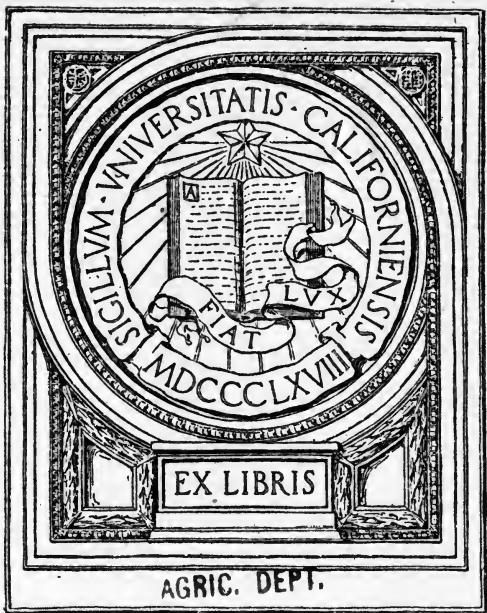


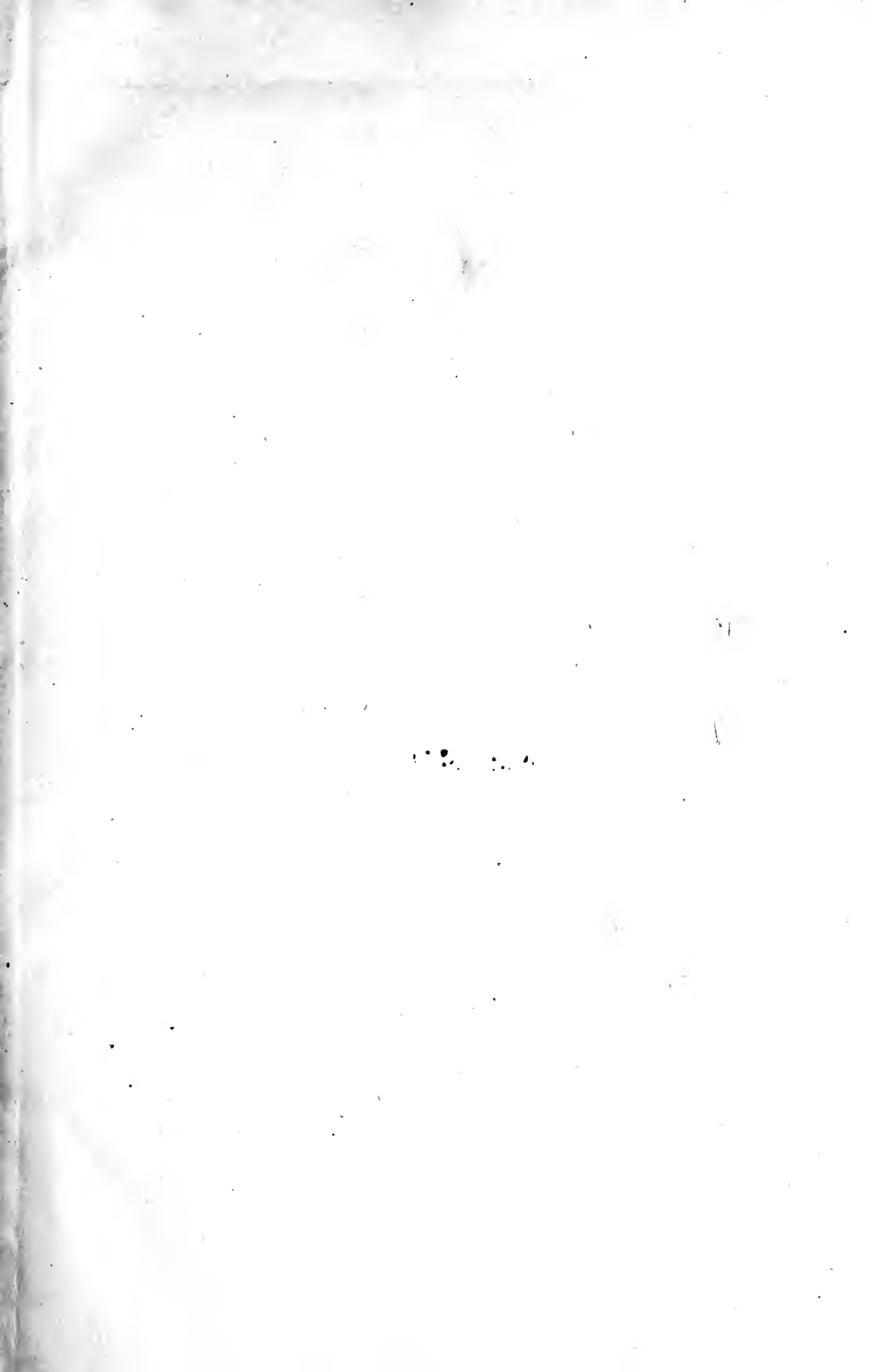
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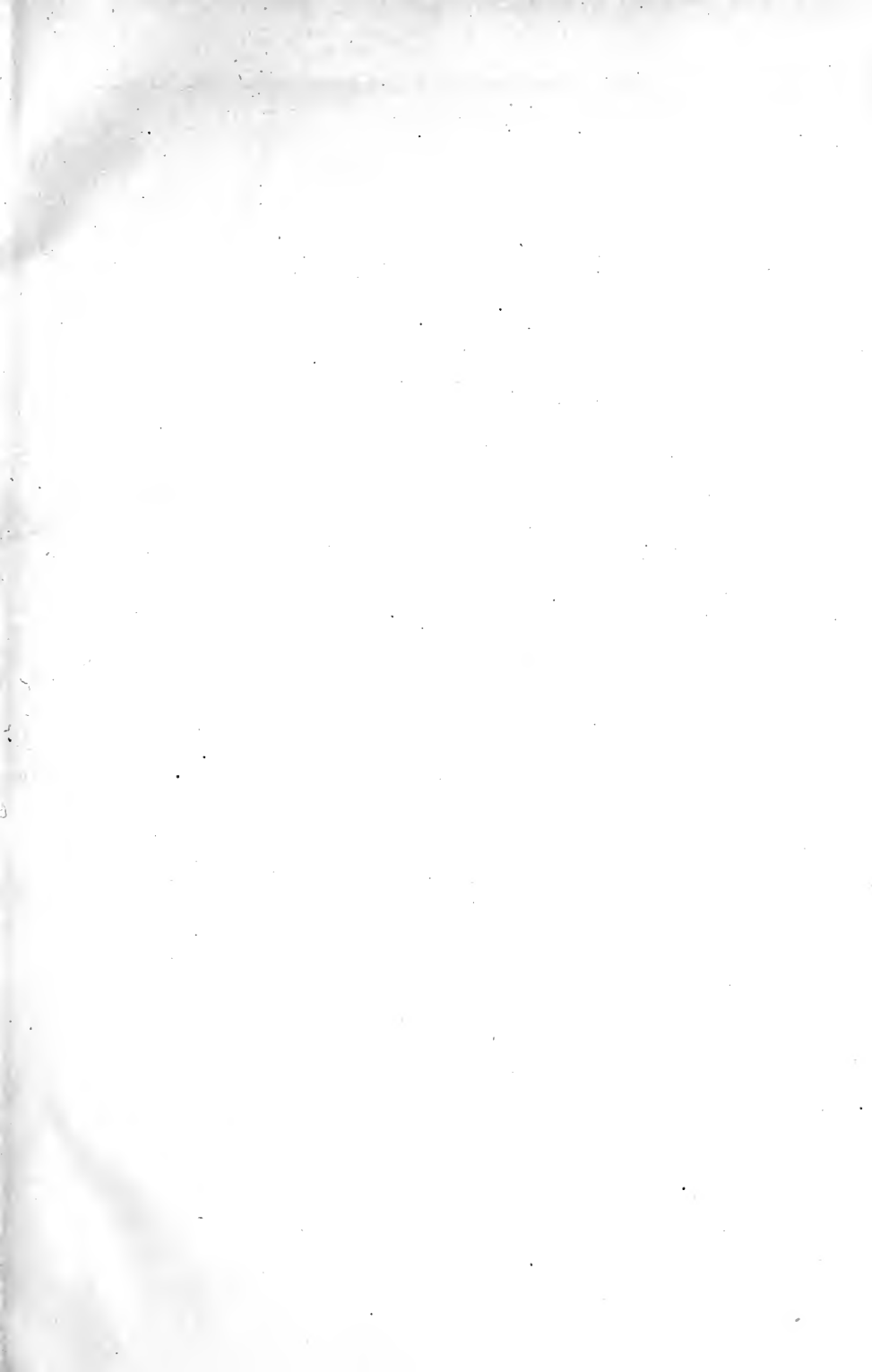
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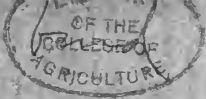


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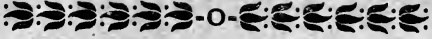
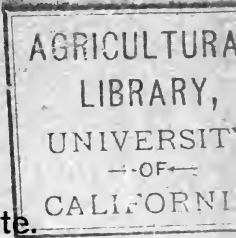


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NATURE STUDY OUTLINES



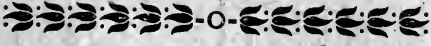
For the use of the teachers of the state.

BY

IOWA STATE HORTICULTURAL SOCIETY

AND

STATE AGRICULTURAL COLLEGE



EDITED BY

JOHN CRAIG,

AMES, IOWA.

DECLARATION

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REPORT

OF THE

COMMISSIONERS

OF THE LAND OFFICE

AND

Iowa state horticultural society

SUGGESTIVE OUTLINES

Bearing Upon the Introduction

...of...

NATURE STUDY

....into the....

Schools of the State.

.....Authorised by the.....

STATE HORTICULTURAL SOCIETY

and

**Prepared by Members of the Faculty of the Iowa
Agricultural College, Assisted by Miss
Julia E. Rogers, East High School
Des Moines, Iowa.**

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CHAPTER I

INTRODUCTORY

TO THE TEACHER.

BY THE EDITOR.

The following pages are the result of a combined effort on the part of the State Horticultural Society and the Iowa Agricultural College to place some outlines before the teachers of the rural schools which might be followed, with the hope of interesting the pupils in some of the natural things about them. The Horticultural Society has in view the advancement of the horticultural interests of the state by developing a love for, and a knowledge of plants, in the hearts and minds of Iowa school children. The Agricultural College labors for the promotion of accurate, systematic, and business-like farming, in other words, scientific farming.

Agriculture may not be a pure science but at all events it can only be successful when based upon scientific principles coupled with business-like practices. As it is difficult to distinguish between the business of agriculture and the science of agriculture, so it is much the more difficult to separate horticulture from agriculture in a manner reasonable and appropriate. In their fundamentals they are identical. They differ in ultimate details only. It follows therefore that a pupil interested in some branch of the great realm of nature is likely to be drawn into the field of agriculture, and if not, is at least the better equipped to enjoy life in the highest and best manner.

That the State Horticultural Society and the State Agricultural College should co-operate with the State Superintendent of Education in the initial steps of this movement is appropriate and gratifying. In no way can the happiness and welfare of the rural classes be accomplished so fully as by giving them an intelligent interest in and knowledge of the common things which surround them in every day life.

This kind of study has been aptly termed "Nature Study." It has been more accurately defined as "Seeing the things one looks at, and the drawing of proper conclusions from what one sees." It is not the study of any science in as much as it is not systematic and orderly. It indicates study and observation and engenders a sympathetic bond between observer and object.

Nature Study has progressed rapidly in New York schools. It

has been successfully introduced into Indiana and has come to many a harrassed and fretful pupil as a welcome recreation. What nature study is and how it may be introduced into schools is admirably outlined in Teacher's Leaflet No. 6 issued by the College of Agriculture of Cornell University, Ithaca, New York. In this leaflet Prof. Bailey says, "The proper objects of Nature study are the things which one oftenest meets. Today it is a stone, tomorrow it is a twig, a bird, an insect, a leaf, a flower.

"The child, or even the high school pupil, is first interested in things which do not need to be analyzed or changed into unusual forms or problems. Therefore problems of chemistry and of physics are for the most part unsuitable to early lessons in nature study; but it is often difficult to secure specimens when needed especially in liberal quantity and still more difficult to see the object in perfectly natural condition. Plants are more easily had and therefore more practicable for the purpose, although animals and minerals should by no means be excluded.

"If the objects to be studied are informal, the methods of teaching should be the same. If nature-study were made a stated part of a curriculum, its purpose would be defeated. The chiefest difficulty with our present school methods is the necessary formality of the courses and the hours. Tasks are set, and tasks are always hard. The only way to reach nature-study is, with no course laid out, to bring in whatever object may be handy and to set the pupils to looking at it. The pupils do the work,—they see the thing and explain its structure and meaning. The exercise should not be long, not to exceed fifteen minutes at any time and above all things, the pupil should never look upon it as a recitation, and there should never be an examination. It should come as a rest exercise whenever the pupils become listless. Ten minutes a day, for one term, of a short, sharp, and spicy observation upon plants, for example, is worth more than a whole text book of botany.

"The teacher should studiously avoid definitions, and the setting of patterns. The old idea of a model flower is a pernicious one, simply because it does not exist in nature. The model flower, the complete leaf, and the like, are inferences, and pupils should always begin with things and not ideas. In other words the ideas should be suggested by the things, and not the things by the ideas. "Here is a drawing of a model flower," the old method says, "go and find the nearest approach to it." "Go and find me a flower," is the true method, "and let us see what it is."

“Every child, and every grown person too, for that matter, is interested in nature-study, for it is the natural method of acquiring knowledge. The only difficulty lies in the teaching, for very few teachers have had any drill or experience in this informal method of drawing out the observing and reasoning powers of the pupil wholly without the use of text-books. The teacher must first of all feel the living interest in natural objects which it is desired the pupils shall acquire. If the enthusiasm is not catching, better let such teaching alone.

“All this means that the teacher will need helps. He will need to inform himself before he attempts to inform the pupil. It is not necessary that he become a scientist in order to do this. He simply goes as far as he knows, and then says to the pupil that he cannot answer the question which he cannot. This at once raises his estimation in the mind of the pupil, for the pupil is convinced of his truthfulness, and is made to feel—but how seldom is the sensation!—that knowledge is not the peculiar property of the teacher but is the right of any one who seeks it. It sets the pupil investigating for himself. The teacher never needs to apologize for nature. He is teaching simply because he is an older and more experienced pupil than his pupil is. That is just the spirit of the teacher in the universities to-day. The best teacher is one whose pupils the farthest out-run him.

“In order to help the teacher in the rural schools of New York, we have conceived of a series of leaflets explaining how the common objects can be made interesting to children. Whilst these are intended for the teacher, there is no harm in giving them to the pupil; but the leaflets should never be used as texts to make recitations from. Now and then, take the children for a ramble in the woods or fields, or go to the brook or lake. Call their attention to the interesting things which you meet—whether you understand them yourself or not—in order to teach them to see and to find some point of sympathy, for every one of them will some day need the solace and the rest which this nature love can give them. It is not the mere information which is valuable; that may be had by asking some one wiser than they, but the inquiring and sympathetic spirit is one's own.

“The pupils will find their lessons easier to acquire for this respite of ten minutes with a leaf or an insect, and the school-going will come to be less perfunctory. If you must teach drawing, set the picture in a leaflet before the pupils for study, and then substitute the object. If you must teach composition, let the pupils write upon what they have seen. After a time, give ten minutes

now and then asking the children what they saw on their way to school."

The above advice offered to the teachers cannot easily be improved upon. It is quite as applicable to Iowa teachers as to New York teachers. In the outlines which follow are contained suggestions which may guide the teachers in the beginnings of this good work. I trust these outlines will be studied by the teacher and applied in the most fitting manner. Teachers who desire something more specific on horticulture are reminded that the State Horticultural Society has a permanent officer, its Secretary, resident in its rooms at the Capitol building, Des Moines, who is ready and qualified to assist them; that the Iowa Agricultural College at Ames has a trained staff of scientific workers and teachers who may be depended upon to render assistance whenever called upon. The opportunity is afforded, let us improve it.

It is not expected that every teacher will find the following outlines adapted to the needs of his or her pupils; it is hoped, however, that some of the suggestions may be helpful to each one and that they will be put into operation. Before taking up the suggestive lessons which follow, I am pleased to offer the thoughts of an Iowa teacher who has had considerable experience in presenting to teachers and pupils various phases of the nature study movement; Miss Julia E. Rogers, of the East Des Moines High School, writes as follows: "The first question is a natural one: 'How shall teachers get ready to do this Nature work?' And then: 'Is there some book that we can get that has the subject written up for us?' How natural, habitual is this question! But I answer you, let the books alone for awhile. Come out into the fields and woods. Drink in the spirit of the summer. Give yourself up to it. Let it reach you through all the avenues of your being. Now get the poems of Wordsworth, the writings of John Burroughs, and Richard Jeffries, and Maurice Thompson, and the rest of them. 'Are these works on Pedagogy and Nature Study Methods?' They are not. But don't you care. Forget the dusty schoolroom, if you can, and among the shadows of the trees let these inspiring writers lead you into that kingdom which is promised to those who seek it. 'Except ye become as a little child ye cannot enter in.'

If such an experience as this can be yours this summer, I congratulate you. To feel an intimacy growing up between yourself and the world of plant and animal life all about you is to feel also an intellectual warmth and joy that is unlike anything felt before—a feeling that binds you to nature by cords that strengthen every day.

“And now comes to your mind the vital and practical question; ‘How shall we present this nature study to our pupils?’ ‘Shall our already over-crowded daily program become further congested by the addition of a new subject?’ The good sense of the teaching profession says ‘No.’ ‘Shall we throw out something and put Nature study in its place?’ Again the answer is ‘No.’

“Nature study comes not to destroy but to fulfill. It is not a single subject to be classified and scheduled for so many hours per week—to be measured as to volume and quality by set recitations and final examinations and percents. Since the moulds are all full, why not let this one thing keep its natural form and comeliness?

“Some people take beautiful, fragrant apples and laborously convert them into ‘butter.’ Shades of Pomona! And there are teachers who would take Nature Study, flower of all the pedagogies, having the dew of its youth and the beauty thereof, and systematize it till it fits into some scheme.

“There is nothing formal or conventional or systematic about the ideal Nature study lesson. The teaching of sciences is good in its proper place. But this is the teaching of children.

“Put away formality. Come down from your platform for a little while. Sit down among the children with some interesting thing in your hand and in theirs. Lead them to tell all that can be learned about it by close observation. Lead them to find out the significance of what they see. Do not exploit your own knowledge of a subject until all other resources are exhausted. It is far more important to awaken an interest in the subject than to store the mind with facts about it. Make Nature Study a recreative exercise. It is not necessary to have stated times for its recurrence. Fill in odd moments with it. It is wonderful to note the revelations of truth and beauty which we get from the careful examination of the common, every day things that we used to consider beneath our notice.

“A very little botany will prepare us “to read the secret of a plain weed’s heart,” and in such study we continually add to the resources of life—to our capacity of appreciation and enjoyment of all that is going on in the great world out of doors. Knowledge gained at first hand is doubly valuable, for with the knowledge always comes an educational blessing. And this blessing you know how to bestow upon the children whose steps it is your privilege to guide.

“ ‘How much time shall we devote to Nature Study?’ You must answer this question yourself. If you have the nature love

strong in you, the season will invite you—the interests of the children will guide you. “Fifteen minutes a day”, some one says. Very well. Fifteen minutes spent each day in the close scrutiny of some interesting object—now a leaf, now a plant, a pebble, a bird or an insects, with an occasional trip to a pond, or an orchard, or to the park—will bear a wondrous harvest. Behold how great a matter a little fire kiddleth! And nothing sets the hearts of boys and girls on fire as does this natural study of natural things.

“Follow the children home—ask the parents what their children talk about and you will find out how constantly the child mind turns back to that which is to it the most real and interesting. “Correlate” is a good pedagogical word. We hear a great deal about it. What better common factor than Nature Study for the correlation of the various branches we are called upon to teach?

“A glass may be brimful of water, and yet we may gradually add a spoonful of sugar and it will not run over. The teacher’s daily cup is full; but let her put in Nature Study—gradually, quietly,—and it will sweeten the whole, and her cup will not run over.”

CHAPTER II.

NATURE AND ORIGIN OF THE SOIL.*

All the plants grown upon the farm or in the garden grow in the soil; even those that appear to be growing in streams and marshes have their roots in the soil beneath the water. Sometimes we see plants grow in water in the house or greenhouse, but most of those found there are grown in pots filled with soil. The plants found on the surface of rocks or on old rail fences are of a low, simple order. We may then conclude that most of the plants that we are most familiar with require the soil, and we therefore shall study for a while the soil, its nature, its origin, and its improvement.

KINDS OF SOIL:—Sandy soil is made up principally of sand. If we take a handful of dry sand we find that it consists of small grains that are easily mixed together. If we moisten it, it will cling together and can be moulded into various forms, but when it dries the particles all fall apart into fine sand as before. Then there is clay of various colors, sometimes red, sometimes almost white, and sometimes nearly blue. If we moisten it we can mould it, but when it dries it keeps its shape and becomes hard. We readily see the difference. When we walk over wet sandy soil and wet clayey soil, the former, when dry, readily rubs off our boots, the latter sticks. Sand is used for making moulds in the foundry and clay is used for making models by the artist; the former readily falls apart after being taken out of the boxes and can be used again, and the latter when moulded and worked keeps its shape as it dries.

Make two sets of objects, such as balls, cubes, cups, vases, or simple figure of small animals, one set from wet sand and one set from clay. Place them in the sun or near the stove and observe the effect of drying.

We see that sand as it dries does not stick together, and clay as it dries does stick together and also sticks to other objects. We now understand how it is that wet clay is sticky, it clings to the plow and the harrow and to the feet of the horses and is hard or heavy to work. Sandy soil is said to be light and clay soil to be heavy, not because of their weight, but because the former is easily worked and the latter is harder to work. If we watch closely the drying out of the two sets of objects that we have moulded we shall observe further that the sand dries more quickly than the clay; the latter holds on to the water longer. Clay soils are unusually wet soils; they are more apt to have water in them than sandy soils.

*From Practical Agriculture, James. By kind permission of Messers. D. Appleton & Co., New York.

The third class soils is unusually dark in color from light brown to dense black, such as are found in the woods where leaves and branches have decayed, and in low pastures and swampy places. This soil is made up of the refuse of leaves, branches and the roots of plants. Sometimes we can see pieces of half-decayed or rotten plants; sometimes there are very slight traces of the original form of plants. This soil has, however, all come from former plants. We call such a soil a vegetable soil, and this dark colored, loose material formed from the decay of vegetable matter is called humus. Notice how it differs from both sand and clay. It is light weight and easily worked and holds water readily.

Place a handful of **swamp muck or leaf mould, humus, on an iron fire shovel and carefully set it upon the burning coals. It dries out, then burns away until only a small quantity of ash is left. Place some wet sand on the shovel and heat, and then a little wet clay. What is the result?**

These, then, are three principle parts of soil—sand, clay, and humus, but in many cases we find them mixed together or one above the other. If sand is the principal part of the soil we call it a sandy soil; if clay, a clay soil; and if humus or muck, a vegetable soil. A loam soil contains a mixture of sand and clay with some humus, and such a soil is usually best fitted for growing most of the crops of the farm.

ORIGIN OF THE SOIL:—We already know where the humus or vegetable matter has come from, and, as it was formerly parts of plants, we conclude that it must contain material for feeding new plants. But where did the sand and clay come from?

Perhaps you have never before asked that question, thinking that the clay and the sand were always in the field in that form. This, however, is not the case, although they may have been there for many years, perhaps hundreds of years, perhaps thousands. Why do we say they have not been there for all time? Well, if we go to the shore of a large lake we see fresh sand being washed up day by day by the waves. If we go to the banks and mouth of a large river or even a small stream, we see sand and clay and vegetable matter washed down, carried away, and spread out to form new layers of soil. If we go to the face of a high, rocky cliff we can see the great rocks being gradually broken down and changed into piles of coarse stone, and later into finer material, and still later into sand and clay. But if we go to a range of mountains or high hills we shall see more clearly the change of great rocks into fine soil.

Under our soil we find solid rock. In some places the rock is at the surface, and we can see it becoming withered and rotten. The

outer surface is softer than the interior. In other places the rock is just under the surface. In some places we have to go very deep to find the rock, but it is always there to be found if we only go deep enough. All of our sand and clay have come from these old rocks, sand from one kind of rock, white clay from another kind of rock, blue clay from another. The nature of the soil will therefore depend largely upon the nature of the rock from which it came. This sand or clay may have come from the breaking up of the rocks that are found just under the soil; in that case the soil is likely to be shallow. But usually it has come from rocks at a distance, a long distance it may be, and has been carried to its present place by water and ice, and spread out over the old rocks.



Figure 1.

Soil formed from a rock at a distance. *a* is solid rock of a hill or mountain. Rock at *c* has been broken off by rain and frost and thrown down to foot of hill. Finest soil is being washed into stream to be carried away to build farms elsewhere.

In this latter case the soil may be very deep and mixed. we can now explain why the soil in some places is quite different in its nature from the rocks under it, and why there is such a variety in the the same locality and on the same farm. One field may be clayey, and across a stream we may find a sandy soil. They have come from different places, and have been washed down by the water and spread out at different times.

A step farther back can now be taken. We go to the hills, to

the great piles of rock. We observe that the old rock is weathered. If we break off a piece, the fresh surface shows a different appearance from the old weathered surface; it is generally harder.

We can rub off some of the old weathered surface; what we rub off is the weathered rock, fine sand or fine clay. We observe long cracks or crevices, some narrow and fine, some wide and deep. The rains find their way into these cracks and fill them up. Then winter comes on and the water in the cracks freezes. What will happen then? Just what happens when the barrel of rain water freezes, or the down pipes on the house freeze solid, or the bottles of canned fruit in the cellar freeze. There will be a bursting. And even though the quantity of water is small, it must expand, the rocks must give to make room for it. The cracks are made larger, a little of the surface is broken away, or a huge shoulder of the rock is burst off. Gradually, year by year, the rocks are broken up by the frost, the atmosphere wears them away, and the rains wash them down. The rocky cliffs are slowly broken down, and the ice, as it slowly moves down the sides of the mountain, scrapes and scratches off more and more. This material is washed away—the larger pieces but a short distance, the smaller pieces further, and the finest sand and clay carried far away, to be dropped or spread out somewhere to make soil. Seeds are dropped by the birds or blown by the winds; some plants sprout, grow, die, and decay and form a little humus. More plants grow and more humus is formed, until out of the material that came from the hard, rough rocks and the decay of roots and leaves a fine soil is formed, sandy in one place, clayey in another, and loamy in another.

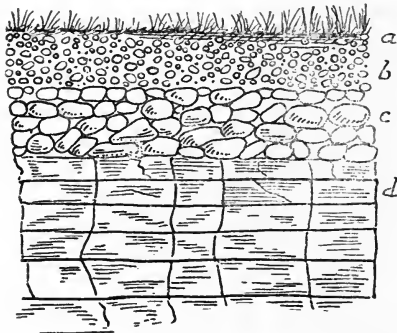


Figure 2.

Soil formed from rock underneath. *a* soil with grass growing on it. *b* subsoil, coarser and more rocky. *c* coarse loose rocks. *d* rocks in layers, cracked. *d* changes to *c*, *c* changes to *b* and *b* to *a*.

Conclusions:

1—All our soils have come from the breaking down of rocky material and the decay of former plants.

2 Soils may be classed as follows: sandy, clay, loam, and vegetable or humus soils.

3—The texture of the soil depends upon the amount of sand, clay, and humus mixed together forming it.

4—The nature of the soil depends to a large extent upon the nature of the rocks out of which the sand and the clay have been formed.

5—The rocks have been broken up by the action of the air, the freezing of the rain water in the rocks, the grinding of ice, and the down rush of rains and streams.

6—Some soils have been carried about from one place to another and spread out by the ice, snow, streams, and even to some extent by the wind.

7—Some soils have been formed out of the rocks beneath them, and from the decay of plants growing upon them.

8—Some soils, such as swamp soils, have been formed almost entirely from the decay of plants.

Suggestive:—

What class of plants are most useful in improving the soil, those with shallow growing roots or those having deep growing roots? Have you observed any difference between the roots of clover and the roots of timothy?

CHAPTER III.

HOW A PLANT GETS OUT OF THE SEED.

By L. H. PAMMEL.

The seed is the starting point of the individual in that great class of plants known as the Flowering Plants, represented by such common types as the pea, bean, corn, rose and cabbage.

THE BEAN. A common garden bean may be obtained at any time. The seed is contained in a pod to which it is attached by a small seed stalk. The seed is smooth, usually longer than broad. There are many kinds of beans, the commonest bean is white, some beans are bluish black, others are spotted with brown, others are yellowish. You will observe that the seed lies on one side. Some beans are flattened on the two ends because they were packed so very closely in the pod that they touched each other.

You will observe that the two sides are much narrower than the middle. On one side is a prominent spot called the scar or hilum. Fig. 3. This is where the seed stalk was attached to the seed. On one side of the scar you will notice a very small hole somewhat sunken

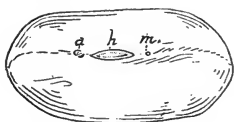


Figure 3.

Seed of bean, *h* hilum or seed scar, *m* micropyle. *a* two processes arillate.

in the bean, the micropyle. On the other end of the scar a pair of slightly elevated points. We will now soak the beans in water for half an hour. They have greatly changed in their outline. The beans are no longer smooth and even as they were when we first examined them. They are very much wrinkled. This wrinkled appearance is due to the water which they have taken up. We can now pull off the white covering or shell as it is commonly called. This white covering is known as the seed-coat or testa. The purpose of this coat is to protect the more delicate parts of the plant within. We shall look out for the little plant tucked away on the inside. We will now examine some beans which have been in water twelve hours. The beans are larger; they have taken up much more water. The ridge near the small opening on one edge of the seed scar is prominent. The seed coat should now be carefully removed. After the removal of the seed-coat two large

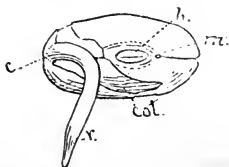


Figure 3.

Bean seed in process of germination. Testa or seed-coat broken, showing the cotyledons, *cot.* The hilum or scar where the seed was attached shown at *h*. The small opening in the testa, micropyle shown at *m*. At the base of the radicle, the caulicle.

fleshy bodies, the seed leaves or cotyledons, and a ridge may be made out. Now separate the seed leaves. At one end of the bean is a pointed body, the first root of the plant (or radicle), below it and connected with a pair of small leaves is the first stem (or caulicle). Fig. 3. The small leaves (or plumule) are snugly packed between the two seed leaves. Here, then, is the beginning of a plant.

2. PEA. We will now study the pea in the same way.

In the majority of cases the skin of the pea is roughened and close inspection will show an elongated body on one end of the seed, (the caulicle and radicle.) With a little magnifying lens you will be able to make out the elevated processes which have received the name of arillate processes as in the bean occur on the other end of the hilum away from the micropyle. Fig. 4. The two cotyledons are round and fleshy, never elongated as in the bean. The plumule between the cotyledons consists of small scale-like leaves. Fig. 5.



Figure 4.

Seed of pea more or less wrinkled. *h* hilum. *m* opening into seed. *a* small processes arillate.

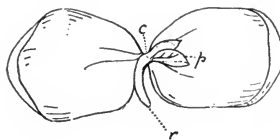


Figure 5.

Seed of pea unfolded showing plumule *p*, and radicle *r*, and initial stem or caulicle at *c*.

3. APPLE. Apples are easily obtained and are interesting objects for child study. The brown seeds of the apple are very different in shape



Figure 6.

Seed of apple. the notch where it was attached.

to the pea or bean. Fig. 6. One end is pointed. The large end usually has a small beak like projection which is connected with a small ridge that comes from the base of the seed. You will observe that the seed is flat on one side and rounded on the other. Flattened on one side because each small compartment of the apple has two seeds which are pressed together. The small seed-scar occurs in a slight hollow at the pointed end of the seed. The covering of the seed (or seed coat) can be removed by carefully

cutting the upper part of the seed-leaves. It can then be pulled off. You will notice that the coat can then be separated into two parts. The outer part is of a leathery nature and brown in color, the inner part is nearly colorless and not nearly so tough. The lower



Figure 7.

Cotyledons of apple unfolded to show plumule *p* and radicle *r*.

part of the embryo has a small point which projects beyond the two seed-leaves. Fig. 7. This is a part of the initial stem, with the initial root at the other end. The plumule lies between the two seed-leaves at the other end of the caulicle, but this is very small.

4 SQUASH. The seeds of squash are flattened with a rim or border on the edges. The seeds are longer than broad, and the seed scar occurs in a depression at the small end of the seed. At the shorter end of the seed occurs a conspicuous opening. Cutting the seed lengthwise, this opening will be seen to extend for some little distance along the edges of the two seed-leaves. Now remove the white covering of the seed. Note that the outer is quite thick and somewhat brittle. The inner part is greenish and is closely attached to the seed-leaves. The small end of the two seed-leaves is pointed. Separate the two seed-leaves at the upper wide part of the seed, and notice that the two seed-leaves are fleshy and thick. The conical part occurs at the pointed end of the seed. This pointed end consists of the very short stem, the plumule between the seed leaves and at one side a small, fleshy outgrowth, the "pumpkin peg". We shall speak of this again.

HOW THE FOOD IS STORED.

In all of the above seeds the nourishing material is stored in the two fleshy seed-leaves. In the bean, pea, and apple this food consists of starch and albumen. Albumen is like the substance found in flesh. In the pumpkin this food consists of fat and albumen. This food is, of course, for the purpose of nourishing the young plant till it is able to take care of itself. In the next representative, maize, (corn) the greater part of the seed is made up of material stored in a special part of the embryo.

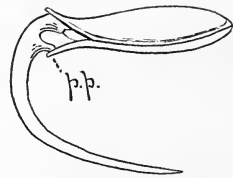


Figure 8.

Pumpkin seed in a process of germination.

5 MAIZE. There are many varieties of maize. These differ in shape, size and color. Sweet corn is much wrinkled when dry. In common dent the upper part of the kernel has a prominent groove, hence, the name dent. Our common pop corn is smooth. The little point at the side towards the groove may be made out. We shall now place our kernel in water for half an hour. Like the bean the surface soon becomes wrinkled because it has taken up some water. Leaving the kernel in water for a longer time the wrinkled appear-

ance disappears, it becomes swollen and much larger since much more water has been absorbed. We shall now remove the shell. At one side we note the yellowish, elongated body, the germ or embryo. Fig. 9. The other part of the seed is white and mealy. This is the endosperm. From this endosperm corn starch is made. This endosperm contains a nourishing substance which is used to assist the small embryo to grow. The small embryo may be removed. It will be found to consist of a single seed-leaf, the small initial root and stem, as well as a small plumule consisting of several very small leaves.

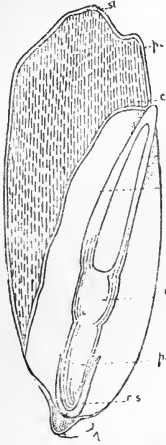


Figure 9.

Section of corn showing embryo. *p* young leaflet; *r* young rootlet. Darkened portion is albumen.

6. PEANUT. The peanut, though commonly called a nut, is not a nut but a pod. It belongs to the same family that the pea and bean do. While the seeds of the pea and bean are produced in a pod above the ground, those of the peanut are produced in a pod which matures in the soil. The peanut matures its seed in a rather interesting way. The flowers are born in the axles of the leaves close to the ground. After fertilization the stalk elongates and pushes the little pod into the soil. Here it develops and produces the pod so familiar to most persons. It is roughened, showing numerous veins on the outside and small depressions. On opening these pods you will find two or three or sometimes only one seed with a brown covering. The brown covering is the seed-coat or testa and is marked by several longitudinal deeper colored lines. On opening a seed one observes that it has a conspicuous plumule between the two cotyledons with a radicle extending beyond the latter. Fig. 10.

7. DATE PALM. The seed of the date palm is rather easy to obtain and it is of interest because its reserve food is not starch, but fats and albuminoids, and a substance which is similar to vegetable ivory. The seed is extremely difficult to cut on this account. The seed is elongated with a

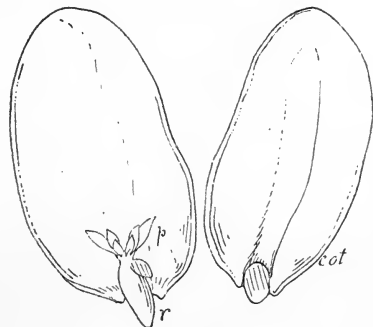


Figure 10.

Embryo of peanut exposed showing two cotyledons, *cot*; the plumule, *p*; and the primary root or radicle, *r*. The caulicle or initial stem just below plumule.

groove on one side. Fig. 11. A cross section made through the seed will show that it is in the form of a semi-circle. Fig. 12. Most of the seed is made up of the hard, horny albumen or endosperm. The small embryo is situated at one end of the seed.

8. FLAX SEED.

This is flattened, much longer than broad, pointed at the lower end where the seed scar occurs. The seed is smooth and brown in color.

Now moisten the

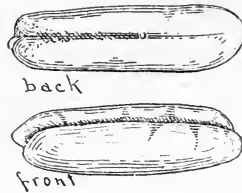


Figure 11
Back and front view of date palm seed.

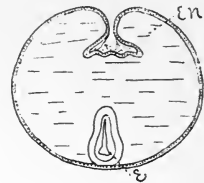


Figure 12.
Cross section date palm seed. The greater part of the seed is hard, horny endosperm albumen. The embryo shown at e.

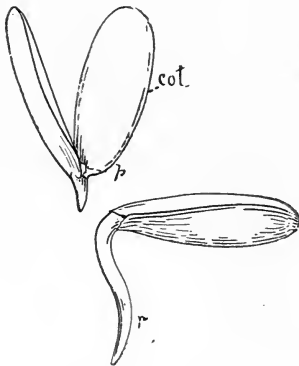


Figure 13.

Flax with radicle or root r. In upper figure, cot, cotyledons or seed leaves and p pitruler.

seed with water; you will notice that it feels like mucilage. The outer part of the seed-coat has the property of swelling when water is added. We will cut the seed lengthwise; you will notice that the brown seed-coat has a light colored substance

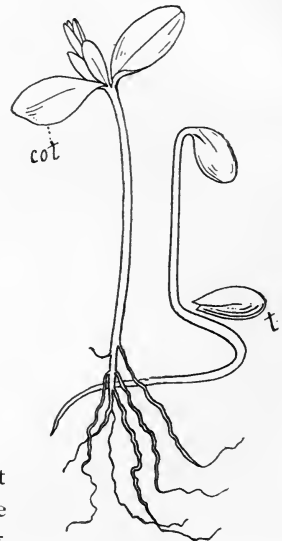


Figure 14.

Flax seed in process of germination. cot, cotyledons, t, testa with cotyledon removed.

next to it; this is nourishing material stored outside of the embryo and has received the name of albumen or endosperm. This is similar to that found in maize, where it is mealy, only it is not so abundant. The embryo is situated in the center of the seed (Fig. 13) and consists of the two seed leaves called the cotyledons, and the conical initial stem and rootlet below, Fig. 14.

9. BUCKWHEAT. The so called seed is not a seed but is made up of a pod with the seed closely united to the pod. This union is not as close as in the case of corn. It is not, however, a true pod. Buckwheat kernels are usually brownish in color, though some are gray. In our common buckwheat the kernel has three

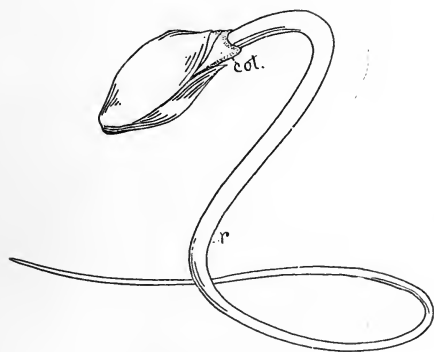


Figure 15.

Buckwheat in process of germinating. *r* radicle pushing its way out. The Cotyledons or seed leaves *cot.* still within coat.

sharp ridges running from the broad base to the pointed tip. The sides are somewhat similar. In some cases you may be able to see three somewhat recurved affairs. Let us now remove the brown covering; underneath it you will observe a lighter colored part, the seed-coat. A small, yellowish brown, circular spot with a darker center occurs where the seed was attached to the

brown hull. We will now cut the buckwheat kernels across near the base. Fig. 16. You will observe that most of the seed is made up of a white, mealy substance the nourishing material

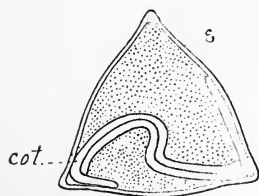


Figure 16.

Cross-section buckwheat, the dotted portion being endosperm or albumen which is food for the growing embryo which is folded inside.

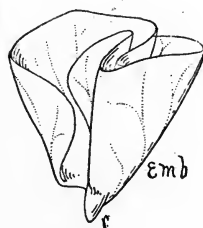


Figure 17.

Embryo of Buckwheat showing manner of folding in seed.

consisting largely of starch for the young growing embryo. This is the endosperm. In this white mealy substance is a small, slender somewhat folded, thread-like body, the embryo.

The seed leaves are very thin and folded and hence have the appearance of being thread-like in cross-section. Fig. 17.



Figure 18.

Buckwheat with two cotyledons or seed-leaves unfolded.



Figure 19.

Castor oil bean. The sculptured testa or seed coat. The caruncle shown at *car.*

HOW PLANTS GERMINATE.

We shall now undertake to find out some simple things about the way plants germinate, and this can be done only by experimenting. This is the only way that we can acquire the information we want. For these purposes it will be necessary for the teacher to get a box or pan three or four feet long, two feet wide and four inches deep. Fill this with three inches of sand, moisten and plant with two dozen beans and two dozen peas. The box should be kept at a comfortable temperature during the day,—a room in which child

10. CASTOR-OIL BEAN. The seed of castor-oil bean is the source from which oil is derived. The seed of our common variety is longer than broad, nearly oval, with a white fleshy outgrowth. At one side is a prominent ridge which divides the seed into two halves. On the lower side the seed is rounded out. The seeds of our common variety are smooth, shining, gray in color marked with brown spots. Fig 19. We will now cut the seed lengthwise; the hard, smooth testa is somewhat brittle. The bulk of the seed is made up of endosperm which is very oily, and contains an abundance of albumen. Starch is absent. The small embryo occurs in the endosperm.

Fig. 20.



Figure 20.

Cross-section *ss* of castor oil bean. *e* elongated embryo surrounded by the endosperm and the seed coats on the outside, *en*. The caruncle, *car.*, an outgrowth over the hilum coming from the micropyle.

ren are comfortable. At night the box should not be allowed to become cold as this will retard the germination. If the room becomes cold during the night protect the box by covering, or keep in a warm place. Watch changes from day to day and note when the first plants appear above the ground.

1. BEAN. The first thing observed in the bean is a small arch, neither the seed-coat or seed leaves can be seen, but a little later the large, fleshy seed-leaves partially show. In some cases the seed-coat may remain attached but generally this remains in the soil. As the young plant has pulled itself out of this protecting covering the seed-leaves and stem soon straighten up. The small, delicate plumule spoken of in connection with the seed is much longer and may be seen beyond the cotyledon. A little later the seed-leaves are pointed upward. The plumule consists of two expanded leaves and a bud at the base. If you will now carefully remove one of these seedlings from the soil the small root may be seen. Coming from this root are small fibers, the rootlets. At the end of the main root is a small point, the root-cap, free from sand. The root pushes its way through the soil by means of this cap. Growth, however, does not take place at the root-cap, but at a short distance back from the tip.

2. PEA. In germinating the pea behaves very different from the bean. The first thing observed is the arch, but the two seed-leaves remain in the ground. They do not perform the function of leaves as do the seed-leaves of the bean. The little plumule is arched till it is above the surface of the ground, when gradually it straightens out. The arch of the bean and pea protect the delicate structure of the plant. In an older pea plant small leaves or scales may be seen at the lower end near the ground. Further up

the stem the leaves gradually become larger. An examination of an older plant with the seed still attached will show that the seed-leaves are withered. What has become of this material stored in the fleshy seed-leaves? It has been used as food by the growing plant. You will observe in peas which are beginning to germinate that a slender cylindrical body is making its way into the soil. This is the primary root. Fig. 21. It is not straight, but curved. If you will watch its



Figure 21.

Pea germinating. *r* radicle
— and plumule at *P*.

growth you can easily see that it goes first in one direction, then in another. Fig. 22. A little later several rootlets make their appearance. In other cases several small rootlets make their appearance close to where the primary root first appeared. Near the end of the primary root and the rootlets, very minute hairs can be made out; these are called root-hairs. The tip of the root, as in the bean does not contain these root hairs. This root-cap serves as in the bean, to guide the root in the soil.



Figure 22.

3. APPLE. The apple germinates much as the bean, but in this case the seeds require a

Pea in process of germination. *p.* plumule. *r.* radicle.



Figure 23.

Germinating pea after all the nourishment in the seed has been used. *l* leaf. *ten* tendril at the end of leaf which enables the plant to climb.

long period of rest. The seeds will not germinate immediately when they are taken out of the apple in the fall. The teacher should put a lot of apple seeds in a box cover them with a little soil, place the box where it will not freeze or in a cellar. During the month of April these seeds may be planted as were the beans and peas. In the course of a week the seeds will germinate much as the bean. The two seed-leaves are pushed out of the soil and expand. The root pushes down into the soil. In a short time successive leaves are formed.

4. SQUASH. The seeds should be planted in a box of earth. In the course of two days an examination should be made of some of the seeds. If the conditions have been very favorable you will observe that the seed is

very much swollen and that where the seed-scar occurs the seed-coat is split. A day later a small root pushes its way out. As this root becomes longer you will notice a small projection, the squash peg, which was mentioned in connection with the seed. Fig. 24. In four days this root is much longer than the seed.

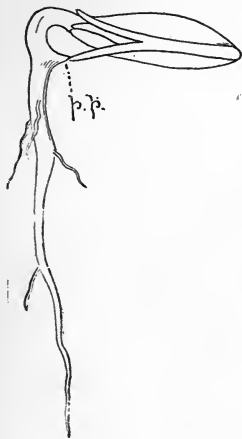


Figure 24.

Pumpkin in process of germinating, trying to extricate itself from its seed-coats. *pp* pumpkin peg.

The seed-coat is forced apart, and "the seed leaves are trying to back out of the seed." The progressive changes should be carefully watched and drawn. The

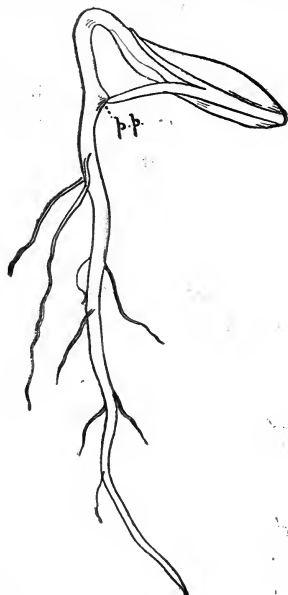


Figure 25.

Pumpkin germinating showing more advanced stage. *pp* pumpkin peg.

first root has produced smaller roots. Fig. 25.

These push their way through the soil, now in one direction, then in another. If you will now examine the seeds which have not been disturbed you will notice the arch and a part of the two seed-leaves trying to push themselves above the ground. A little later they have succeeded, the small stem is curved, the two seed-leaves are horizontal with their ends partially spread apart. Let us wait a little longer. You will notice that the stem is slightly curved, the small leaves are straight. Fig. 26. The seed leaves gradually unfold and the little plumule may be seen. The first real leaf grows rapidly, followed by others.



Figure 26.

Squash with two cotyledons. Seed leaves folded lengthwise.

5. MAIZE. The embryo of corn is much more complex than the pea, bean, apple or squash. In a previous paragraph I called attention to the embryo with its single cotyledon, the large amount of food found in the mealy part of the maize which the embryo uses in its development. Maize kernels which have been placed in sand and kept in a warm place may be examined in forty-eight hours. The embryo is much larger than the dry grains because of the water it has taken up. The seed-leaf never leaves the kernel, but the plumule soon elongates in the presence of moisture and heat. The radicle at the lower end also elongates. A maize kernel three or four days in the soil shows a small projection. If this is carefully laid out the student will be able to see that the plumule consists of a succession of very small leaves in specimens that are well out of the ground. The small leaves have flattened out, the lower leaf is nothing but a scale, not green like the expanded leaf. Let us now examine some of the plants with good developed roots. Fig. 27. From the lower end of the

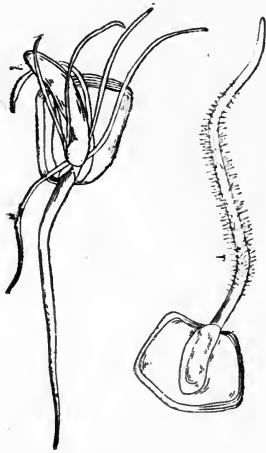


Figure 27.

Germination of good seed. *r* primary root in figure to the right with root hairs. *p* secondary roots; *p* plumule.

root in the seed, numerous small fibrous roots may be seen. These produce other small rootlets. The root-cap may be seen at the tip, and back of it the small root-hairs which have fastened themselves to the soil particles, with a kind of mucilage they have formed. Let us examine other seedlings. You are sure to find some where roots come from the seed near the plumule.

In others, especially such as are germinated on moist paper,

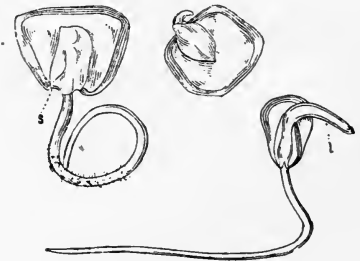


Figure 28.

Seed with weak germination except top corn on the right. *s* scutellum underneath; *p* plumule.

root in the seed, numerous small fibrous roots may be seen. These produce other small rootlets. The root-cap may be seen at the tip, and back of it the small root-

the primary root becomes very long, containing few rootlets. The primary root is not straight, but bent first in one direction then in another. Fig. 28. If these seedlings are placed on moist sand, the top bends toward the ground and soon forces its way into the loose sand. Examine young corn plants two or three weeks old and you may be able to make out the first joint above the ground. Fig. 29. If you will watch the progress of these you can see small

rootlets coming from this joint. A corn plant early begins to form its air roots. These roots are directed towards the earth. When they strike it, small root hairs and small rootlets are formed.

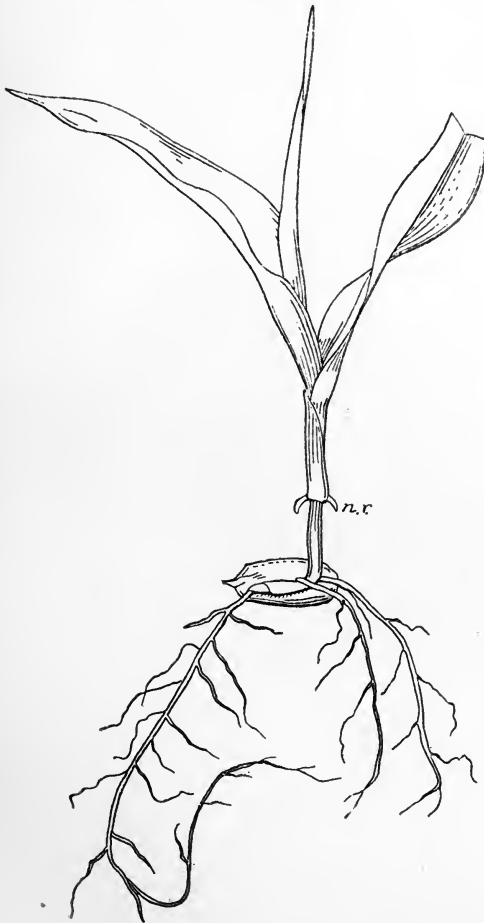


Figure 29.

Germinating corn. Nutritious material in seed ex-
" r nodal roots.

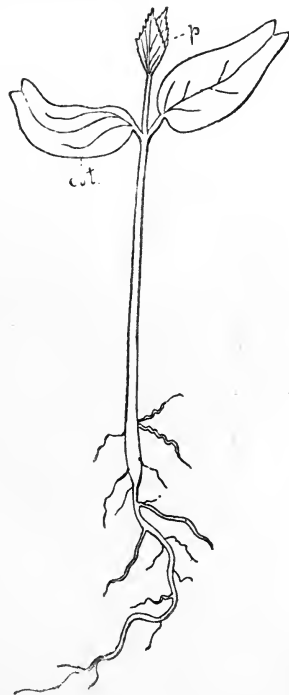


Figure 30.

Peanut in process of germi-
nation. p plumule; cot cotyl-
dons.

6. MAPLES. The maples are very suggestive. Our common soft or silver maple drops its fruit during the month of May and who has not observed the keys of this fruit in a grassy lawn, with the heavy end sticking in the grass? The two fleshy seed leaves are broad and short, straight except a small fold near the top. They do not appear above the ground as is usual in other maples. The small root pushes its way into the soil while the small stem with its plumule rises above the ground where the small leaves unfold. The red maple and black maple have crumpled embryos with considerable development of caulicle. The black maple, which is not uncommon in this state, may be obtained in quantity during the month of May, showing all stages of germination. We observe that the black maple does not germinate till spring. The two cotyledons appear above the ground, the short stem below, the plumule elongates and soon produces fully developed leaves.

CHAPTER IV.

A SUGGESTIVE READING LESSON.

SOME FEATURES OF PLANT GROWTH.

JAMES ATKINSON, Ames, Iowa.

With the exception of products of the sea the entire food supply for mankind is derived from the plant world. Whether it be breadstuffs or meats, they are alike the finished product of vegetation. Nature has made provision for the support of primitive man, but as civilization advances the art of man is used to multiply the products of vegetation, both in variety and quantity. It matters not whether our lot be cast in a great metropolis or on the prairie plains, our vital concern in the products of vegetation is the same and should be sufficient to stimulate us to acquire a knowledge of the habits of growing plants, and the characteristics of some of the world's staple crops.

ORGANS OF VEGETATION:—If a seed is placed in a soil under certain conditions of warmth and moisture, green leaves soon make their appearance above the ground while roots develop and penetrate the soil. These, together with the stem, constitute the organs of vegetation. It is our purpose to investigate some of the problems connected with the development of these organs.

COMPOSITION OF PLANTS. All plants are not alike in composition, but in a general way they are alike in being composed of water and dry matter. Nine-tenths of such crops as potatoes, turnips, and beets are composed of water.

To find out whether or not plants contain water, a simple experiment may be tried.

Pull about a pound of green grass, weigh it carefully, then place it in an oven. Leave it there until it seems perfectly dry, then remove and weigh again. The loss in weight represents the amount of water the plant contains.

WATER. From what source is this water obtained and of what value is it to a plant? As the roots penetrate the soil they constantly come in contact with a certain amount of water. Sometimes this is present in sufficient quantities to completely saturate the soil, while at other times the soil may scarcely be damp. It passes through the roots and stem and is evaporated from the surface of the leaves. In its passage through the plant it carries with it plant food from the soil, and also carries the food formed within the plant to where it is required.

Besides being a vehicle of food, it has other functions to perform. In the first place its passage from the cool soil into the

plant tends to regulate the temperature. Evaporation is a cooling process, and as this is constantly taking place from the surface it has much to do with keeping the plant cool in the presence of direct sunlight.

In order to prove that evaporation does take place from the surface of all green plants, take a quart or pint jar, remove the cover and place it, mouth downward over some green grass in the presence of sunlight. It will be found that moisture will collect in the inside of the jar in sufficient quantity to form large drops.

DRY MATTER. This is the part of the plant that remains after the water is driven off. It is composed of two parts, one of which is given off when the plant is burned, while the other remains behind in the form of ashes.

A very simple experiment will illustrate this point quite clearly.

Take the dry grass used in the previous experiment and place it in an iron vessel on a stove or in some way bring it in contact with a good fire. It will be found that only a small portion, the ash, remains.

We spoke about the source of water in plant life. We shall now enquire into the source from which the remaining substances were obtained. We are all well aware that the leaves of plants are constantly surrounded by atmospheric air. This air contains a substance known as Carbonic acid which is taken up by the leaves, of the plant and becomes part of the structure of the leaves, stem, and root. The carbon taken from this source forms about half of the dry matter of the plant. Oxygen, Nitrogen, and Hydrogen are other elements that enter into the composition of the part of the plant that burns. The first of these is taken partly from the soil, being contained in the water that surrounded the roots. The ash, or that portion of the plant remaining after burning, forms but a small portion of the entire plant. It is composed of iron, potash, lime, magnesium and phosphoric acid. These form, as it were, the frame work around which the whole fabric of the plant is constructed. They are usually present in soil water, and enter the plant through the medium of the roots. The presence or absence of these substances in suitable form constitutes the difference between a rich or poor soil.

From what has been said it will be observed that the food materials enter the plant in the form of a fluid, either a liquid as water, or a gas as carbonic acid and oxygen. It was long thought that small particles of the soil entered the roots, but it is now known that this is not the case.



Figure 31.

Showing root growth of the corn plant.

SEED PRODUCTION. The primary object of most farm crops is the production of seed. The corn plant is familiar to most of us, so we will use it to illustrate the process of seed production. During the first few weeks the energy of the plant is devoted to the production of leaves, roots, and stem. When these have attained a degree of maturity, there appears at the top of the stem, what is known as the tassel, which is indicated by the letter (a) in Figure 31. Midway between the root and the tassel appears the silk, indicated by the letter (c) in Figure 31. These constitute the flower of the corn plant. At a certain period in the development of these, there is given off a fine dust-like substance from the tassel. This is carried by the wind and brought in contact with the silk, which is composed of many threads. These little dust-like particles, or pollen grains, send out tubes which pass down the silk threads until they penetrate the body of the ear, (b) Figure 31. Here a union takes place, known as fertilization, which gives rise to a kernel of corn for every thread of silk. Figure 31, then, represents a partially matured ear showing how the silk threads are attached to the grains or kernels. In case of other cereals, such as wheat, oats or barley, fertilization is in no way dependent upon the wind, as both parts of the flower are within the same glume or chaff,

ROOTS. In discussing the habits of plants it would be a grave omission to omit their root development. It is the common belief of many persons that the roots of plants occupy only the first few inches of the surface soil. For the purpose of finding out the extent of root development, some corn and grass plants were taken from the soil with much care in order to avoid breaking the roots. Figure 31 shows two hills of corn that were taken from the soil and placed in a frame where the soil was afterwards washed from the roots. The cut shows the root development to a depth of fifty-six inches and even at this depth some of the roots were broken off, showing that they penetrate to a greater depth than this.

Figure 32 represents a bunch of Kentucky blue grass taken from the soil in the same manner, which shows the root development to a depth of three feet.

But such root development as is above described cannot take place unless the soil is in the proper condition, and without a perfect root system, plants cannot reach their fullest development. If the reader's interest has been aroused in this matter, it would be well to inquire into the various conditions of the soil which has so much to do with the perfect or imperfect development of plants.

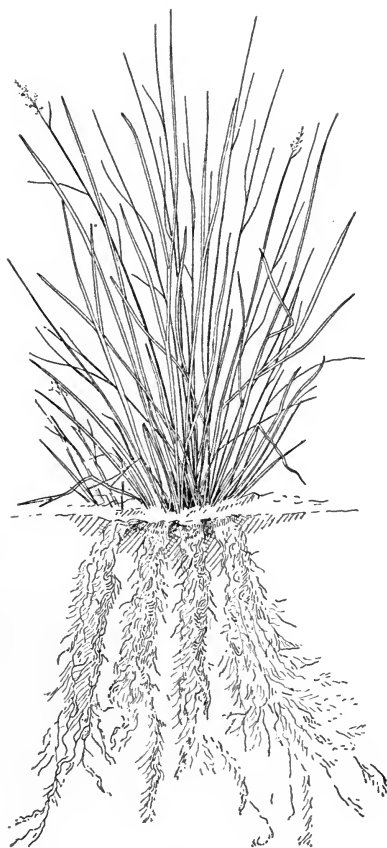


Fig 32

Figure 32.

How the roots of blue grass run down into the soil.

CHAPTER V.

HOW TO OBSERVE INSECTS.

H. E. SUMMERS., Ames, Iowa.

Insects, in consequence of their abundance, their convenient size, and the ease with which they may be kept alive in the school room, furnish perhaps the best material with which to begin the study of zoology with young pupils. They may be studied in many different ways, each of which will lead to the discovery of new facts concerning them and bring us nearer to a full knowledge of their relation to the entire living world. Their structure as illustrated in various selected forms may be investigated, and by a comparison of these forms the student will come to appreciate the meaning of homology, and when the reason for this homology is learned, to understand the principles in accordance with which animals are classified. Again, observation of the habits, especially of aquatic insects, furnish a never ending source of delight and instruction to children. Last to be here mentioned, their metamorphoses, or the transformations that they pass through before reaching the adult state, bring the pupil in contact with facts so wonderful that an interest is often aroused that lasts through life.

This paper is devoted to some hints on what and how to observe certain facts illustrating more particularly this last topic. And it should be fully understood that these suggestions are for the use of the teacher, not of the pupil. Most of what is here dogmatically stated, the teacher should, by judicious questioning, lead the pupils to discover for themselves.

Throughout the entire summer there may be seen flitting about in gardens, especially around the cabbage and other plants belonging to the mustard family, medium sized, white butterflies, usually with a few black spots, and often slightly tinged with yellow. There may be two different kinds of these; the one usually most common is known as the cabbage butterfly, the other as the checkered white. Figure 33. The former is the one here considered, although most of what is said applies equally well to the latter.

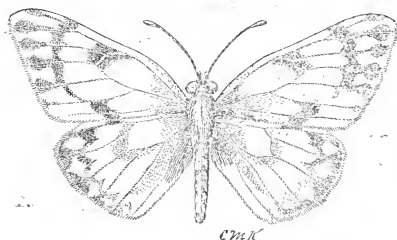
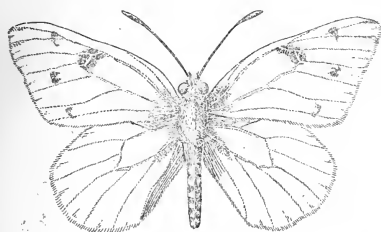


Figure 33

Checkered white, male.

Checkered white, female.

Closely observed they will be seen to alight occasionally on a leaf, usually on the under side, and then to fly away to another plant. If the exact place on the leaf where one alights be carefully noted and then examined after the butterfly has departed, there will generally be found a single egg, that has been attached there by the insect. This is of a light yellow color, and on examination with a lense is seen to be most beautifully and regularly marked with longitudinal ribs. If possible, the pupils should watch the butterflies laying their eggs in the field. In any case, there should be brought into the school-room, in a pot or box, one or more living cabbage plants on which eggs have been deposited.

In a few days there hatches from the egg a tiny, green, worm-like larva or caterpillar. Being possessed of a good appetite, it eats the shell from which it has just issued, and then attacks the substance of the cabbage. While small it can eat only the surface of the leaf, but it does this with such assiduity that it soon increases twenty fold in size, and is in a short time able to bite through the entire thickness of the leaf. It is especially active at night, eating then almost continuously, but in the day time it is satisfied with only an occasional meal. Between these periods of feasting it lies quietly stretched along a leaf vein of about its own diameter, and so exactly does its color resemble that of the cabbage that it is difficult for us to detect it. We can therefore understand that it commonly escapes the eyes of the birds that would think it a dainty morsel for themselves or their young.

As its body increases in size, its skin, unable to stretch much, becomes too small and the larva is obliged to shed it. As the time to molt approaches, the larva spins a carpet of silk on the leaf to give it a firm foothold and then becomes quiet. Its inaction is occasionally interrupted by struggles intended to loosen from its body the skin it is about to cast. Finally the skin bursts open on the back and the insect struggles free from it. After making a meal off the cast skin it remains quiet for a time to give the new skin a chance to harden. It then begins to eat and grow until it is time for it to molt again. When it has grown to its full size, of about one and one half inches in length, it usually leaves the cabbage and seeks the underside of a board, fence rail, or other convenient object.

If observations are being carried on in the school-room, the plant on which the larvæ are feeding should be placed in a box with its front closed by mosquito netting before they have reached their full size; otherwise they are liable to wander so far as to be lost.

Having found an object from the underside of which it can suspend itself, it spins a band of silken threads crosswise under its back, attaching the band at each end to the object it is resting beneath. Figure 34. A silken pad is also spun at its tail end. It then sheds its skin in somewhat the same manner that has been described for its ordinary molts, but instead of simply a large larva coming forth,

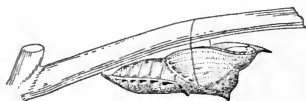


Figure 34.

Pupa of cabbage butterfly. after Scudder.

there appears a smooth, shiny object, without any external appendages, known as a pupa. During the process of shedding its larval skin, the tail end of the pupa is firmly attached to the silken pad already mentioned, and the silken loop extending crosswise under its back like a hammock suspends it with sufficient security.

The pupa is incapable of any movement beyond a slight twitching when disturbed. The general color of the pupa is usually light gray but it varies often to yellowish green; numerous brownish dots are scattered over its surface.

The pupa state lasts, in summer, for from ten to twelve days. Its transparency is then seen to change somewhat, and soon after the skin bursts open on the back, and the adult butterfly, known

as an imago, issues. At first its wings are merely small soft pads, but if it has a free chance to crawl up some vertical surface they will be seen to grow to their full size in a very short time, and after a while to become dry and brittle. The butterfly is now ready to take flight, to seek its mate, and soon after, if a female, to lay its eggs on the cabbages for another generation.



Figure 35.

Cabbage butterfly--larva and imago.

Three broods are usually produced in our northern states during the season. The larvæ of the last ones reach full size and change to pupæ in the autumn, whence issue the first brood of imagoes the following spring.

The danger to the larva of the cabbage butterfly from the attacks of birds has already been referred to. Birds, however, are not its only enemies. There are certain parasitic insects related to the bees and wasps that deposit their eggs on the butterfly larva soon after it hatches. The young of the parasite on hatching bore into the body of the butterfly larva and feed upon it until they reach maturity. As they are careful to avoid any of the vital organs of their host the latter does not die, but about the time that it should pupate there issues from its body a number of small larvæ which spin cocoons on its surface. In a few days there issues from these, adult parasites like those that laid their eggs on the butterfly larva. Besides these parasites and birds both the larva and imago are preyed upon by many other insects. A bacterial disease likewise attacks and oftens destroys the larva.

The transformation passed through by the butterfly in passing from the egg to the imago is such that none would suspect from an examination of the larvæ, pupa, and imago that they were different stages of the same insect. Insects in which the different stages are so entirely different are said to have a complete metamorphosis. Butterflies and moths both have a complete metamorphosis. In these the larva is commonly called a caterpillar. Two-winged flies, whose larvæ are maggots; beetles, whose larvæ are commonly called grubs, as well as bees and wasps all have a complete metamorphosis.

In certain other insects, however of which the grasshopper may furnish a typical example, (see next lesson) the insect that hatches from the egg is in general form similar to the adult. That is, it possesses six legs, antennæ, commonly called "horns," on its head and in a division of its body into head, thorax, and abdomen, is similar to the adult. The chief difference is that it lacks wings. A young insect that thus resembles its parent is called a nymph. As it grows it sheds its skin or molts at frequent intervals. At each molt it gradually becomes more and more like the adult in size and in the proportion of the different parts of its body. Finally at the last molt it changes into the imago.

Insects which thus resemble their parents in all stages from the egg upward are said to have an incomplete metamorphosis. Besides crickets, cock-roaches, and other forms related to the grasshopper the true bugs and some less well known insects have incomplete metamorphoses.

CHAPTER VI.

A NATURE STUDY LESSON ON THE GRASSHOPPER.

By JULIA E. ROGERS, East High School, Des Moines.

The day the fall term began the teacher asked the children to fetch in some live grasshoppers and put them into a cage that stood on her desk. It was a strange looking cage, and made in the following way: A strip of wire netting 36 inches long and 9 inches wide, was cut from an old screen door. This strip was bent so as to form the four sides of a nine inch cube. Two pieces each 9 inches square, were set in to form the top and bottom. The corner seams were sewed with a wire thread over and over. A round hole two inches in diameter was cut in the top, and a three inch disc of cardboard formed the cover, held in place by a brass paper fastener. (The teacher and the little boy where she boarded made this cage on Saturday.)

The children came on the second morning and nearly all had "hoppers" to slip into the cage. There were several of the ordinary red legged variety, a few delicate-looking green ones, a big, striped fellow which looked muscular and pugnacious, and didn't like the cage at all. When the bell rang, and the opening exercises were over the following conversation took place:

"Did you have any trouble finding grasshoppers this morning?"

The tone and manner of the teacher were so pleasant and reassuring that the children were soon at their ease and ready to tell their experience. John was not shy, and the teacher said, nodding to him, "Tell us how you got the big one."

"He was in the road and I almost stepped on him. He made a loud snapping noise as he flew away and I lost him; he is just the color of the road. But I ran him down and caught him under my hat."

Mary. "I heard mine singing in the grass, and went up close, but it stopped. I looked a long time and at last it began again, and I saw it on a grass stem. It was just the same color. I grabbed it before it had time to get away, and brought it to school in my handkerchief."

Alice. "I got the brown one last night on our grape vine. It was hard to find, too, 'cause its the same color as the vine."

Jim. "I came acrost Gray's medder, and I found this fer yuh," and he laid in the teacher's hand a piece of sod in which was a large mass of eggs, cemented together, and packed away for safe keeping.

Tr. "Thank you, Jim, I didn't expect such good luck as to get eggs the first day. You may put these into the empty chalk box, and we will call it the incubator. It will be a very interesting box as the days go by."

Carl. "I got a lot off the corn leaves as I came through the field. They are the common kind with red legs, and not very big."

Tr. "I am going to keep these grasshoppers here all day, if I can make them comfortable. What can I do for them, John?"

John. "They want something to eat, I guess."

Alice. "Maybe they're thirsty."

Tr. "What would you suggest to feed them with, Arthur?"

Arthur. "They'll eat corn, or wheat or just anything green, I guess."

Tr. "Jim, you may go out and find something to feed the animals."

He goes and soon returns with a cabbage leaf dripping wet.

"I thought I might as well water 'em at the same time," he explains.

The leaf is poked in through the narrow door, and the children come up close to see the result. After a moment the insects begin to eat.

Tr. "I wish you would find out all you can in the next minute or two. The sharpest eyes will see the most, of course, let's see whose they are."

Time being called, the responses come thick and fast. The only rule is: "Don't interrupt any one who is speaking."

Carl. "Don't they work their mouths funny!"

Tr. "How, Carl?"

Carl. "Why, they chew up and down and sidewise all at once."

Mary. "And they have funny little fingers at the corners of their mouths."

Jim. "This one is eatin' right on the edge of the leaf."

Tom. "And he sticks his toes in to keep from falling off."

Alice. "They all nod their heads while they eat."

John. "They swell out their bodies about once a second. Is that the way they breathe, do you s'pose?"

Tr. "Watch them awhile, John, and think it over."

Ellen. "They have long horns on their heads, and they wave them up and down. Sometimes they lay them on the leaf."

Otto. "They have sharp teeth."

Arthur. "Yes, or they couldn't cut it off so clean and smooth, could they?"

Tr. "How many legs does the creature have?"

All. "Six."

Mary. "The hind pair are to jump with, so they're big and strong."

Tr. "How many wings?"

All. "Two!"

John. "There's four! That big grasshopper had a pair of black and yellow ones when he'd got up to fly. They must all be the same."

Tr. "Think about this a little longer, children. Get a grasshopper and ask him how many wings he has. He will tell you to look and see."

Carl. "Are those his eyes on the corners of his head?"

Tr. "Would that be a good place for eyes?"

Jim. "He could see in all directions. He wouldn't have to turn his head."

Alice. "The back part of the body is made of joints like a stove-pipe, only they move a little. And there are some dots on the sides."

Tr. "You have all been very good observers. I can't say who is best. I think we have stared at our visitors as long as we ought to today. You may write for your language lesson what you have learned about the grasshopper. You may find out all you can about the young ones tomorrow. Keep watch of the incubator and look for young ones out of doors. You will find their cast off clothing on the ground in grassy places, if you are patient and press the grass roots apart with care. Try to find out for sure how grasshoppers breathe; why they are so differently colored; and if they have the senses of sight, hearing, touch, taste, and smell. Mary and Alice may act as a Committee on Entertainment tomorrow, and see that there is no lack of food and water in the cage. Jim will watch events in the chalk box, and let us know the moment the first egg hatches. I have not answered questions for you because I wish you to work them out yourself, as you would an example in arithmetic. Next week, or perhaps before next week, we will talk over the new things we learn about the grasshopper,"

CHAPTER VII.

SCHOOL GARDENS.

By JOHN CRAIG, Ames, Iowa.

How often one sees a school house planted in the middle of a bare and unclothed piece of ground. No trees, shrubs or flowers to relieve the barrenness and give a touch of civilization, life, and home-likeness. Why not undertake a small garden patch this year or next? It is astonishing how much pleasure and information may be derived from a strip of soil five by fifteen feet. It is remarkable how much horticultural knowledge may be stolen from it. Here seeds may be planted and watched as they sprout and spring into various forms. Here wild plants may be set and observed as they respond to improved conditions and better surroundings.

Where shall we establish the garden? In the center of the lot? I think not. Our tiny plot would be lost in such a position, besides running the risk of being trampled by the feet of play loving children. Where do flowers look best? Where a picture hangs to best advantage, against a suitable background. Then let us choose a sheltered corner by the schoolhouse, or a strip where we may have the friendly protection of a hedge row, or even the companionship of a fence. If our choice brings us alongside a fence, hedge, or walk where the bed can only be approached from one side, it should be quite narrow, not more than three feet wide.

THE FIRST THING TO DO: Get some of the larger boys interested, ask them to bring spades and then superintend the "digging bee." See that the grass and weed roots are all shaken out and thrown away or buried deep beneath the surface. At this point the teacher may start the children to thinking by asking the purpose of this mellowing and deepening process. How are soils formed? (See Chapter II.) Look for decaying weed and grass roots and show the changes going on which form soil out of the roots of clover and trees. Note how readily the water is absorbed by the loosened soil; the deeper it is loosened up, the more water it will hold. When the bed is thoroughly loosened up the next thing to be done is to rake the surface until the clods are all broken up perfectly fine and smooth.

This raking and fining of the surface is to hold the moisture. How is this done? By making the surface soil very fine. Notice soil in the school yard which has been undisturbed. It is hard,

has many cracks in it and is very dry. It has dried out—lost its moisture through these cracks and through many small openings. If these openings are covered the evaporation is arrested. We might accomplish this by covering the surface with straw or other mulching material; but we may do it much easier by keeping a thin, dry, dust covering which is secured by stirring the surface once or twice a week with a rake.

Our bed has been spaded and raked, what shall we put in it? Something that will grow quickly and give us plenty of flowers. We would suggest sweet peas first. They grow three or four feet high and should be placed in the background. The seeds are cheap and easily obtained. Plant them at least three inches deep. They should be put in early in the season—in the last week of April or the first week in May, before the corn planting time. Place the seeds an inch or two apart in the row and thin the plants when they come up so that they will stand four or five inches apart. They may either be planted in double rows six inches apart or in little clumps. Sweet peas have weak stems and should be given something to lean upon. Small branching limbs of trees will do very well stuck in the ground behind the rows or in the center of each cluster. It should not be imagined that one must use the rather unsightly brush to hold up the sweet peas. Wire netting does well, but this is more difficult to get and more costly to purchase. Anyhow sweet peas may be grown without either brush or wire netting. They take up a little more space if allowed to tumble about unsupported, but will give nearly as many flowers as if staked.

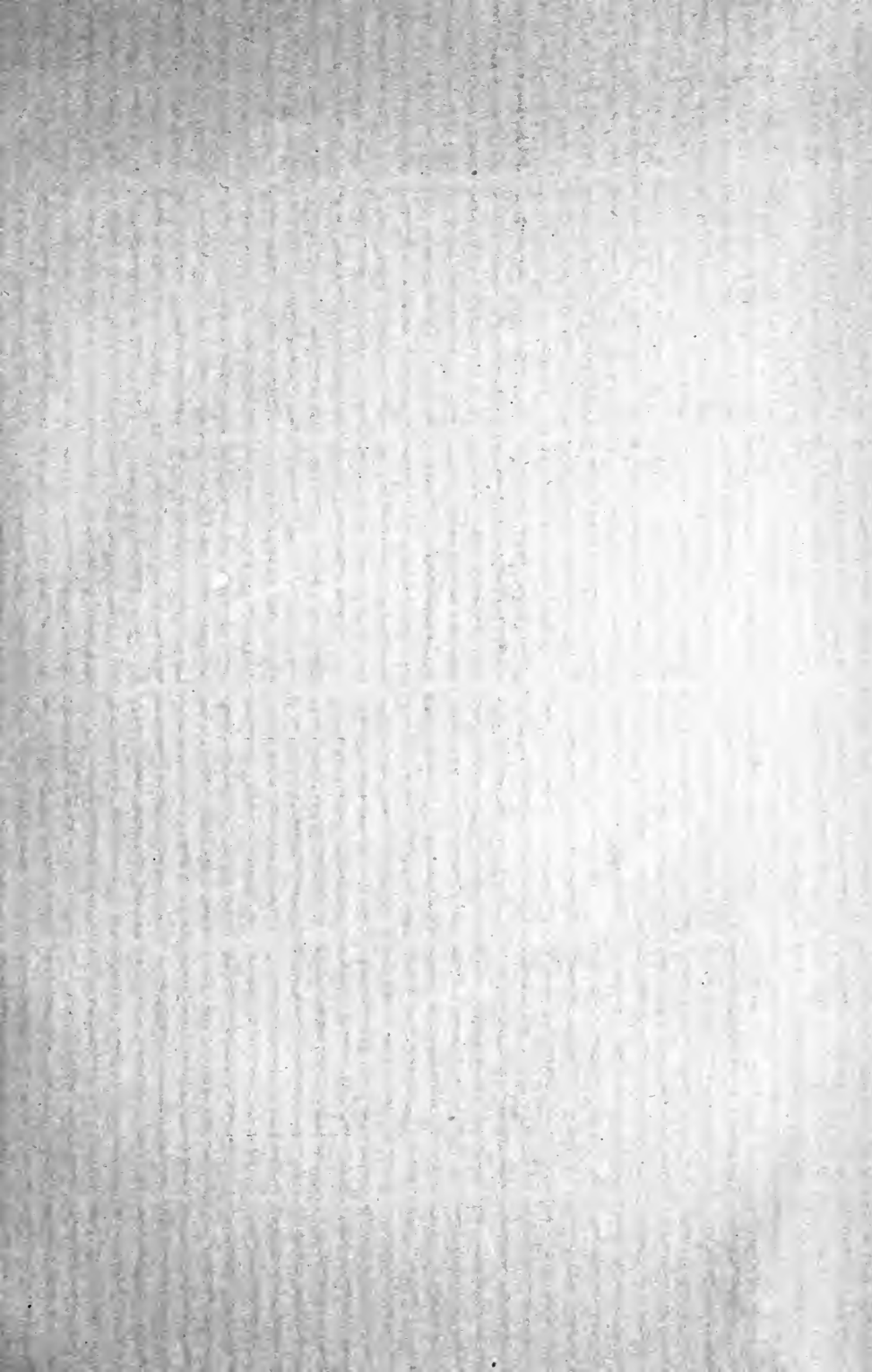
There are many kinds of sweet peas. A slight difference in the height of a plant or in the color of the flower allows the seedsman to call it a variety and give it a name. Sweet peas are sold in mixed packages which contain a variety of colors and in packages of a single color only. The single colors will be found more interesting. So let us buy some purples, lavenders, whites, pinks and yellows. Seedsman's catalogues describe each variety so that selection is easy. Discuss the matter with the scholars, choose the variety and raise the money by taking up a collection. When the plants begin to flower remember that it is nature's work to produce seed. If the flowers are picked off each day the plant keeps on trying to produce seed by growing more flowers, and thus the flowering season may be much extended.

So much for sweet peas. What else shall we grow? The sweet peas will furnish us an abundance of bloom during mid summer but begin to wane in September. Asters bloom best late

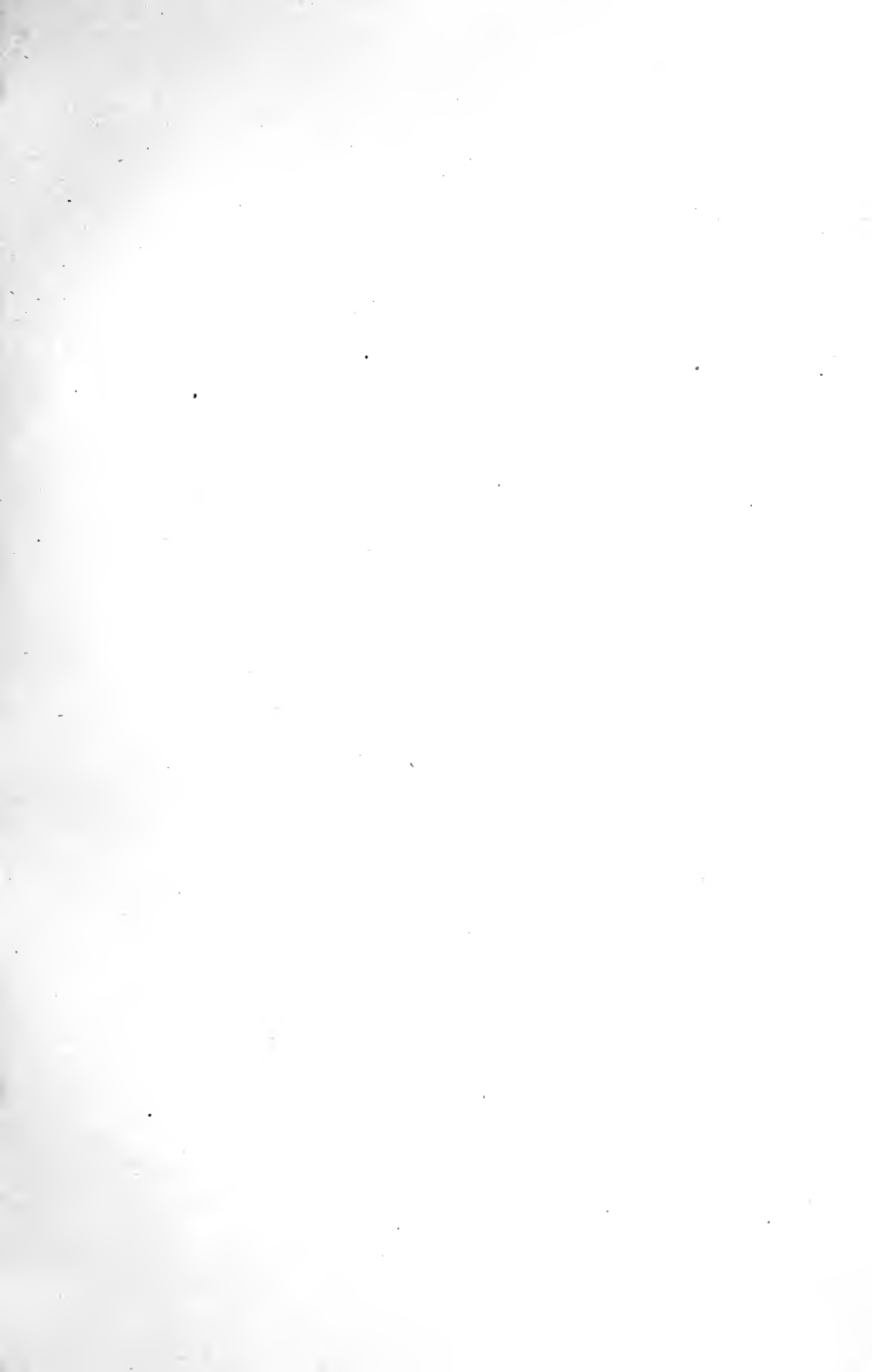
in summer so they ought to make a good second choice. There are tall growing asters and low growing kinds. The latter are called dwarfs on account of their small stature. A row of tall ones might be planted next to the sweet peas and a row of dwarfs next to them. In this way we may be able to see them all at a glance. Let us look at the aster seed; we find it very tiny compared to the fat sweet peas. If it were covered as deep it might not be able to push the young shoot through to the surface. We must therefore plant it very shallow—just covering it with soil well pressed down. Asters are sturdy little plants and need a good deal of elbow room. When they come up let us thin the tall ones to ten inches apart and the dwarfs to six inches. Let us put in two tall kinds and two dwarfs.

Shall we plant anything else? If we still have some space I would put in some pansies or phloxes. They will make a pretty edging and give lots of flowers. The seed may be covered about an inch deep and the plants thinned to six inches.

How many school teachers will try a garden next year? Write us for suggestions. We shall be glad to help you make your garden a success. If at any time the soil should be very dry, get the boys and girls to water the plants, but see that the wetting is very thorough, not merely on the surface. The watering should be done at night. Next morning the surface should be raked to prevent the dry air carrying off all the moisture and leaving the ground hard and baked.











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