing up the surface of the rocks and reducing the small fragments to fine powder. There is, however, one respect in which this account is very incomplete. Water does not owe its wearing power altogether to its expansion when it freezes. Another property of water greatly assists in this process, namely, the property it has of taking up certain substances called acids, which are formed chiefly from the decay of plants. These acids are dissolved in the water and greatly assist in its rock-cutting work. To explain the action of these acids would require more space than we can now spare, and so we shall leave it until you come to study the subject of chemistry. We have also said nothing about the small parts of plants that form an important part of all soils. This belongs to botany, and you will readily see the importance of these subjects if you wish to understand fully how soils are made.

## THE UNDERGROUND WORK OF WATER.

We now turn to the answer to a question which you must have been inclined to ask some time ago. How do rivers continue to flow when there is very little rain? It is true that in very dry seasons the river contracts a good deal, but it is clear that it must get supplies of water from somewhere since it continues to flow at all. This leads us to consider the underground work of water.

The next time there is a heavy shower notice what becomes of the rain that falls on level ground. You will find that where it descends on sand it sinks down as rapidly as it falls, and a short time after the rain is over the surface of the sand will be fairly dry. We have already pointed out that water also sinks through sandstone or limestone, though much more slowly, and in a quarry you will probably find that the rock taken out holds a great deal of moisture, which the workmen call "quarry water." But if the rain continues for a long time the pores of these rocks become choked up and no more water soaks in. But see what happens when the rain falls on clay or on a very firm rock like granite. It can not now soak down, for the pores in these materials are much too small to allow the water to pass through rapidly. You will here find it useful to employ two terms to indicate these different actions. Substances which allow water to pass through rapidly are said to be *permeable,* and those which do not allow it to pass through are called *impermeable.* Now what happens to the water which sinks through permeable material? Some part of it no doubt does not get to any great depth. After mixing with the earth and taking out of it certain substances which it can hold as water holds a spoonful of salt, it is sucked up by the roots of plants and yields to the plants the materials it has washed out of the earth. This assistance that it gives to growing plants is one of the most important of the many useful duties discharged by water, for animals live on plants and without water it would be safe to say that neither plants nor animals would exist.

But what becomes of the water that sinks still deeper down? We could learn a great deal about it if we could follow a miner as he digs the shaft of a mine, or even by going down a newly dug well, the sides of which had not been walled up. Probably you can learn a good deal about the matter at the nearest railway cut, where, to get a level track, a road had to be made through a hill. There are, it is true, many different kinds of such cuts, and the one you inspect may not be exactly like the one we are going to describe. Examine all within your reach and you may find one such as the following. You may discover that it consists of sand or a permeable soil above, but at a certain depth down you come to clay. Usually the line of division between the two slopes in some direction. If the main slope is in the direction of the track you will see that the rain which soaks down through the sand can not get through the clay; and so runs down along the surface of the clay and where the cut has been made the water oozes out between the sand and the clay. But if the main slope be across the direction of the track, the water runs down hill away from the track on one side and toward the track on the other side, and more water flows into the cut on one side than the other. Now, if the cut be a long one and you follow it you may be able to find where the sand stops and only the clay is left. This will, of course, be on a side hill. If you leave the track where the sand or soil ceases you will be able to follow along the side of the hill the line that divides the soil above from the clay or, perhaps, rocks below. You will then probably be able to see what becomes of the water that sinks through the soil. If, in leaving the track, you have taken the direction in which the surface of the clay slopes you will find springs or wet places, showing where the water runs out between the soil or sand and clay. This is one of the simplest ways in which springs are tormed. If you know of any springs in your vicinity you should see if they can be explained in this way. If not you may find that they are produced by little streams issuing from cracks in a rock, through which the water has sunk.

In the preceding we have supposed that clay or an impermeable material through which the water will not pass comes out to the surface on a side hill near the bottom of a valley. But this may not be the case. The valley may not go deep enough to reach that layer. How, then, shall we get at the water? Evidently we must make an opening down to it. Such an opening is a well. In an ordinary well we know that the water has to be raised by a pump or bucket, but there are others called artesian wells, which require no bucket or pump, for the water, when we once reach it, rushes up to the surface. What is it that produces some kind of pressure below and forces the water up? If we could see down an artesian well we would find that at its bottom there is water confined in a permeable substance like sand by one layer of an impermeable substance like clay above and another impermeable layer below. Now, let us in imagination start from the bottom of the well and follow this sand layer. We will find that it slopes upward, and at a great distance comes out on a hillside, where it catches water when it rains. This water runs down through the sand, being prevented from escape by the two impermeable layers, and accumulates in the sandy layer so as to produce great pressure. When this reservoir of water is tapped by the hole bored down, the water rushes up with great force. If you wish to see how such action takes place punch a small hole in the bottom of a tin can (say a two-pound coffee can) and after half filling a bucket with water, push the can down into the water and notice how the water spurts in through the hole, rising nearly to a height of the water in the pail.

There are many other interesting kinds of springs, such as hot springs and springs that sometimes stop and then start again every few hours, but as you may not hear of any in your neighborhood, we shall only say a few words about them. The water that comes from a hot spring is often very warm. It has in fact been heated by the great heat there is deep in the earth. A miner will tell you that the earth grows about one degree hotter for every sixty feet he descends. Now, some water that falls on the surface of the earth finds cracks in rocks, especially limestone, and passes down in all kinds of zigzag directions until for some reason it can get no further, when it turns around and comes up by another series of zigzags. Having gone to a great depth, it is greatly heated and when it finally reaches the surface it is still very hot and gives rise to a hot spring. The other kind of spring mentioned that starts and stops in a very mysterious fashion is difficult to explain, so I shall not attempt to account for it here.

We thus see that a spring is a place where water comes to the surface after a long underground journey. Is it the same kind of water as when it went in? Try a drink of fresh rainwater and then a drink of spring or well water, and see. You will probably find the rainwater rather flat and tasteless compared with the spring water. The difference will remind you of how food, for instance oatmeal, tastes with and without salt. In fact, the spring water does contain salt, while the rainwater does not. There are places where springs are so salt that thousands of tons of salt per year are gotten from them. But the spring water contains other things also, chiefly lime, and this is what is left when the water is boiled away in a kettle. Thus we see that water is continually busy transporting materials from the depths of the earth to the surface. The things which are thus brought up are often of great importance. The lime contained in the water furnishes material for the bones of animals and the iron, which is another ingredient, supplies the coloring matter for their blood. It is true that most of what is needed of these materials is gotten from our solid food, but as spring water contains them it is healthier than rainwater for drinking and cooking. When we thus think of the water carrying away material from the solid rock we can see how so many cracks and fissures come to exist. As water passes through a very small crack it carries some material away with it, and so enlarges the crack, and so the crack grows until quite a stream can pass through.

We now see how rivers continue to run during hot weather when no rain falls. They are supplied by the water from springs and underground streamlets, and as this water often has great distances underground to travel it only reaches the river a long time after it has fallen as rain. Some of this water must evidently be many months journeying in the earth before reaching the river and a small part of it perhaps even years. But at last it emerges, joins the river and reaches the ocean.

You may imagine that now its useful work is done. By no means. For let us see what happens to it after reaching the ocean. We have already seen that it carries a large burden of mud with it. This it drops gradually, some near the shore and some far out at sea. Thus it coats the sea bottom with clay, which in the course of ages solidifies into rocks and these rocks will in still more distant ages probably be raised to the surface to form new continents. Some of the materials carried by the rivers into the ocean also serve as food for the creatures that live in the ocean.

This, however, is not the only useful work which the currents in the ocean do. Let us consider, for instance, the water carried down by the Mississippi. It falls into the Gulf of Mexico in a very hot region of the earth. There it becomes heated more than before, and along with water from other rivers it starts off on a long journey up the eastern side of North America, forming a remarkable current called the Gulf Stream. This Gulf Stream is in fact a river in the ocean instead of on land. The warm water that forms it does not mix to any great extent with the cold water which it passes on the way. It flows in a bed of its own over the ocean of colder water. It is quite a shallow river compared with the depth of the ocean beneath it. After continuing its way up to Newfoundland it strikes across the Atlantic. It divides into branches in the middle. One branch passes up to the British Isles and has a remarkable effect on their climate. To understand the effect you must remember two things: First, that the water of the Gulf Stream is much warmer than that of the rest of the ocean around it, and, second, that water when warmed up contains a very great deal of heat, much more than an equal quantity of most other substances. To better understand this latter point try the following experiment: Take two bottles exactly alike or two similar tin cans with covers. Fill one with water and the other with anything else, say sand or earth. Then place them in a pot or tin pail and pour water into it until they are nearly covered. Place the whole on the stove and leave it until the water gets too hot for you to put your finger in. Then dip some of the water out of the pot or pail and take the bottles or cans out and put them out in the air to cool. Notice how much more quickly the one containing sand or earth cools than the one containing water. The one containing water has so much more heat that it can not lose it nearly as quickly as the other, and so cools much more slowly. This is the explanation of how the Gulf Stream keeps the land of the British Isles warm in winter, although there is not nearly as much water in the Gulf Stream as there is land in the islands.

Now, we have only spoken of the Gulf Stream, but there are many other such warm streams in other oceans flowing from the hot parts of the earth to cooler parts and helping to keep these cooler parts warm and fit for habitation. But since warm water is thus spreading from the hot parts of the earth to the cold parts, cold water must flow from the cold parts to the hot parts, and this cold water plays the equally important part of keeping the temperature in the hotter regions lower than it otherwise would be. Were it not for the moderating influences thus received by ocean currents tropical countries near the equator would be too hot for man to live in, and most of Europe and North America would be unbearably cold.

Now, we have seen that water is continually flowing by means of the rivers from the land to the seas. The process has been going on for ages past. It evidently couldn't continue unless there was some means by which the water came back from the seas and oceans to the land. What is the road which it travels on this return journey? To discover it let us trace the rain to its origin. Rain comes from moisture condensing in the clouds. Where do the clouds come from? Some of them form from vapor which rises from the land, and some from moisture that rises from the sea. Now this is the only known path by which water returns from the ocean to the land. The vapor rises gently and invisibly from the sea, and it seems almost incredible that such huge masses of water can rise in this imperceptible form as is carried by the Mississippi and all the innumerable rivers of the earth. Yet such is the fact, and when we think of the immense currents that carry water from the land to the ocean we should at the same time try to imagine the equally immense overhead rivers of vapor which convey the water back from the ocean to the land.

But water does not move of its own accord. To what great agency, then, do we owe this tremendous activity of the water on the globe? Firstly, to the heat of the sun, which falls silently on the waters of the ocean, tearing particles free and raising them as vapor into the air. It is really the sun, too, that starts into motion the winds which carry this moisture over the land, where it falls as rain. Then we have the assistance of gravity or the attraction of the earth, for it is to this that the flow of the brooks from the hillside to the river is due, and also the further flow of the rivers to the ocean.

No. 19.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

# HEAT AND WHAT IT DOES.

## IN TEN SHORT LESSONS.

BY PROF. A. W. DUFF.

### I.

How do you know there is such a thing as heat? You have never seen it, and yet you probably believe there is such a thing. Put a piece of iron out in the sun on a hot day, and after some time feel it. No doubt you will say that it feels hot and that it got its heat from the sun. Now, hold your right hand on the iron for a while and then put your right hand on your left and you will find that your right hand feels hot to your left. Your right hand must have gotten its heat from the iron. This shows that when the iron feels hot it must be giving heat to the hand. Such is always the case; a body feels hot when it is giving heat to the hand. But your right hand felt hot to the left, and, therefore, your right hand must have been giving heat to the left. Now, how did your left hand feel to the right? You will say that it felt cold. And so you see that when a thing feels cold to the hand, heat is going from the hand to that thing. So the terms hot and cold simply refer to the direction in which heat is going.

Feel the iron of a hammer which has been in a cool place, and then feel the wooden handle. Which seems cooler? Evidently the iron does. Do you really believe that it is any cooler? It is difficult to see how it can be, since both were in the same place. Perhaps it is because the iron is readier to take in heat just as water can be more readily poured into a tumbler than into a bottle. How shall we test this supposition? Suppose the tumbler and the bottle were both full of water, out of which could you pour the water the more readily? Out of the tumbler, of course. Now, let us try the same thing with heat. Put the hammer into a hot oven for a few minutes and feel which is hotter, the head or the handle. The iron is; and so we find that when the hammer is cold the iron feels colder than the wood because it takes in heat more readily, and when the hammer is hot the iron feels hotter than the wood, because it gives out heat to the hand more readily. You will thus see that touch is a poor way of finding how hot a body is. How can we discover a better way? We must find something else that heat does, and perhaps that will give us a better way of measuring it.

## II.

### HEAT EXPANDS LIQUIDS.

Fill a bottle with cold water just up to the bottom of the neck, and put the bottle in a pan or pot of moderately warm water on the stove. Watch how the water rises in the neck as the water becomes warmer, how it finally comes to the top and at last overflows. You thus see that heat expands water, and if there had been any other liquid than water in the bottle the result would have been similar, except that the amount of expansion might not have been the same. We conclude, then, that heat expands liquids.

### HEAT EXPANDS SOLIDS.

Take a bolt, and a nut that is a neat fit and will just screw on the bolt. Heat the screw of the bolt in the fire and then see if you can screw the nut on. Probably you can not; certainly you can not if they fitted closely enough when they were cold. But if you had heated the nut up instead of the bolt you would have found that it went on more readily than before.

If the school building is heated by steam or hot water, see if you can find a part of the pipe at least 25 or 30 feet long. You will notice that at certain places the pipe is supported on upright wooden strips. Stick needles into these strips at two places 25 or 30 feet apart so that the head of each needle is above the pipe and very close to it. Then make a mark just below the head of each needle with a knife. If you have done this when the pipe is cold, wait until some time when the pipe is hot and see if the knife-marks are still just below the needles. You will thus discover that the pipes become longer when heated. This is one reason why the pipes are hung in brackets attached to the board instead of being fastened more solidly, and the noise you hear when the pipes are being heated up is partly due to their slipping in the brackets.

## III.

### HEAT EXPANDS GASES.

We have now seen that heat expands solids and liquids. Will it also expand a gas like air? You will find the following a beautiful experiment: Hold a glass bottle by the neck and dip it quickly a few times in very hot water merely to warm it up gradually so as not to break it. Finally hold it in the hot water until it becomes thoroughly heated up. Then invert it quickly in a pan containing water to the depth of about an inch and watch what happens. You will find that as the bottle cools, water is quickly sucked up into the bottle until finally the bottle becomes about one-fourth full of water. This shows that the air in the bottle contracted as it cooled. Will it also expand when it is heated? To test this, all you have to do is to pour hot water over the bottle as it stands inverted in the pan, and you will find that the air expands again and drives out some of the water. (Why does it not drive all the water out again?) To vary the experiment, invert the cold bottle in the pan and pour hot water over it, and notice how bubbles are driven out by the expansion of the air. When you have driven out as many bubbles as possible, let the bottle cool again, and you will find that water is sucked up as before. (Is there as much sucked up this time? Why?)

### WHY HOT AIR RISES.

You will now be able to understand better why hot air rises. It is because on being heated it expands, and therefore becomes less dense, and so it rises above the cold air just as a piece of wood rises in water because it is less dense than the water. An interesting proof of the rising of hot air can be obtained by making a little paper mill, fastening it to the end of a stick by a pin and holding it over a hot stove. You will find that the current of hot air, rising, will turn it, just as wind turns a windmill. Other examples of the rising of hot air will occur to you, such as the rising of hot air and smoke in a chimney, and the fact that the air in a room is much warmer near the ceiling than near the floor. See if you can think of some more examples.

## IV.

### THE THERMOMETER.

This expansion of bodies when heated gives us a means of finding how hot anything is, that is, finding its temperature. For instance, to find whether it is hotter out of doors than in a room, you might take a bottle with a very narrow neck and fill it up to the middle of the neck with water. Now let it stand in the room for half an hour and mark where the surface of the water stands in the neck; then put it out in the sun and let it stand for another half hour, and see whether the water has risen or fallen. This will tell you whether the temperature is higher or lower indoors than outdoors. But if it should happen to be about as warm outdoors as indoors there would only be a very small rise or fall of the water in the neck. You can easily understand that the change of level would be much greater if you used a bottle with a much narrower neck; but then the neck would need to be very much longer to prevent it running over altogether. (Why not try it with two bottles, one with a broad, short neck and the other with a long, narrow neck?) And now you know what a thermometer is, for it is merely a very small bottle with a very long and very narrow neck. There is, however, one other difference—it does not contain water, but mercury. One reason for not using water you will see if you think what would happen to a thermometer containing water on a very cold day in winter. There is also a scale marked on the thermometer or attached to it, so that it can tell you different degrees of temperature. If you can get a thermometer to use, try some temperatures with it. For instance, note the temperature when the thermometer is in the air, and then bury the lower end of it in a small hole in the ground and find whether the soil is warmer or cooler than the air. Do this at different times of the day and of the year and keep your results in a notebook, and you may make some interesting discoveries. If you are near a river or lake, make notes of its temperature in the same way. If your thermometer is one with degrees marked on the glass, put the bulb of it in your mouth and find how hot you are; see whether you are warmer on a hot day than on a cold day, or at noon than at night. See also whether working makes you any warmer. You may try the temperature of the cat and the dog also, if you can coax them to be quiet enough. You will be able to think of many other interesting things to try with a thermometer.

## V.

### HOW HEAT TRAVELS.

Heat being invisible, it is somewhat more difficult to find how it travels than it is to see how something visible, like water, travels, and yet the difference is not so very great. For, just think of how water travels. It can run through a pipe that conducts it. Similarly heat can run through many things that conduct it and are called conductors. When heat travels in this way it is said to travel by conduction. For instance, when an end of a poker is kept a good while in the fire the heat travels the whole way to the handle and it may become too hot to be held. Hence, iron is a conductor of heat. So, too, are all other metals, but some conduct better than others. For instance, put an iron or tin spoon and a solid silver spoon into a cup of hot water and notice which becomes hot at the upper end sooner. You will then readily see that silver is a much better conductor than iron or tin. (How can you test whether a silver spoon is solid or merely plated with silver?)

Suppose we next compare silver with copper. If you can find a Canadian copper cent you will see that it is almost exactly the size of a silver quarter. Put both of them at the same time on a hot stove lid and quickly hold two matches on them and see which match burns first, and so you will discover which is the better conductor, silver or copper. If you can't easily find a Canadian cent, try a dime and a copper cent. They will tell you the same thing, but for a reason that you should try to think out, you can't trust this form of the experiment so much. To see how paper conducts, as compared with copper, use two copper cents in one heap and a cent with a piece of pasteboard about as thick as a cent on top of it as the other heap, and see which will light a match first. Try also pieces of glass, then flat stones and china and other things, and you can easily make up a list of poor conductors and good conductors in this way. Compare also slate pencils with nails of the same length, holding them upright on the stove and trying on which you can hold your finger longer. Having these ways suggested to you, you will easily go on and discover many other ways for yourself.

But so far we have been talking of the conducting power of solids only. Can we find out anything as to the conducting power of liquids and gases? This is more difficult. Perhaps the best way is to get a kind of very thin tube called a test-tube at a druggist's. Fill it with cold water and hold it by the lower end at a slant so that the upper end may be over a gas or lamp flame. You will find that the water may be boiling for some time at the top before it begins to feel hot below. This shows that water is a very poor conductor. You may ask why we don't hold it by the top and heat it below. It would heat up much more quickly in that way, but we would not be really testing the conducting power of the liquid in that way. Perhaps you can think out the reason of this statement for yourself, but if you can not you will understand the matter more fully when you read the next section. What we have seen from the former of these experiments, namely, that water is a poor conductor, is true of all liquids.

As to the conducting power of gases, it is so very difficult a thing to test by experiment that you must for the present be satisfied to know that gases are very poor conductors indeed. In fact, the warmth of woolen or flannel clothes is mostly due to the fact that air clings to the threads and in the openings between threads, and it is the very poor conducting power of the air that prevents the heat of the body escaping. You will now be able to explain why ice houses are often built with double walls having an air space between the walls, and why in cold climates outside doors and windows are put on in the winter time. You will no doubt think of many other examples, if you try.

### HOT CURRENTS AND COLD CURRENTS.

There is another way in which heat travels in liquids and gases, namely, by the formation of currents that carry the heat with them. This is the way in which water in a kettle is heated by the fire. You may see this process, which is called convection, by the following experiment: Take an ink bottle in which about a spoonful of ink has been left. Warm it up gradually by dipping it a few times into a vessel of warm water. Then fill it with hot water and put it at the bottom of a pail full of cold water. The inky hot water will come out of the bottle and you can see the way in which this hot water rises through the midst of the cold water. Now, that is the way in which water moves in a pot or kettle that is being heated on the stove. But it is evident that as the hot water rises in the middle of the pail, cooler water must go down along the sides, and so we have hot and cool currents moving up and down and conveying heat to all parts of the pot. Here is an interesting illustration which you may try for yourself. Make a box out of thick writing paper by folding it at the corners and stitching the flaps with thread to keep them from opening. Then hang it up by threads attached to the four corners, half fill it with water and bring a flame beneath it. You will find that the water can be boiled without scorching the paper. This shows how rapidly heat is carried off by convection. Currents of hot water rise to the surface conveying heat away and cold currents descend to take the place of the hot water that has risen. Thus the bottom of the box is kept cool. If it were not for this action the paper would burn. In fact, if the flame is too big the paper does get scorched above the water line.

## VII.

### HEAT RAYS.

But how does the heat pass to your hand from a hot body when you are not touching it? This is perhaps not so easy to understand. In some way the heat passes off from the body and crosses the space between the body and your hand, just as the sun's rays come from the sun to the earth. For this reason the process is called radiation, and the body is said to radiate heat. Some surfaces radiate much better than others. Here is a simple experiment to illustrate it: Blacken one side of a tin can with shoe-blacking, or by holding it in a very smoky flame, then fill the can with boiling water and hold one hand near the bright surface and the other equally near the black surface and find which feels warmer. You will thus arrive at the conclusion that black surfaces radiate heat better than bright surfaces.

While we are speaking of giving heat out by radiation, it will be well to say something about taking in heat that other bodies radiate out. This taking in of heat is called absorption. Let us first see which takes in heat better, a bright surface or black surface. You can test this by getting two similar tin can covers and blacking the outside of one with shoe blacking. Now, support them just above the middle of a hot stove on little pieces of glass, all of the same thickness, which rest on the stove. Put a couple of matches in each and observe which cover first becomes hot enough to light the matches. If you suspect that one was over a hotter part of the stove than the other, exchange their positions and try again. Instead of putting the matches in, you may pour equal quantities of water into the two covers by using a small cup for measuring, and then see in which the water will boil first. You will thus learn that black surfaces absorb heat more quickly than light surfaces. Now, think of these things and try to decide which part of a kettle should be brightly polished—the bottom or the outside. Try also to think of other cases of such differences. Consider, for instance, house paints, colors of summer and winter clothes, etc.

If you are studying this subject in the winter time you may try the effect of putting different colored cloths of about the same thickness on the snow on a bright, sunny day and finding under which the snow is most melted by heat taken in from the sun. These are only some of the ways in which you can make experiments on the subject. You may be able to think of other ways yourself.

## VIII.

### CHANGES IN MATTER PRODUCED BY HEATING.

We have already referred to two of the changes heat can produce in matter, namely, an increase of size and a rise of temperature; but if you try to think of the most striking change that heat gives rise to, you will probably decide that it is the change from solid to liquid or from liquid to vapor. To illustrate the former change, suppose you take two similar cans, fill one with crushed ice well packed in, and in the other pour ice-cold water until the two cans seem equally heavy (you may weigh them if you have a balance). Now, put them on a stove, taking care to see that they are on nearly equally hot places. You will find that when the water is so hot that you can barely put your finger in it, the ice has merely melted and the water it has formed is nearly ice cold. Now, they must have taken in about equal quantities of heat from the stove, and so you see that to melt ice requires nearly as much heat as to raise the same quantity of water from the melting point to the boiling point. This heat that goes to melt ice does not produce the ordinary effect of making the substance warmer and hence the heat so used is called hidden or latent heat.

Now, let us turn to the other case, that in which water turns into vapor. This is somewhat more difficult to experiment on, but you will see into it to some extent by putting a canful of water on the stove and placing a thermometer in it. You must take care not to use for this purpose a thermometer such as is used for finding temperature out of doors, but one that cooks sometimes use for finding the heat of the oven will do for the purpose. You would only break the former, for it is not supposed to go as high as the temperature of boiling water. Supposing, however, that you have the right kind of thermometer, you will notice that after the water boils its temperature does not rise any higher, in spite of the fact that it must all the time be taking in heat from the stove. This heat has been taken away with the vapor and is necessary for the turning of water into vapor. Here, then, we have another case of hidden heat; the heat required to make vapor from water is called the latent heat of vapor. You will get another example of it if you wet a finger and hold it up in the wind (as claimed in Leaflet 12); you will find that as the water evaporates the side to the wind becomes much cooler than the rest, showing that heat is taken up in vaporizing the water, and as this heat is taken from the finger it leaves that side colder. You will see the same thing much more clearly if you let a drop of ether fall on the back of your hand.

## IX.

### HOW HEAT IS MADE.

So far we have not considered how heat is produced, but have merely assumed that there is a source of heat near. Now, the question of how heat is made in the first place is rather a difficult one and it would take us too long to explain the whole of the subject. Burning something is, of course, the best known way. For instance, where does the heat come from when you strike a match? You might suppose it due altogether to something contained in the match. But try rubbing a brass button on a board, and you will find that you can make it too hot to be held comfortably. By rubbing two sticks together you can make them quite hot, and can understand how savages get fire without matches. You may not be able, like a savage, to get the wood to burn, but rub hard enough and you will get another interesting case of heating by friction. I shall leave you to think of what it is for yourself.

And now you should be able to explain what sometimes happens when the axle of a carriage has not been oiled, and in consequence grows hot and perhaps sticks fast in the wheel, or else the hub may be torn from the spokes. You know that sawing produces heat, but this is, of course, merely another case of rubbing. Hammering will also cause a body to grow hot. No doubt you can make a nail quite warm by hammering it on a stone. An expert smith can make a piece of iron red hot by hammering. This production of heat by hammering will perhaps help you to understand the flash of light you sometimes see when the shoe on a horse's foot strikes a stone. So much heat is formed that something actually burns and produces light. You can do the same in a dark room with a hammer and a stone; and let me suggest that while you are in the dark room you should try crushing a lump of sugar with a blow of the hammer; you will see quite a flash of light. This is perhaps a somewhat different case, for electricity is produced, and the light you get is like a lightning flash, due to a discharge of electricity. This last remark will remind you of the production of heat and light by electricity, but as we can not take space here to describe all the ways in which heat is produced, you must be left to think of as many as you can for yourself.

## X.

### WHAT IS HEAT?

And now that you have made some experiments and observations on heat without knowing what it really is, I am going to ask you to exercise your imagination a little and to try to picture to yourself what this thing is that you have been studying. You must think of any portion of matter, whether it is solid, liquid or gas, as consisting of an immense number of very small particles which are not at rest, but all the time in vigorous motion. You can not see these particles, for they are too small to be seen, but you can imagine how they act if you think of people seated close together in a crowded room. If you were far enough above the people you can easily understand that you would think the whole audience to be a solid mass without motion, but when you come close enough to them you can see that each one has a certain amount of freedom and can move to and fro a little, though always confined to a particular seat and kept pretty closely in contact with his neighbors. Now, that is exactly the state of affairs in a solid. The particles are continually vibrating backward and forward, but nevertheless they do not get any considerable distance away from their average position, and when you heat the solid all that happens is that each particle vibrates more vigorously than before, and, owing to this more vigorous motion, all the particles shove one another farther apart, and so you find the solid expanding.

But what about liquids? Think of how the same crowded audience would act if they were standing up and there were no seats in the way. Each one would keep bumping to and fro among his neighbors and gradually, though slowly, making his way from one place to another. This will help you to imagine what a liquid is like, for in a liquid the particles are continually vibrating to and fro, frequently striking against their neighbors, and thus gradually straying from one part of the vessel to another. Heating not only increases the vigor of the vibration, but enables the particles to move around more freely. Moreover, as in the case of the solid, we have an expansion of the whole mass due to the particles shoving themselves farther apart.

Then, as to a vapor or gas like the air, we will get an idea how the particles in it behave if we think of skaters on a lake dashing rapidly to and fro and going considerable distances without colliding with others or being stopped by the banks. Here, again, a higher temperature means a greater speed of motion of the particles.

No. 20.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

# OUR FRIENDS, THE BIRDS.

BY MISS LILLIAN SNYDER.

We sometimes forget that every animal, however insignificant it may seem, as it lives its life, is either helping or hindering man in his work. We are afraid of late springs and early frosts, of too much rain or too much sun, but often forget that if all these conditions are as we would have them, that other enemies are endangering our food supplies. I believe that the most harmful of these enemies are the insects. Do you know that two hundred million dollars worth of fruit and grain and other crops of various kinds are destroyed in the United States each year by insects? The insects are in many cases so small and conceal themselves so skillfully that we fail to know they are present until the damage has been done and the crop ruined. Then sometimes they come in such countless numbers that man is helpless and can only stand and watch the destruction of his year's work. But if we do not interfere too much with nature's way of working we will find that she has her own method of holding these insect hosts in check. If you look about you closely you will find that our native birds are, for the most part, busily at work protecting our crops through feeding upon insects. Prof. E. E. Fish says that the birds save for agricultural purposes because of their destruction of insects, one hundred million dollars each year in the United States. If this statement is true, and careful studies have shown that it is true, will it not be a wise thing to find what birds are our friends and the ways in which they help us? When we find how much they save us in labor and money we will not be so apt to kill them and destroy their nests.

The best way for you to find our bird friends is to study birds and their habits; but it is sometimes hard to know just how to start in such a study, and so in this leaflet I will try to show how some of our common birds help us. See if you cannot find other ways than those given and if you can add other birds to the list of those helping man.

Perhaps the first bird you will see in the early spring will be the robin. The robin is one of the first birds to come to us, and I think there is not a boy or girl in the whole State who does not recognize this pretty red-breasted visitor at a glance. If you make a study of the robin during the season you will discover many interesting facts about his food habits, and will soon come to think of him as one of our best friends. It may be that you have been told that the robin is a very bad bird, that it steals cherries and strawberries and other products of the farm and garden. But watch the robin in a freshly plowed field or in your yard and see what he is doing. Evidently he is working eagerly for his dinner, and cherries and strawberries do not grow in such places. It is plain that he is seeking his food among the insect forms, and if we watch closely we will find that grubs, caterpillars, crickets, grasshoppers and other smaller forms make up the larger part of his meal. Yet these are the forms which are most harmful to the grain, and so every time you kill a robin you kill one of your best friends. If you get up early enough in the morning you may find him hunting for cut-worms. You know these worms do their harmful work in the night and the robin knows that if he gets any cut-worms for breakfast he must be up very early in the morning. If a single robin destroys so many harmful insects for his own use, how many more do you think he will destroy when he has a family to feed? Did you ever see a nest full of young robins, with their great mouths wide open for food? Notice the kind of food the old birds give them. Are they fed cherries and fruit, or worms and bugs? Do not take any person's word for this, but see for yourself. For what I want is not to tell you things, but to have you see things. I think that you will find that animal food is necessary for the growth and welfare of the young birds. I think you will also find that the old robin is kept very busy all day long hunting worms and insects for the little ones in the nest. Try to find how many times in an hour the old bird brings food to the nest. Some one who has taken a great deal of interest in the robins has found out that a young robin requires each day, more than its own weight of animal food.

Another early bird, though not so abundant as the robin, is the blue-bird. The blue-bird has the good qualities of the robin without any of his questionable ones. You may find him eating some vegetable food in the fall, but for the most part he eats insects. The insects chosen by the blue-bird are chiefly harmful ones, especially those forms that are injurious to trees. Do you know where to look for blue-birds, in the woods, the open fields or in gardens?

One of our common birds, which boys are fond of shooting, is the meadow-lark. The meadow-lark is one of the farmers' most efficient helpers. Its food is chiefly made up of beetles, caterpillars and grasshoppers, varied by an occasional diet of seeds. At the Department of Agriculture at Washington, the contents of the stomach of a meadow-lark were examined and 54 grasshoppers were found. See if you can work out the number of grasshoppers destroyed by meadow-larks under the following statement. If one meadow-lark eats 50 grasshoppers in a day, and there are 20 meadow-larks to the square mile in your region, how many grasshoppers will these 20 meadow-larks destroy in a month? Now, it has been found that a grasshopper weighs about 15 grains and that it eats about its own weight of vegetable food each day. If you care to you can work out how much vegetation the grasshoppers would have destroyed in a square mile had they not been destroyed by the meadow-larks.

All of you have seen the red-headed wood-pecker, hammering away at the tree trunks with his chisel-like bill. The red-head has a number of near relatives in the State. Indeed there are seven kinds of birds in Indiana belonging to the wood-pecker family. We have the downy wood-pecker and the hairy wood-pecker, which are commonly known as the sap-suckers, and the yellow-bellied wood-pecker, which is the true sap-sucker, and the yellow-hammer, and other forms not so common. Now all of these birds, with perhaps the exception of the yellow-bellied wood-pecker, are of great value to the farmer. Their food is very largely made up of insects of various kinds, but especially of those which are injurious to trees. You can see that this must be true, because of the habits of the bird. Indeed the health of forest trees depends very largely upon the work of the wood-peckers in destroying the insect enemies of the trees. Do you know that the oak tree is the home of 500 different kinds of insects, all of which are more or less injurious to it? The combined work of these insects would in time destroy the trees were the insects not kept in check by the wood-peckers and other birds. Other trees are the homes for large numbers of insect forms, but none have quite so many resident enemies as the oak. The constant hammering of the red-head and his relatives, simply tells us how ceaselessly they are working to preserve our trees. And yet every boy that has had a gun has taken a shot at these guardians of our trees. The true sap-sucker or yellow-bellied wood-pecker, may do some harm especially to young trees, because of the holes he drills in the trunk and the resulting loss of sap. But even in this case it is a question whether the good done does not more than balance the evil. The sweet sap as it comes to the surface attracts insects, and as they become entangled in the sticky fluid they fall an easy prey to the sap-sucker and other insect-loving birds. You can always tell if the true sap-sucker has been at work. The holes he drills are in a straight row right around the trunk; the holes drilled by the other wood-peckers are scattered. At any rate this bird which may possibly be harmful is only a summer resident, while the other wood-peckers spend the entire year with us. The wood-pecker family should be very carefully guarded and every boy and girl should know everything they can possibly discover about these good friends of man. Wood-peckers are wonderfully adapted in their structure to their habits of life, more perfectly perhaps than any other land bird. Some time when you have opportunity examine their feet and tail and bill and tongue, and see how they serve to help the wood-pecker in his work.

Were you ever given a gun to keep the blackbirds out of a freshly-planted field? If so you were given a foolish thing to do. When the blackbirds first come in the spring they usually are compelled to eat grain until the ground is broken by the plow. but this grain is usually the waste grain upon the ground. As soon, however, as the soil is turned by the plow and the blackbirds can secure animal food, they become so eager to secure every grub and larval form exposed by the plow that they will come within a few feet of the man who is plowing. It has been estimated that at least one-third of the corn planted would be destroyed by insects were it not for this preliminary work of the blackbird in ridding the soil of grubs.

The crow has a fairly bad reputation. and I presume he does at times pick up some corn that the farmer has planted. But what do you think he is doing all the remainder of the year, for corn is not being constantly planted. Examination shows that by far the larger per cent. of his food is made up of insects, largely grasshoppers. In the long run, taking the entire year, the crow will be found to be of great service to the former, and his destruction would be a great injury to agriculture. You will find the crow a very interesting bird to study, because it is so cunning, and more than that. because it is so very wise. If you read the *"Story of Silver-spot,"* in Scribner's Magazine for February, 1898, you will see what I mean by saying that crows are wise.

Then other of our familiar birds are helpful—the cat-bird, the barn-swallow and even the jay-bird. The more you come to know of the lives of these feathered tenants of the farm, the more will you come to regard them as friends well deserving our most careful protection.

I have not said anything about the birds of prey. Generally the sight of an owl or hawk is the signal to run for the gun in the hope of killing it or at least driving it from the farm. Yet only a few of the largest of our birds of prey are injurious. These larger forms do destroy poultry and game birds and perhaps are rightfully killed. But the smaller forms, such as the screech-owl, the barn-owl and the sparrow-hawk, are among our very best friends. Their favorite foods are mice and the larger insects, both of which are extremely destructive to grain and growing crops. Indeed some of our crops might be shown to be dependent upon the presence of the smaller owls and hawks.

There are many other birds you will meet during the year; probably there are 200 different kinds in your county. How many of them are really harmful? Suppose you watch closely for a year and make a list of all the birds that harm man in any way. You will be surprised to find how short the list will be.

These birds have a right to live, and every farmer and farmer's boy ought to protect them carefully, because but for their incessant labor, many agricultural possibilities would disappear.

It has been estimated that if all the birds were destroyed, that within three years the insects would be so abundant, that there would be one to every square inch of this great land of ours. Does not this give enough reason for the protection of birds?

FOR THE USE OF TEACHERS.

No. 21.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE

FACULTY OF PURDUE UNIVERSITY.

## A CHILDREN'S VEGETABLE GARDEN.

BY PROF. JAMES TROOP.

It is probable that there are very few farmers' boys who have reached the age of twelve years, who have not had some experience in "weeding the garden;" and I dare say that this experience has not always been of the most pleasant kind. At least I did not find it so, and it was not until I was older that I discovered what was the trouble. In order to really enjoy doing a piece of work we must have an interest in it. We must love the work, and as a rule, in order to do that we must be able to look ahead and see what is to come from it.

Some one has said that when one grows pumpkins and potatoes and such things he is usually thinking how much he is going to get out of it at the end of the season. In one sense that is true, because we usually grow vegetables either for our own use or to sell to some one else; but before we can grow them, to secure the very best results, we must certainly learn something about them, how they grow, how to supply their needs from the time when they first peep their tiny heads through the soil until they put forth their leaves and blossoms and finally ripen their fruit or seeds. By so doing we shall be able to work in harmony with nature, and thus in the end have the satisfaction of growing the best and receiving the largest returns.

In a former leaflet Professor Bailey has told you about raising Sweet Peas and China Asters. I suppose that he selected those varieties because they afford an opportunity to study and enjoy their beauty for a long time.

Now I propose that we have a vegetable garden in connection with the flowers, because, while we all love flowers, I am sure there is not one of us who does not enjoy nice, crisp vegetables as they are prepared for the table fresh from the garden. And then you know they always taste so much better when we have planted the seeds and cared for them all by ourselves.

There are four things necessary to make a successful vegetable garden:

1. A suitable soil.
2. Pure seed.
3. Clean cultivation.
4. A good supply of fertilizer or plant food.

If one of these is omitted, the garden will not be the success that it ought to be.

### PREPARATION OF THE SOIL.

Almost any kind of soil will grow some kind of crop, because plants have a way of adapting themselves to circumstances, and will grow under very discouraging conditions; but if you expect to gather a bountiful harvest, the soil must be of the very best. It sometimes happens, however, that the soil contains enough plant food, but it is not in the proper condition for the plant to make use of it. It may be due to a lack of moisture. The soil may be baked so hard that the rain can not get into it, and instead all runs off into the ditches and streams just as it runs off the roof of the barn into the gutter. When this is the case, this hard crust must be broken up by deep plowing and thorough cultivation. This will allow the rain to soak into the soil and dissolve the plant food so that the young growing rootlets can make use of it. When soil is prepared in this way there will be no need of carrying water for the plants, for if the top soil is kept stirred, as it must be in keeping out the weeds, there will be no time during the driest season when there will not be moisture for the plants. If you have read Leaflet No. 5 on "A Children's Garden," you have learned why this is so.

If the soil is naturally so poor that it will not grow a satisfactory crop of corn, then it should have a good dressing of well rotted stable manure, plowed under and well mixed with it. I wonder if any of you know how much manure the large market gardeners put on an acre of land? I have heard them say that they use from fifty to seventy-five wagon loads per acre. Do you wonder then that they can raise large crops?

Now, before sowing or planting the seeds, the soil should be made very fine so that the seeds may all be covered at a uniform depth, and so that the young rootlets may find plenty of plant food near at hand as they begin to grow. Do you know how the root takes its food? If you will place a few kernels of corn between some moist woolen cloth and keep them in a warm room until they begin to grow you will see a great many little white hairs growing out of the sides of the roots. These little hairs absorb or drink in the liquid food from the soil for the use of the plant.

### HOW MUCH GROUND TO PLANT.

In the list of varieties suggested there are none that will need any hand weeding, except what can be done with the hoe, so I think that about one square rod for each kind will not be too much. This will give six square rods. The shape of the plats will depend somewhat upon the size and shape of the garden where they are located, but I would suggest that they be somewhat longer than broad, say 10 ft. by 27½ ft. This will allow a little room for a walk through the middle. A grass walk 18 inches wide extending entirely around the plats and also through the center, if well kept, will add greatly to the general appearance, but this is not necessary.

### WHAT TO PLANT.

How many kinds of vegetables do you suppose are generally grown by market gardeners? If you will get a seedsman's catalogue and look it over, I think you will find fifty or more different kinds. Of course you do not want to plant so many as that, because they would require too much labor to properly care for them. It will be better to select only a few kinds and give them the best of care. Nor will you all want to plant the same things, so I will name a few kinds which may be grown with very little trouble, and each one may select such kinds as he may wish to raise. Here they are: Bush Beans, Table Beets, Cabbages, Cauliflower, Sweet Corn, Musk Melons, Onions, Peas, Radishes, Salsify or Vegetable Oyster, and Tomatoes. Such things as Potatoes, Squash and Pumpkins require too much room for our present purpose, and may be grown in the field just as well.

Having selected the kinds to plant, you should be careful not to plant more than you can attend to properly. A small plat of each well grown, will be much better than double that amount partially neglected. Now, I am going to suggest the following varieties for our garden: Golden Wax Bean, Gem Musk Melon, Knott's Excelsior Pea, Stone Tomato, Early Snowball Cauliflower, and Moore's Early Concord Sweet Corn. These are all excellent varieties and may be easily grown.

One of the most interesting things about vegetable gardening, is the size of the crop gardeners get from their land. Some "truck farmers," as vegetable gardeners are often called, harvest enormous quantities of produce from an acre of soil. They never let the land lie idle. It is always producing in the growing season. This suggests a scheme for you. Suppose you plan to have one plat divided into halves, each part being of the same size. You perhaps plan to plant some tomatoes. Then place just twice as many plants on one-half as the other, and give them equal treatment. Keep count of the number of green tomatoes, of those that ripen and of the weight of those you pick from each half. Then, if you are sharp and handy with figures, you can tell at the end of the season what the difference was in total yields of those half plats and what the difference would be in yield per acre. This seems to me to be a plan that will interest the home folks, and would be a very interesting thing for a school report on a truck farming experiment. This is not suggested so much to study the yield of tomatoes as to learn how much can be secured from two equal pieces of ground differently planted.

*Peas.*—Almost any of the garden peas may be sowed just as early as the ground can be worked, as they are somewhat hardy and light frosts do not injure the plants. Rake the surface of the soil before sowing the seed, in order to destroy any weeds which may have germinated since the ground was plowed This will give the peas an equal chance with the weeds, and the labor of cultivation will be much lessened. Make the rows 16 inches apart and perfectly straight by stretching a line across the bed. With a stick make a mark about one inch deep and drop in the seed two inches apart, and cover with fine soil. Now if the soil is pressed down by laying a board over the row and walking on it, the seeds will germinate much quicker than if the soil is left loose. This should be done with all seeds which are sown in the open ground.

Examine the seed peas before sowing and see if you can find any that are "buggy." That is, those that have had a portion of the inside eaten out by the pea weevil. Older people have frequently asked the question if these "buggy" peas will grow. In order to test the question for yourselves, take a quantity of these peas, and after counting them, sow them in a row adjoining the good seed and treat them all alike.

Now take your note-books and note the date of planting, date when the plants first show above the ground, the per cent. of buggy seeds that germinate and of the good seeds, the date of blossoming, the date of first picking and date of last picking, the number of pods on a stem of the buggy seed as compared with the good seed. Keep a record of the number of quarts or pecks grown on one square rod of ground, then you can easily figure the yield per acre.

*The Tomato* will not bear any frost, so the seeds should be sown in a box in the house, and when the plants are three inches high they should be transplanted into another box of fresh earth and placed where they can get plenty of sunlight. Keep them in the house till all danger of frost is over, then they may be planted out in the garden. Set the plants four feet apart each way, and as soon as they get to be 14 or 16 inches high they should be staked in order to prevent them from falling to the ground. Here I want to suggest an experiment, viz.: Select two rows as nearly alike as possible; let one grow in the ordinary way, with bushy tops. Take the other row and cut off all side branches, as soon as they appear, thus causing the plant to run up to a single stem. Place a stake about eight feet long beside these single stem plants, and tie them fast as they grow. When the fruit begins to ripen, take your note-book and put down—

1. The date of first ripe fruit on each plant.
2. Number and size of ripe fruits on each plant each day.
3. At the end of the season, if frost comes before the plants are done bearing, note the number of green fruit remaining on each vine. If you have done your work well you will be able to tell some of the other people which method has given the better results.

*Cauliflower* is seldom raised by farmers, but when you learn what a delicious vegetable it is I am sure that more of you will want it. So here is a chance to grow something that is comparatively new. Cauliflower is only a variety of cabbage, and may be as easily grown as cabbage. There are two conditions necessary, viz., the soil must be moist and it must be rich. The Early Snowball variety is grown more than any other. The seeds should be sown in a box in the house the last of March, if an early crop is wanted, and the young plants transplanted into the open ground in April or May. In fact they should be treated in all respects as we treat early cabbage plants. Place your rows three feet apart and set the plants two feet apart. Keep the ground well cultivated and watch for the cabbage worm. When it makes its appearance get a little insect powder and dust it over the plants; this should kill the worms. After a time the plants will form large, fleshy, white heads when they are ready for use. Now compare these heads with the cabbage head. You will notice that while the cabbage head is made up of leaves, this is composed of fleshy flower stalks and undeveloped buds. This is only one of the many varieties of cabbage which are grown by the market gardeners.

Beans, musk melons and sweet corn may usually be planted during the first week in May. None of these will bear any frost, so it is necessary to wait until the soil has become quite warm before planting.

*Beans.*—Plant the beans three feet apart, and the hills one foot apart, in the row. Write down in your note-books the date of planting, the date when the plants appeared above the ground, the date of blossoming, the date when the beans are large enough to use and the date of ripening, if any are left to ripen. Notice the difference, if there be any, between the beans and peas in their manner of getting out of the ground.

*Musk Melons.*—The hills for the musk melons should be about four feet apart each way, as this variety does not make so large vines as some of the others. Before planting the seeds, dig a hole about eight inches deep, and put in a shovelful of well rotted barn manure; then cover this with soil and plant the seeds, covering them an inch deep. Press the soil down firmly with the hoe. After the plants are well up, pull up all but three good, strong plants. These will make a better growth and bear nicer fruit than if all were left to grow. Now keep a careful watch for a little striped beetle. They are very fond of melon and cucumber leaves, and if they get a chance will ruin them before you are aware of it. You may be able to keep them off for a time by making little boxes eight to ten inches square and covering them with cheese cloth, and placing these over the plants. The cheese cloth will admit air and sunlight and at the same time will keep out the insects.

Keep a record of the number of melons grown on a square rod; from this you can figure the yield per acre.

Many people every year get badly deceived in buying musk melons. They think a large, fine looking melon in a wagon, or at a store, must be nicer to eat than a smaller, less handsome one. If you will study this subject I feel sure you will many times in the future be gratified that you did. If you plant some melon seed you may get ideas of value, by doing two things: First, plant a few hills of a large and a few hills of a small variety. Second, plant a few hills of a variety that has a yellow or salmon colored flesh, and a few hills of a variety with green flesh. You can find out about the size of melons and color of flesh by looking in the seed catalogues, or writing to the State Experiment Station at LaFayette. After you learn this you will know which ones you will wish to plant.

*Sweet Corn* may be planted at different times during the summer, but for the early crop it should be planted from the 1st to the 10th of May. Plant in rows three feet apart and about three feet in the row, making three hills across the plat. Now it may be that after the plants are nicely up, a cut-worm may steal into your garden and cut off some of the young corn or cauliflower plants. If so, you can probably find him hiding under a clod of dirt close by the plant, when he may be dug out and killed. Now to prevent any more injury I would suggest that if fresh clover be taken, soaked in a solution of Paris green and water, and then scattered about the hills of corn and among the cauliflower plants it will destroy these cut-worms, as they will take the clover instead of the vegetables. But since Paris green is very poisonous, and as your father will know better how to use it, I would suggest that you ask him to do this for you.

There are a number of other experiments which might be suggested, but I think these will be all that you can attend to in one season.

The radish is an interesting plant, and varies in size from the little red ones, hardly larger than a hickory-nut to the white Japanese ones, resembling big turnips. Radish seeds sprout soon, and the plants grow very rapidly. You plant some, and, lo, in a very few weeks they are ready for the table. If you are quite impatient to see things grow fast, as some children are, then try radishes. People eat the radish because it is a juicy, tender, peculiar flavored vegetable that is eatable raw. How much do the varieties differ in productiveness, flavor and tenderness? A row of several kinds in your garden will tell quite a story.

It may not have occurred to you, but the fact is, almost any industrious boy or girl, who loves to see plants grow, can on a very few of these little pieces of ground grow many vegetables and earn some money for himself. What a pleasure to get up early in the bright, sunny days of spring and summer, and go into the garden and work among the plants glistening with dew. Then the music of the birds sounds sweetest, the air is freshest and one can fairly see the melons and other plants covering the ground. Then one can work with a will and a clear head. At harvest time, of course, the neighbors will buy nice fresh vegetables of you and you will learn one way of earning money while studying nature and learning many things.

FOR THE USE OF TEACHERS.

No. 22.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE
FACULTY OF PURDUE UNIVERSITY.

## AN EXPERIMENTAL FARM FOR YOUNG PEOPLE.

BY PROF. W. C. LATTA.

In Leaflet No. 9 you learned about a *School Garden*. If you have acted on the suggestions of that leaflet, you are beginning to realize how attractive, interesting and instructive such a garden may become. More than this, you have learned how easily and cheaply you can beautify the school yard with flowers and vines.

In this leaflet I wish to show you how to have a miniature *School Farm*, which may be made quite as interesting and instructive as the school garden.

But I fancy I hear you say, "Where can we find room for such a farm? We can't take it out of our playground. It is too small now." You are quite right. Don't take any part of your school yard, but persuade the school authorities to provide a small enclosure—at least one rod by four in size—just outside the school yard. Doubtless, some kind-hearted farmer who has not forgotten that he was once a boy will let you have the ground, and then I am sure you can get the school board to put a strong, close fence around it.

In this small enclosure the older boys can prepare the ground, plant the seeds and cultivate the crops "by hand." About the only tools you would need for this purpose would be the spade, the hoe and the rake.

In such a piece of ground you could conduct a great many simple experiments with the farm crops. You could watch the process of germination, growth, fertilization and development of grain, and you could also note when, where and how insects and fungous diseases attack the several crops. By conducting these experiments you would learn many interesting facts that would prove very helpful on the farm.

It is not expected that you would be able to grow as good crops as the farmer can under more favorable conditions. You must remember that the *chief* object of the school farm is to *get knowledge*, which would, later in life, help you to become more successful farmers.

Do you know how valuable knowledge gained by careful observation and experiment really is? Just this kind of knowledge is considered so valuable that our government expends annually nearly a million of dollars to maintain Agricultural Experiment Stations in the several States and Territories and in the District of Columbia.

This vast amount is expended in conducting and in publishing the results of experiments that will help the farmers to avoid mistakes and employ only the best methods. By using this experimental knowledge the farmers of the country will be enabled to save many times this sum.

A prominent farmer of northern Indiana estimates that the farmers in his county alone might have saved one and one-half millions of dollars in the last ten years by fully using the information afforded by the Experiment Station and the Farmers' Institutes.

Experiments have shown that the stinking smut of wheat can be effectually destroyed by simple treatment with hot water. If this remedy *alone* were faithfully used by all farmers whose wheat is affected, it would save them millions of dollars.

The farmers of Indiana annually expend many thousands of dollars for new varieties of grain, in the belief that the old varieties are "running out." Many carefully conducted experiments at Purdue University and elsewhere have clearly shown that these varieties do not *necessarily* run out, and that the old and tried sorts, if well cared for, will generally do as well as, or better than, the new kinds for which some farmers will pay three or four prices.

The value of the experiments which you can conduct on a school farm will depend on what you undertake and how you do the work. If you begin at the wrong time, do the work in a careless manner, or if you fail to finish what has been well begun, your observations and experiments may have very little value. But if you will carry out even the simplest kind of an experiment from beginning to end in a careful manner, you will surely gain some useful knowledge. More than this, you will acquire the habit of systematically taking and recording observations which will prove invaluable to you all through life.

In order to help you, I will suggest (1) a few very simple experiments that you can try in the garden at home, or in some corner where they would not be disturbed, and (2) how to arrange and manage a school farm, in which you could join with your schoolmates in conducting a variety of experiments.

One of the very interesting things you might do in the garden at home is to collect and plant all the varieties of peas you can get. This might include the Canada field peas, the several kinds of garden peas and the different varieties of sweet peas. Plant in drills at least one foot apart, dropping the seeds two or three inches apart in the drill. Do all the planting in one day in the early spring, and cover about two inches deep. Note (1) when each kind "comes up;" (2) the difference between the first or seed leaves and those which follow; (3) how tall each kind grows; (4) when each kind blooms; (5) differences in the size, color and fragrance of the flowers; (6) differences in the form and size of the seed pods and in the number of pods produced on a single plant of each kind; (7) when each kind matures. You will, of course, need supports for the taller varieties. When each variety comes into bloom it will be interesting to carefully dig up one plant of each kind and examine the roots for nodules (little rounded enlargements), which will vary in size from a pin head to a pea. The little colonies of microbes which live in these nodules have the singular power of capturing the free nitrogen of the air and of rendering it available for crops.

Most if not all of the leguminous plants (including peas, beans, clovers, etc.) have this peculiar power of "fixing" nitrogen through the agency of microscopic soil microbes, and this is one reason they are called soil-renewing crops.

This experiment would be nearly, if not quite, as interesting if made with varieties of beans, or corn, or potatoes.

If in addition to, or instead of, these experiments at home, you desire to join with your schoolmates in making a *series* of experiments, the school farm will best serve your purpose. An enclosure one rod wide by four long is perhaps as large as you can well take care of "by hand." In such an enclosure you can lay out a series of twenty plats, each one yard square, for the small grains, and another series, each six feet by seven, for corn, potatoes, etc. The accompanying diagram, containing half the plats in each series, shows how the plats may be arranged, and indicates also the number of hills or drills to each plat.

## LIST OF EXPERIMENTS. SERIES I.

No. 1. Wheat sown broadcast.

No. 2. Wheat sown in drills.

Nos. 3 and 4. Rye sown as Nos. 1 and 2.

Nos. 5 and 6. Oats sown as Nos. 1 and 2.

No. 7.* Two drills seed wheat covered ½ inch deep, and two drills seed wheat covered 1 inch deep.

No. 8. Two drills seed wheat covered 2 inches deep, and two drills seed wheat covered 3 inches deep.

Nos. 9 and 10. Seed oats sown as Nos. 7 and 8.

No. 11. Two drills small shrunken seed wheat and two drills large plump seed wheat.

No. 12. One drill seed wheat sown September 1 to 15, and one drill, each, seed wheat sown 2, 4 and 6 weeks later.

No. 13. Two drills seed wheat, 12 grains to each drill, and two drills seed wheat, 24 grains to each drill.

No. 14. Two drills seed wheat, 36 grains to each drill, and two drills seed wheat, 48 grains to each drill.

No. 15. One drill seed oats sown March 1 to 15, and one drill each seed oats sown 2, 4 and 6 weeks later.

No. 16. Two drills seed oats, 12 grains to each drill, and two drills seed oats, 24 grains to each drill.

No. 17. Two drills seed oats, 36 grains to each drill, and two drills seed oats, 48 grains to each drill.

No. 18. One drill each of red clover, crimson clover, alsike clover and alfalfa, sown about April 1.

No. 19. One drill red clover, sown February 15 to 25, and one drill each red clover sown 2, 4 and 6 weeks later.

No. 20. Four drills crimson clover, sown as No. 19.

## SERIES II.

No. 1. Corn in hills, three grains to each hill.

No. 2. Corn in hills, four grains to each hill.

No. 3. Corn in drills, six grains in each drill.

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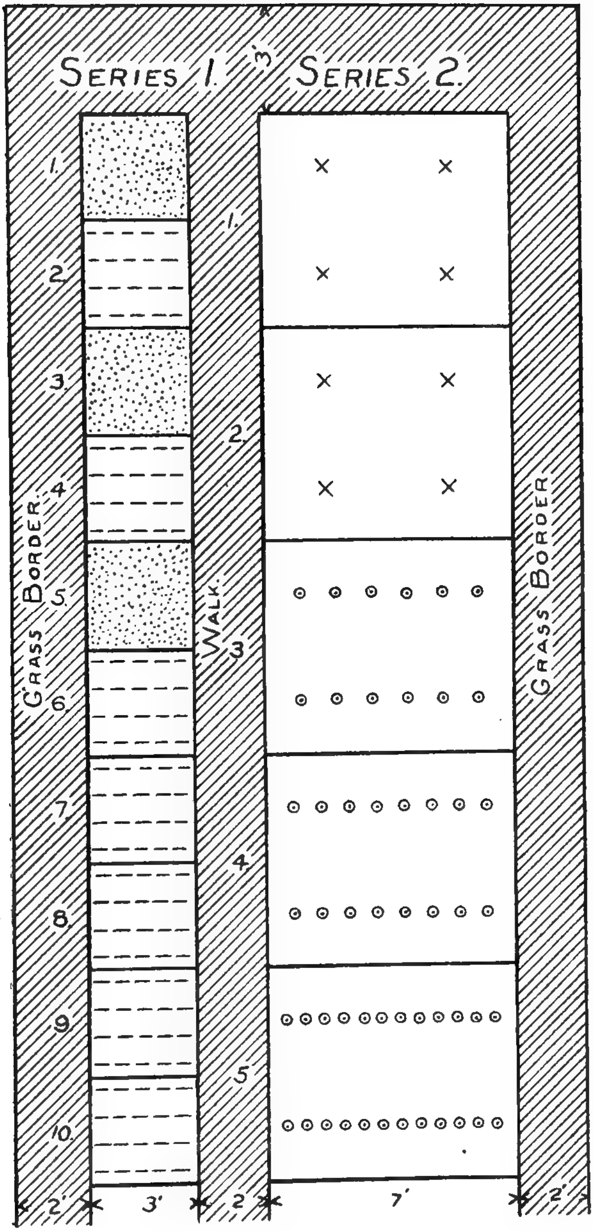
*Sow 20 grains to each drill of Nos. 7-12, inclusive, and to each drill of No. 15.



Series 1.
3'
Series 2.
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
1.
2.
3.
4.
5.
Grass Border
Walk
Grass Border
2'
3'
2'
7'
2'

No. 4. Corn in drills, eight grains in each drill.
No. 5. Corn in drills, twelve grains in each drill.
No. 6. Corn in drills, planted April 20 to 30.
No. 7. Corn in drills, two weeks after No. 6.
No. 8. Corn in drills, four weeks after No. 6.
No. 9. Corn in drills, covered two inches deep.
No. 10. Corn in drills, covered four inches deep.

The following are some of the many other experiments you might undertake:

1. A test of varieties of corn, oats and wheat.
2. Treatment of seed wheat, oats and potatoes for fungous diseases.
3. Planting large and small cuttings of potatoes.
4. Planting potato cuttings, part with the "eye" *up* and part with the eye *down*.
5. Planting tip and butt kernels of corn.
6. Planting sound and defective seed corn.
7. A test of frequency and depth of cultivation of corn or potatoes.

## INSTRUCTIONS.

1. Get advice from your elders as to best time and manner of doing the work, etc.

2. As far as possible, avoid working the ground when wet. This is very important if the soil is heavy. In early and late planting you cannot always avoid this.

3. Try to get the soil well pulverized before planting or sowing.

4. Each one of the older boys should have a memorandum book, in which he should draw a diagram of the plats, and number each one in both series.

5. Under the proper date and number, note when and how each plat is prepared and planted.

6. Treat the several plats of a group just alike in all respects except the point under investigation. To illustrate: If you want to learn the effect of planting seeds deep and shallow, take care that the several plats in this group are prepared alike, planted the same day, with the same kind of seed, the same number of seeds, and cultivated at the same time and in the same manner.

7. Observe when the seeds in each plat "come up," the per cent. of seeds that germinate, how the young plants look, etc., and make careful notes of these and other observations under the proper numbers and dates in your memorandum book. The chief purpose of this is

to *acquire the habit* of making close observations and carefully recording the same. Your teacher will show you how to make the notes in your book.

8. From time to time during the season make careful observations, always comparing the several plats of the group with each other, and note in your book the points of interest.

9. Be on the lookout for the first appearance of rust on wheat, oats, rye and corn. Examine both upper and under surfaces of leaves. Note to what extent each variety is affected by rust.

10. Note what per cent. of smutted heads appears in wheat, oats, and rye. Be very careful to note the effect of treatment of seed on the amount of smut present.

11. Note when and where corn smut first makes its appearance, and whether any varieties show more smutted stalks than others. Note how many of the smutted stalks produce no ears. Extend your observations to the fields of corn near by. By counting stalks in the field with and without smut, and noting the per cent. of ears in each lot, you may learn how the proportion of grain is affected by smut.

12. If any plants become sickly or die before they mature, try to find the cause. It is quite likely to be the work of some injurious insect. If you do not look very carefully, the little fellows may escape notice. Prove that boys have "sharp eyes" by finding and capturing the culprits.

13. It will be necessary to continue operations on your school farm during the summer vacation. Six or eight of you can do this by taking "turns" on successive weeks. Why not organize a School Farm Club and elect one of the older boys Director of Experiments? If no one of the scholars feels competent to take charge of the experiments, invite some wide-awake, progressive young farmer of the neighborhood to act as director.

Your teacher will cheerfully aid you to organize and conduct such a club. You could meet each fortnight at the school house and compare notes and observations. You would find such a club both interesting and profitable.

14. In performing the experiments many puzzling questions will arise as to principles and methods of cropping. If your school farm does not give you the answers consult the other leaflets of this series. Consult also your teacher, parents and others, and if you are not fully satisfied, write to me, and I will try to give you the desired information. I will be glad to hear from you at any time, and will be especially pleased to have you report anything of interest in connection with your school farm.

No. 23.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE

FACULTY OF PURDUE UNIVERSITY.

## POINTS FOR A YOUNG FARMERS' CLUB.

BY PROF. W. C. LATTA.

In conducting an Experimental Farm, as suggested in Leaflet No. 23, many questions will arise. Many times will the interested and inquiring pupil ask the what, when, where, how and why of things—as, for example, *what* are plant diseases; *when* and *where* do they make their attacks; *how* can they be prevented; *why* will not the same treatment answer for all?

While it is impossible within the limits of a leaflet to anticipate and answer many of these troublesome questions, the writer desires to give, in the following pages, some information relative to crops and principles of cropping that will prove helpful to the teacher in answering questions and to the more advanced pupils in conducting their Experimental Farm.

The prime agencies or *essentials* in crop production are seed, soil, water, air, warmth and light. Among the chief *obstacles* to success

**NOTE TO THE TEACHER.—In Leaflet No. 22 it was suggested that it might be well for the teacher or some young farmer whom the teacher might interest in the enterprise to organize a Young Farmers' Club. This might be formed of the older pupils in several contiguous school districts. Such a club, properly supervised, might prove to be very helpful. This leaflet is designed to serve as a reference leaflet, from which information can be obtained and thus aid the members of the club in the discussion of various topics which they may desire to consider.**

in growing crops may be mentioned plant diseases, insect attacks, extremes of temperature and moisture, lack of available plant food, and an unfavorable physical condition of the soil due to deficiency of vegetable matter, want of drainage, or to improper tillage. You thus see that growing crops are constantly subject to influences and conditions favorable or unfavorable to their perfect development. To a greater extent than you might first suppose these conditions and influences are under man's control. As students of agriculture you are interested to learn just how far the conditions of crop production may be controlled.

Of the *essentials* mentioned above you can control the seed by selecting that which is sound and of a variety that is hardy and prolific. You can also, by an intelligent treatment of the soil, largely secure a desirable *degree* of soil moisture, warmth and fertility—the sunlight and air will do the rest. Then, too, the *obstacles* referred to above may be largely held in check by the prompt intelligent effort and co-operation of farmers.

Your attention is now called more particularly to the considerations which are especially important in successful crop production.

1. *The Soil.* The soil should receive earliest consideration (1) because of its importance in crop production and (2) because its capacity to grow crops is so easily increased or diminished by the treatment it receives from man. The soil must not only contain all the mineral elements of plants, but it must supply these elements in available form to the growing crops as rapidly as needed. To accomplish this the soil must be enriched, if not naturally fertile, and be kept suitably moist, open and warm. The prime agencies in securing and maintaining these desirable soil conditions are under-drainage, tillage, manures, green manures, and also an occasional liming of very close, sticky clays. In all heavy, retentive soils *drainage* is the first and fundamental means of improvement. It not only will remove the excess of water but it will also make the soil more open and warm, and, curiously enough, it will in a great measure prevent the ill effects of drouth. This has been abundantly proved both by farmers and experimenters. Next in importance is to maintain the supply of humus or organic matter in the soil. This is renewed by manure, green manure and by turning under straw and other refuse matter. If the land is properly drained and filled with humus, *tillage*, the next thing in order will have its maximum effect. The tillage should be both thorough and frequent to make it most effective in destroying weeds, admitting air into the ground and in conserving soil moisture.

If you will carefully observe the fields on your way to and from school you will doubtless find a number of places in which the crops are not doing well. Try to find whether the reason is lack of drainage, tillage, humus, moisture or manure. The more you observe these "poor spots" and compare them with fields which you have helped to improve the better will you be able to decide what is needed in each case to remedy the defect.

2. *Drainage.* What has already been said about drainage has doubtless raised the question, "*Why* is drainage helpful in time of drouth?" The reason is that by removing the excess of water in wet weather the drain permits the soil to become warm earlier, admits the air and this stimulates the chemical activity of the soil. Under these changed conditions the crop can be sown or planted earlier. It thus gets a better start, becomes more deeply rooted before dry weather begins and is, therefore, better able to pass the drouth without serious injury. Experiments have also shown that a drained soil is actually moister in a dry time than one that is not drained.

3. *Tillage.* Although farmers' boys are familiar with the *general* purposes of tillage or cultivation I will call attention to an interesting "what," "how" and "why" of this subject that may make it clearer to you. Just *what* is the *specific* purpose of tillage at different times of the season; *how* may the desired effect be best secured, and *why* does tillage conserve or save soil moisture?

As to the "what," I would say that the *specific* object in cultivation will vary with the time of year and the climatic conditions. When the seed bed has been properly prepared and the seed has been sown or planted the chief purpose of tillage at first will be to break the crust formed by packing rains, and thus admit air so that the seeds may germinate promptly. This will be the first object *whenever* the land has become *encrusted.* In case the land has been allowed to become foul, owing to poor cultivation in previous years, the chief purpose will doubtless be to destroy weeds. The admission of air, the destruction of weeds and the mixing of the particles of soil with each other or with manure or fertilizer, are the chief purposes of tilling in the early part of the growing season. Later in the season, when the weeds have been subdued, especially when dry weather sets in, the *chief* purpose of tillage will be to *conserve soil moisture,* that is, to prevent its evaporation from the surface of the soil as much as possible, in order that the thirsty plants may get sufficient moisture for vigorous growth. Now as to the "how." All of the above named purposes may be secured in most properly prepared soils by the use of a cultivator having many small points or hoes. The spring-tooth cultivator is well adapted to accomplish these purposes. In case the soil is lacking in vegetable matter and tends to become packed below, some form of cultivator with larger and rigid points or shovels may be necessary during the *earlier* cultivations. Let us now consider "why" tillage will conserve moisture. It does it by loosening the upper two or three inches of soil and thus destroying or weakening the capillary power of the upper soil. By capillary power I mean the power of the soil to lift water from below toward the surface. You have often observed how soon the surface soil appears dry after being cultivated. This is because the upper soil has been made so open or porous that it can no longer lift the soil water to the surface. The moisture therefore remains in the lower soil just where the plant roots may profit by it. Some farmers will roll their fields during dry weather. This will do while seeds are germinating, as it will tend to bring the soil moisture near to the surface so that the seeds will sprout more quickly. But when the young plants get two or three inches high the roll should give place to the cultivator in order that the moisture may be more fully saved for the growing crop.

4. *Manure.* According to an old adage we are to make the soil (1) dry, (2) clean, (3) rich. Sooner or later all heavily cropped soils must be enriched by the addition of manure or fertilizer. In our efforts to enrich the soil we should keep two ends constantly in view, (1) to restore humus to the soil and (2) to renew the supply of available plant food.

We need to restore the humus because it renders the soil open and friable, enables it better to endure the extremes of wet and dry seasons and, also, because it will aid in the elaboration of mineral plant food from inert matters in the soil. We need also to renew the supply of available plant food, as the soil, when constantly cropped, is unable to elaborate this food rapidly enough from its own store to meet the demands of full crops.

Fresh stable manure is best to enrich the soil, as it supplies both humus and available plant food.

Commercial fertilizers may be used in connection with green manuring crops (such as clover or rye plowed under), the former to supply the plant food and the latter to renew the supply of humus.

I prefer the stable manure whenever it can be had, because its effects are uniformly good and lasting, while commercial fertilizers are quite variable in their action and their effects are transient. In one experiment at Purdue University fresh horse manure has produced an aggregate increase per acre of 128 bushels of corn in fifteen years and the effect of the manure still continues as shown by an increase of 2.4 bushels to the acre in the fifteenth crop. In order to have its maximum effect the manure should be carefully saved and promptly applied. Many farmers fail signally in both these respects. Their barns are so constructed as to permit the liquid manure, which is the best part, to escape through the floor. Then, as if this loss were not enough, they throw the solid manure out in piles under the eaves to be washed and bleached by rains. Prof. Roberts, of Cornell University, says that stable manure left exposed for six months will lose about 50 per cent. of its fertilizing value. The manure that might be made and saved in one year by feeding out the crops of a 100-acre farm would contain plant food that would cost, in the form of commercial fertilizers, at least $1,000. What farmer can afford to lose 50 per cent. of the manure by letting it escape through the barn floor or wash out of the barnyard?

You cannot fail to see that the farmer, who would grow the very best crops, must feed out these crops on the farm and very carefully husband and apply the manure to his fields.

In order to save and utilize the manure most fully, I would advise (1) water-tight floors under the stables, (2) plenty of bedding to absorb the liquid manure, (3) hauling the manure to the field as fast as made and scattering it at once upon grass or clover sod which is to be plowed under for corn in the spring.

With his land thoroughly drained, in good tilth and suitably enriched, the farmer may properly turn his attention to his crops.

5. *The Seed.* This heading doubtless recalls what Prof. Arthur told you in Leaflet No. 14 about acorns, peas and beans. The seeds of corn, oats and wheat are quite different from acorns, beans or peas in many respects, which you can readily learn by sprouting them. In the case of corn, oats, rye, wheat, etc., the seed is a tiny plantlet with a store of plant food packed around it to give it a start in the world. In order that the seed corn or wheat may produce a vigorous young plant two things are necessary, (1) the plantlet, which we call the germ, must have strong vitality; that is, be able to germinate promptly and vigorously, and (2) the store of plant food, packed in the seed, must be sufficient to furnish the growing germ an abundance of material with which to build a few active rootlets, a strong stem, and one or two green leaves, by which time the young plant will be able to get its food directly from the soil and air. As a rule, bright-looking, plump seeds may be depended on to germinate

promptly and well, while small, shrunken seeds will produce, at best, only a comparatively weak growth. In an experiment conducted on Purdue University farm, large, plump seed wheat produced two and six-tenths more bushels to the acre than other seed only a trifle smaller and not quite so plump. In selecting seed oats, rye and wheat, it is usually quite sufficient to blow and screen out the light and small seed by means of the fanning mill. Seed corn, on the other hand, may be large and plump and yet lack vitality. This is very apt to be true of the later varieties of corn, which may not become thoroughly dry before freezing weather begins. As farmers frequently suffer serious losses from poor seed corn, it is very important, in order to avoid possible failure, to learn, before planting, whether the seed will grow well or not. It is so easy to do this, that any boy or girl may make the test, either at home or in the schoolroom, if the latter place is not allowed to get too cold at night. To make the test, place one or two layers of blotting paper or heavy cloth on a plate. On this put one hundred grains, taken at random from the seed to be tested. Cover with two or more layers of the same material, set in a warm corner of the room, and keep moist, but not wet, for a few days. From time to time examine, and remove all grains which have germinated. At the end of five or six days you can tell what per cent. of the seed will germinate under favorable conditions.

Other seeds may be tested in the same way, and if the test is made in the schoolroom, all will be interested in watching the process of germination and in noting the differences in the rate and order of development of stem and roots of various plants.

6. *The Variety.* The several varieties of corn, oats, wheat, etc., differ much in size, manner of growth and hardiness: in ability to endure extremes of wet and drouth, resist diseases and insects, as well as in adaptation to different soils and climates. To illustrate: It has frequently happened in the experimental work at Purdue University that some varieties of wheat have been almost completely winter killed, while others with the same treatment have escaped serious injury. Again it frequently occurs that certain varieties which can endure severe winters have been so seriously damaged by rust alone as to reduce their yields twenty to fifty per cent. Late varieties of corn have frequently suffered much more from dry weather than early kinds when grown side by side on the University farm. Many other interesting illustrations might be given. We cannot always tell just why one variety does better than another, but you can readily see

how important it is to get the varieties best suited to the locality. As a rule it is better and far cheaper to continue the standard home-grown varieties rather than buy from professional seedsmen expensive new kinds which have not been previously grown in the neighborhood. In the case of large and small varieties of corn, I think, if you will observe closely, that you can discover why the smaller kinds have an advantage in dry seasons.

7. *Time of Sowing.* When to sow or plant is an important matter with the farmer. It is not easy to determine, as the time will vary with the locality and the season. By keeping a record of early and late sowing or planting for a series of years one may learn approximately the best time for these operations. This has been done with wheat and corn on the University farm. In the experiments with wheat, covering eight years, the dates of sowing and the average yields per acre were as follows:

| *Time of Sowing.* | *Average Yield.* |
|---|---|
| Sept. 18 to 20 | 30 bushels. |
| Sept. 25 to 28 | 28.7 bushels. |
| Oct. 2 to 5 | 26 bushels. |
| Oct. 10 to 12 | 21.2 bushels. |

It would perhaps be better still to sow about the middle of September in the latitude of Lafayette, but for the Hessian fly, which is more likely to seriously damage very early sown wheat.

The experiments with corn have not been quite so decisive, but better yields have been produced by planting in the first third of May than later.

The time of sowing or planting will vary also with the latitude. For each sixty miles north of the latitude of Indianapolis wheat may be sown about one week earlier, and for each sixty miles south a week later. This is true also of corn, but the order is reversed. That is, the planting should be later to the north but may be earlier to the south.

In this connection it will be interesting to note how much earlier than others the naturally or artificially drained soils get into condition for planting in spring.

8. *Rate and Manner of Sowing or Planting.* The following general rule, as to amount of seed, will apply to those crops which "stool" or tiller as wheat, oats, rye, etc. Sow *less* seed (1) if the date is early, (2) if the seed bed is thoroughly prepared, (3) if the soil is fertile, and conversely sow *more* seed (1) if the time is late, (2) if the preparation of the seed bed is not thorough, (3) if the soil is impoverished.

The reason for this rule is that, under the first set of conditions, the young plants would tiller or multiply and thus make a good "stand," while under the second set of conditions little tillering would occur.

Experiments on the University farm, covering eight years, show clearly the advantage of thick sowing of wheat. The advantage is greatest in severe winters. The average yields per acre from the different rates of seeding are as follows:

| *Seed Sown.* | *Average Yield.* |
|---|---|
| Two pecks | 22.5 bushels. |
| Four pecks | 27.4 bushels. |
| Six pecks | 29.5 bushels. |
| Eight pecks | 30.9 bushels. |

Experiments with thick and thin planting of corn have been carried on eleven years at Purdue. The corn has been drilled in rows three and two-thirds feet apart, the individual stalks standing about ten, twelve, fourteen, sixteen and nineteen and one-half inches apart, respectively, in the rows on the different plats. Here is a brief summary of the results:

1. Thick planting has produced *more* grain in *favorable* seasons and much *less* grain in very *dry* seasons than thin planting.

2. Thick planting has yielded more corn fodder than thin planting.

3. Medium thick planting (stalks twelve inches apart) has produced the most corn fodder and also the greatest total yield of grain and stalks.

4. Medium planting (stalks fourteen inches apart) has yielded the most grain.

Here are some interesting questions to which I hope you may find correct answers.

1. Why did thick planting in dry seasons reduce the proportion of *grain?*

2. Why did it not reduce the proportion of *stalks?*

3. Why did the thinnest planting in dry seasons yield a greater proportion of grain to stalks than any thicker rate?

4. Why is it that, as a rule, severe drouths reduce the proportion of grain in the corn crop?

5. Why do not drouths reduce the proportion of stalks?

6. In growing corn to feed the entire crop of grain and stalks to cattle, which of the above named rates of planting would you prefer?

7. If you were to plant two fields to corn, one of which suffers

from drouth while the other does not, what rate of planting would you prefer for each field, and why?

The manner of sowing (whether broadcast or drilled) is also important, especially with wheat. Either method may be followed in sowing oats, but I prefer the drill because it distributes and covers the seed more uniformly.

Fall crops like wheat and rye should always be sown with the drill in which case they will pass the winter more successfully. Can you tell why? If you cannot, try both ways with wheat on your school farm and watch the results.

9. *Rotation of Crops.* The succession of crops on the farm has much to do with their vigor, quality and yield. Corn can follow almost any other crop better than itself and this is equally true of all the other farm crops. It has been repeatedly and clearly shown by farmers as well as by experimenters that better results can be secured by growing a variety of crops in a rotation than by growing the same crop every year. In carefully conducted experiments at Purdue University the yields have been fifteen per cent. to forty per cent. greater from rotative than from successive cropping. The more important reasons for rotative cropping are (1) the crops are more vigorous and suffer less from fungous diseases, (2) injurious insects are held in check, (3) it is better for the soil, (4) the yields are greater and consequently the profits are increased.

In choosing crops for a rotation we must select from those suited to soil, climate, market and the needs of the live stock. In arranging the order or succession of crops we should as far as it is practicable try to have (1) a hoed crop follow a sown crop, (2) a slow maturing crop succeed a quick maturing one, (3) a grass or root crop follow a grain crop, (4) a leguminous crop, as clover or peas, succeed a farinaceous crop, as wheat or rye. So far as the soil is concerned the following rotation would be satisfactory: (1) corn, (2) oats, (3) potatoes, (4) wheat, (5) clover. The oats and potatoes might not prove profitable in some localities, in which case the rotation might be cut down to a three-course, consisting of (1) corn, (2) wheat, (3) clover, which, though not the best for either the soil or the live stock, is the most common one in the State.

10. *Inter-crops.* In case there should be an interval of several months between any two crops in the rotation the gap may often be filled to good advantage by what is known as an inter-crop. The purposes of the inter-crop are (1) to prevent the land from lying bare, in which case valuable plant food might wash or leach away, and (2)

to furnish a green manure for the succeeding regular crop of the rotation. For example, in the five-course rotation, given above, an inter-crop of winter rye might follow the oats and be turned under the succeeding spring for the potato crop. If for any reason it should seem desirable to follow one corn crop with another, an inter-crop of rye or crimson clover between the two corn crops would prove a decided gain to the soil by saving plant food and renewing the supply of humus.

11. *Plant Diseases.* We may have good seed of an approved variety as well as a fertile, well drained and properly cultivated soil and yet fail to secure the best crops if they are attacked by parasitical diseases. The more common of these diseases are popularly called rust, smut, scab, blast or blight. These so-called diseases are minute microscopic parasitic plants that attach themselves to the wheat, oats or corn, feed upon their juices and grow within their tissues. For some time the "host" plant (corn, oats or wheat) may seem perfectly healthy although the micelium or threadlike growths of the parasite may be found inside, on examination, with a compound microscope of high power. Sooner or later the parasite breaks through the epidermis or bark of the host plant and exposes its fruit or seed (spores) to view. Each species of parasite has its own peculiar way of showing itself on the host plant. One appears as rust on wheat, oats, rye and corn; another as loose smut of wheat, the entire head of wheat being changed to a mass of black powder; another as loose smut of oats much like the last; another as bunt or stinking smut of wheat, which develops within the wheat grain, causing it to grow thick and short and filling it with a brownish-black mass of spores that have a very unpleasant odor; another as wheat scab, which causes the wheat head, or some part of it, to turn lighter in color, giving it the appearance of premature ripeness; another as smut of corn, with which you are familiar; another as potato scab, which attacks the surface of the potato tuber, marring the appearance, injuring the quality and reducing the size of the potatoes. The germs of the smuts of wheat and oats and of potato scab attach themselves to the seed or potato cuttings and make their attacks underground. To prevent this it is only necessary to have both seed and soil free from the germs. In case the seed is affected it may be treated as follows: For stinking smut of wheat and loose smut of oats immerse the seed five minutes in water heated to 135 degrees Fahrenheit.

For potato scab soak the seed tubers or cuttings two hours in a formalin solution, using one-half ounce of formalin to a gallon of water.

For loose smut of *wheat*, soak the grain four hours in cold water, set away in wet sacks for about four hours, then immerse the seed five minutes in water heated to 132 degrees Fahrenheit. In sowing use double the usual quantity of seed treated by the last named method to make up for the part killed by treatment. In all these cases sow the treated seed in soil which has been freed from the germs by a rotation of crops. The rust, wheat scab and corn smut make their attacks on the above-ground portion of the plants. The corn smut has been prevented by spraying the growing corn from time to time during the growing season with *Bordeaux** mixture. To be thoroughly effective the spraying must be repeated after each rain and at intervals of about ten days in dry weather. It must also be continued throughout the growing season. Some degree of success has attended the spraying of wheat to prevent rust.

It is manifestly impracticable, however, in regular farm practice, to spray large fields of wheat and corn. We must therefore resort to preventive measures. These are (1) selection of varieties least liable to attack, (2) adoption of a rotation of crops extending through three or more years so as to more fully rid the soil of the disease germs, (3) removal and burning of smutted stalks as soon as the smut appears, (4) co-operation, by the farmers of the neighborhood, in these measures, because if the germs are allowed to develop on one farm they will be blown onto adjoining farms and thus spread the disease.

12. *Injurious Insects.* Last but not least are the insect pests. These little marauders sometimes cause losses amounting to more than all the taxes of the State. As the crops of corn, oats, wheat, etc., cover such large areas the farmer cannot destroy the insect pests by using insecticides as the fruit growers do. He must, therefore, resort mainly to preventive measures. Some of the means which farmers may employ in combating insects are (1) rotation of crops, (2) changing time of planting or sowing, (3) burning of stubble and rubbish after crops are harvested, (4) fall plowing, (5) destruction of volunteer wheat, (6) breaking up of meadows in two or three years after seeding, (7) making barriers or traps to head off or capture migrating insects.

Perhaps the best general preventive of insect depredations is rotation of crops. Certain insects, like the corn-root worm, can be quickly

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*To make Bordeaux mixture, dissolve ½ pound of blue vitriol in three gallons of water, then slake ½ pound of quick lime and add it to the blue vitriol solution. Stir thoroughly and pass the solution through a fine sieve or straining cloth to remove all coarse particles.

and completely destroyed by changing the crop. Many other insects can be held in check by this means. While the individual farmer may do much to hold injurious insects in check, much more may be accomplished if all the farmers will co-operate in fighting these pests of the farm.

By hunting up the hiding places of these troublesome little fellows and by noting where they lay their eggs, when these eggs hatch and how the young insects feed you will not only become greatly interested but you will also learn better how to destroy the *injurious* insects without harming the *beneficial* ones.

I have not named all the conditions of successful crop production, but I am sure enough have been said to convince you that, in order to be most highly successful, the farmer must be a very close observer, an earnest student and a careful experimenter.

If, as pupils, you act on the suggestions of these leaflets on Nature Study, you will acquire habits of close, accurate observation and study that will prove very helpful to you later in life, whether you engage in farming or in some other business.

Those of you who live in the country possess many advantages for Nature Study. The fields on every side invite you to watch Nature's processes and pry into her half-hidden secrets. By making the most of your opportunities for Nature Study you will not only find healthful and delightful recreation but gain added preparation for leading happy and useful lives.

FOR THE USE OF TEACHERS.

No. 24.

# LEAFLET

## ON NATURE STUDY.

ESPECIALLY ADAPTED TO THE USE OF CHILDREN IN SCHOOLS IN RURAL DISTRICTS.

PREPARED BY THE

FACULTY OF PURDUE UNIVERSITY.

# THE CARE OF THE SOIL.

BY PROF. H. A. HUSTON.

We cannot make something out of nothing. In order that plants may come to maturity they require certain materials which are properly called plant foods. Plants get this material from the soil and from the air. The value of the plant food taken from the soil by crops ought to be considered in the same light as the money we take out of our savings bank. The more we take out the less there is left. When we raise 40 average acres of wheat we take from the soil plant food having a value of $147.20, and when we raise 40 average acres of corn we take from the soil plant food worth $261.60. These two crops remove every year from the soils of Indiana plant foods having a value of over $32,000,000, or one-twenty-third of the total value of the farms of the State. We cannot take such enormous quantities of plant food from our storehouse—the soil—year after year, unless we make some suitable return. In order to do this to the best advantage we must study carefully both the soil which furnishes the food. and the crop which uses it. We are encouraged to make the study because the

**NOTE TO THE TEACHER.—The purpose of this leaflet is to give teachers such information as will enable them to answer such questions as may arise in the progress of nature study. It may, however, properly form the basis of several interesting oral lessons, and will suggest topics for Young Farmers' Clubs or for Farmers' Institutes.**

soil, unlike the other great factor in food production—climate—can be so modified by man as to produce very large and very profitable returns for the required outlay of labor and money.

This leaflet is written for the purpose of calling attention to some of the more important points that should be kept clearly in mind if we are to use our soils to the best advantage.

## WHAT IS A SOIL?

Any mixture of small pieces of broken rocks and decaying vegetable matter on which plants may grow is properly called soil. As we go about we notice that the soil of some fields looks quite different from that of other fields. In some places we find a loose soil which we can easily see contains a large amount of common sand. In other places we find soil that contains so much clay that bricks can be made from it. We also find mixtures of the sand and clay, some containing nearly equal parts of each and others having a greater quantity of either sand or clay. The mixtures of sand and clay are often called loam.

## KINDS OF SOIL.

Some soils are much more easily plowed and cultivated than others and such soils are known as light soils. The more sand a soil contains the more easily is it cultivated. For this reason a soil containing much sand is known as light soil. But we must not think that such soils are light in weight, for a cubic foot of sand weighs about twenty-five pounds more than a cubic foot of what we call a heavy clay. We call the clay heavy because it sticks together and is hard to work.

Different parts of the same field may be quite different in color. The red color of some clays is due to iron compounds, but the brown and black color of moist soils is due to the black matter, or humus, which is the result of the decay of plants. The leaf mould which we find under the dead leaves in the woods is a good example of this material which plays such an important part in our soils.

We often describe a soil by the kind of timber that grew on it. This is a useful method, because it has been found that the walnut and maple grow on rich, strong lands, the poplar and oak on lands of medium quality, and the beech and black gum on cold, wet, heavy lands, that require very complete drainage if they are to be used for crops. The treeless prairie and the muck swamps have black soils, and are very productive when properly drained. Try to find out what kind of trees grew on some of the fields about you, and notice whether some of these fields produce better crops than others.

### PURPOSES OF THE SOIL.

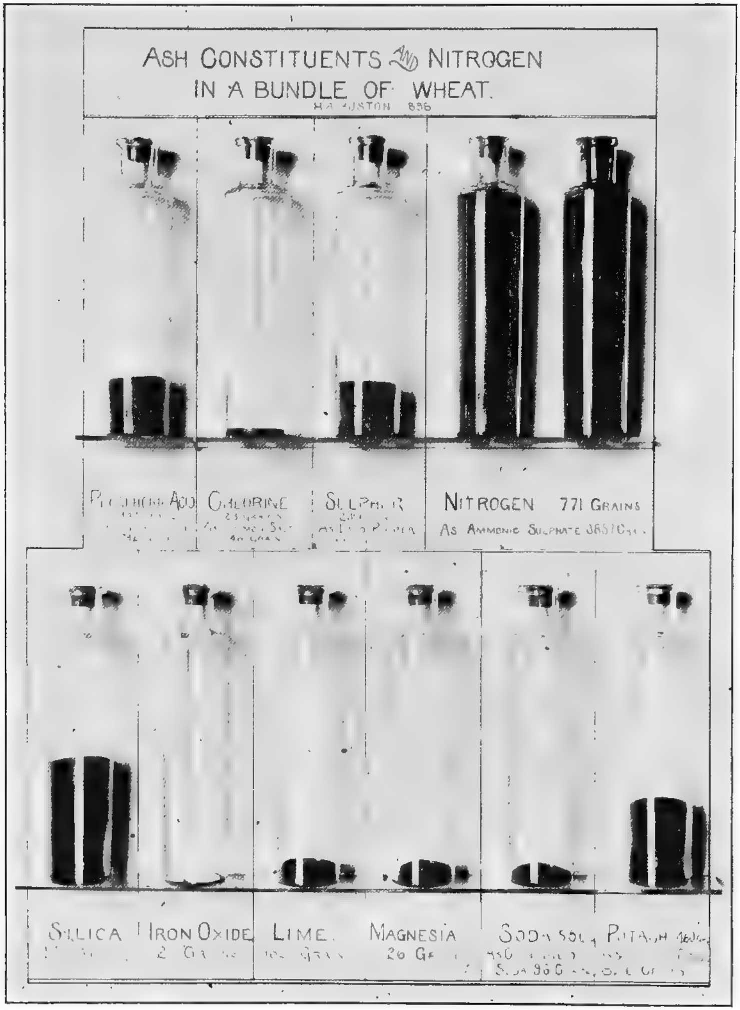
The purpose of the soil is twofold—to furnish a *physical* support for plants and to furnish some of the material of which plants are made, or as they are often called, some of the plant foods. For the first purpose almost any kind of soil that is well drained and will permit the roots to readily pass through it will suffice. But the plants can only get food from soils which contain these foods in sufficient *quantity* and in such *forms* that the plants can take up the foods from the soil and use them to build up its own tissues.

### SOURCES OF PLANT FOOD.

Ordinary plants are composed of thirteen simple substances. These the living piant uses to build up a considerable number of complex substances, such as starch, sugar, oil and gluten. All plants contain some mineral matter which remains as ash when the plants are burned. These simple substances are taken from the soil and from the air.

### QUANTITY OF PLANT FOOD REQUIRED.

Different plants require different amounts of the simple substances that serve as their food. Water and the carbonic acid of the air furnish the material for the greater part of the plant. But if the other things are less in amount they are not less in value, and unless the plant can get all the things that it needs it cannot use to advantage those that may be present in abundance. To obtain some idea of the relative amounts of the different substances that go to make up plants we may take as an example an ordinary bundle of wheat just as it comes from the self-binder. It weighs about ten pounds, and nearly nine and one-half pounds of the material are taken from water and the carbonic acid of the air. A large part of the farmer's labor is devoted to operations for supplying the ingredients that make up the other half pound. This half pound contains ten simple substances and no two substances are present in equal amounts. The cut shows the amounts of these different substances contained in the bundle of wheat. They are not shown in their elementary state, but in the form of familiar compounds and in the case of those most important to return to the soil the form is that well adapted for this purpose.




SOIL EXHAUSTION

Some of the plant foods are present in very small amounts in many soils. And of this small amount only a part is in such a form that plants can get it. If we raise crops year after year and remove them from the land, making no return to the soil, one or more of the necessary plant foods will be reduced so much that the crop produced will be too small to pay for the labor of raising it. When a soil has reached this condition it is said to be exhausted. This does not mean that nothing can be grown on the land but that the crop will be too small to be profitable. Some lands will reach this condition much sooner than others, since some lands contain a better supply to start with. We cannot make plants out of nothing. We must sooner or later make a return to the soil for the material that has been taken away in the plants. Those materials which it is most frequently necessary to return to the soil have a money value as real as that of the grain that we sell. A bushel of wheat removes from the soil plant food having a money value of 26¾ cents, and a bushel of corn removes 19¾ cents' worth. The grain on the average acre of wheat—13.6 bushels—removes from the soil plant food worth $3.68, and the grain on the average acre of corn—30.4 bushels—removes plant food worth $6.04. When we recall that Indiana produces an average crop of 37,000,000 bushels of wheat and 109,000,000 bushels of corn per year, we see what an enormous drain is being made on the soil. Yet this relates to the grain only. The corn stalks, wheat and oat straw remove each year from the soil of the State plant food valued at $28,000,000. Not one-half of this is returned to the soil. The loss of $14,000,000 per year would bankrupt any other business than farming. These vast drains on the soil's fertility cannot continue long without reducing the soil to a condition in which it will no longer yield profitable returns. Rotation of crops and improved tillage will not put back all this plant food. Sooner or later we must return plant food to the soil. The sooner we begin the better, for it is more economical to keep a soil fertile than to restore it after the soil has become impoverished.

### SOURCES OF PLANT FOOD—MANURES.

Where shall we get our plant food? We may use the same material over and over again. If farm crops are fed and animals and animal products sold over four-fifths of the plant food in the crops may be saved in the form of farmyard manure. These manures being produced from farm crops, have nearly the same relative amount of plant food as the crops removed. But many farmers are not favorably disposed to animal production and dairying, and so sell grain. These can at least utilize the side products such as straw and stalks. These coarse materials not only furnish plant food but are of high value in improving the mechanical condition of the soil.

## CLOVER.

Another great source of single plant food—nitrogen—is the clover plant and its relatives, such as the cow pea and the vetches. But does not clover get its food from the soil like other plants? It gets much of its food from the soil, but it has the highly useful faculty of getting the most expensive plant food—nitrogen—from the air. How does this plant do what other plants can not do? If you will dig up a healthy growing clover plant and carefully wash the earth from its roots you will find a number of thickened places on the smaller roots. These look as though the roots might have been stung by some insect. Within these enlarged places on the roots are many very minute organisms too small to be seen by the naked eye, yet these minute beings are of great importance in the world. They have the power of taking up the *free nitrogen* of the air and converting it into a form which the clover plant can use for food. These little organisms live only on the roots of the clovers and related plants. So these plants can serve as a means of gathering the most expensive of plant foods and fixing it in a form suitable for food for plants or animals. The use of clover for this purpose is one of the forms of green manuring. Yet the clover brings but one element to the soil, and while it is of immense value, it is not to be forgotten that plants require other things for food, and we must not allow these other things to be continually removed from the soil without making a suitable return.

## COMMERCIAL FERTILIZERS.

When the home supply of plant food has been utilized it may be that still more can be very profitably used. Since material from outside sources must be transported considerable distances, it generally takes the form of concentrated manures called *commercial fertilizers.*

Farmyard manures are all of the same general type, but commercial fertilizers differ very widely among themselves, and may contain one, two or three of the most important plant foods. These foods may be in various *forms,* some of which are more quickly available to plants than others. One of the earliest and best forms of wheat fertilizers was finely ground bone. On this account a custom has grown up of calling all fertilizers "bone dust," no matter what they may contain. Yet a mowing machine and a self-binder may be less different from each other than are two fertilizers sold under this common term.

The possibility of making mixtures of fertilizer chemicals in various proportions places in our hands the means of perfectly adapting the material to the needs of our soils and crops. All such goods bear a label showing what they contain, yet many men spend their money for them without a thought of how many pounds of really valuable material of each kind they are buying, and without knowing whether the material is suited to their needs. Too often the price is the only thing that receives consideration. A fertilizer may be excellent for fruit and commercially well worth the price charged for it and yet be unprofitable if used on wheat. There is nothing so difficult about the composition or use of these concentrated fertilizers that an intelligent school boy may not understand the essential facts about them. They place in our hands the means of producing crops under the best possible conditions of plant food supply.

As the fertility of our virgin soils becomes reduced, the question of food for plants becomes of more vital importance. The starting point for any real progress in this direction must be careful observation and study of that great storehouse of plant food—the soil itself.