Nature-Science

AND

...Agriculture...

Teachers' Home Series

A Normal Course

in . . . .

Nature-Science and Agriculture

In Six Papers.

National
School of Correspondence,
Quincy, Illinois.

Jost & Bohne, Printers, Quincy, Ill.

Nature-Science and Agriculture.

"Every age has its work, every man his mission, and every generation is a link in the chain of passing events."

The development of Natural Science Study is the tendency in education at the present time. Whether we consider it from the standpoint of science teaching, laboratory work, sense training, object-study, elements of agriculture, nature study, etc., the progressive, up-to-date teacher must grapple with the problem of the selection of topics for the cultivation of the observing powers of children and the methods of teaching them, in order to be in harmony with the scientific civilization in which we live and with the spirit of modern education.

In addition to this, it is not too much to say that when the matter of true elementary science instruction is once understood and made effective, the very effort put forth in the selection of topics and in their adaptation to the needs and requirements of proper teaching will effect a solution of many problems in all subjects taught in the public schools. We refer, of course, to the power the student thus acquires and its effect upon pedagogic methods.

It would be neither interesting nor profitable to consider the history of this subject from its obscure beginnings. Doubtless Adam was an observer of natural phenomena, and the primitive peoples followed Nature, but our study properly begins with a time when there was at least some semblance of method in education.

In the history of education among the Greeks we find that Socrates believed that no science could be taught; only drawn out. Aristotle was well versed in the natural sciences and almost all these were included in the vast programme of the instructions he himself gave in the Lyceum; but, as his was an aristocratic system of education, it was restricted to a small minority.

Roman education, too, was literary, ethical and prudential, rather than scientific, in the time of Quintilian, Plutarch and Marcus Aurelius.

Religious training was the dominating character of the Middle Ages.

The first introduction of what may be called modern education with special reference to the study of nature, was in the instruction of Rabelais, (1483-1553), and in his Gargantua, a collection of pamphlets which appeared early in the sixteenth century. His pupils were taught to love and experience nature as well as to know her.

It remained for Comenius, (1592-1671), in the first half of the seventeenth century, to apply the principles of modern instruction which embody natural science study. Comenius said three hundred years ago, "We must offer to the young, not the shadow of things, but the things themselves, which impress the senses and the imagination. Instruction should commence with a real observation of things, and not with a verbal description of them."

The first classical work of French pedagogy was written by Fenelon (1651-1715) in the latter part of the seventeenth century. In his valuable treatise, "On the Education of Girls", he displayed his knowledge of the aid to be derived from object lessons. He says:—"Curiosity in children is a natural tendency which comes as the precursor of instruction. Do not fail to take advantage of it. For example, in the country they see a mill, and they wish to know what it is. They should be shown the manner of preparing the food that is needed for human use. They notice harvesters, and what they are doing should be explained to them; also, how the wheat is sown, and how it multiplies in the earth."

No event in the eighteenth century is fraught with more importance to the educational world than the publication of Rousseau's Emile. The whole would bear quoting, for all his recommendations contain at least an element of truth. In reference to the physical sciences he says: "You are looking for globes, spheres, maps. What machines! Why all these representations? Why not begin by showing him the object itself?" And again: "Do not treat the child to discourses which he cannot understand. No descriptions, no eloquence, no figures of speech. Be content to present to him appropriate objects. Let us transform our sensations into ideas. Let us always proceed slowly from one sensible notion to another. In general let us never substitute the sign for the thing, except when it is impossible for us to show the thing."

In Germany, from the opening of the eighteenth century, "a change for the better takes place. Ideas become facts. The importance of education bocomes more and more recognized; pedagogy shakes off the latent dust of the school and interests itself in actual life."

The beginning of a more liberal spirit was with Basedow (1723-1790). The criticism upon his work, however, is that the use of object lessons was overdone.

A review of the life and work of Pestalozzi would be helpful, as embodying and establishing in a very large measure, the principles of modern educational ideas. We can give only a brief reference to this celebrated educator.

It is, perhaps, in the institute at Burgdorf (1802), that we see exemplified most satisfactorily the natural method of instruction "which makes the child proceed from his own intuitions, and leads him by degress and through his own efforts, to abstract ideas." Natural history was studied during walks and in the fields. Practically the same methods were pursued at Yverdun (1805-1825).

"To popularize science" was one of the five essentials in Pestalozzi's system as distinguished by the philanthropist, Fischer; two of the remaining four essentials may be construed to have reference to the principles involved in elementary science-teaching.

Pestalozzi said of his own work, "My method is but a refinement of the processes of nature." A more modern writer has even ventured the criticism that he refined too much, since he sometimes made an abuse of sense intuition.

Froebel, who had spent two years at Yverdun with Pestalozzi, was in most respects, his faithful follower. Greard, in his study of the method of Froebel, places the taste for observation as the first aspiration of a child. It is evident, also, that Froebel places nature above everything else in the elements of education. He says: "Teachers should scarcely let a week pass without taking to the country a part of their pupils. They shall walk with them as father among his children,—in making them observe and admire the varied richness which nature displays to their eyes at each season of the year."

Among English writers of the nineteenth century, Herbert Spencer made a notable step toward a rational pedagogy in his book on **Education.** In this work he makes science the basis of education and emphasizes its importance in family life as well as in aesthetic education. He also shows that for moral education, as well as for intellectual, the method which approaches nature nearest is also the best.

Mention may be made also of the work of Alexander Bain on **Education as a Science.** Although his ideas of education have been criticized as exclusively scientific, they are evidently sincere and his book possesses the merits of a studied analysis and scholarly minuteness which have doubtless helped to shape the present tendency towards scientific thought.

In America, we might point to an array of leaders in advanced pedagogical methods, notably the late Col. Francis W. Parker, Dr. W. T. Harris and others, whose recognition and adaptation of the methods having Nature Study for a foundation are well known and not without far-reaching influence in the educational world.

It will be seen that educational ideas, as relating to certain first principles, are of long standing. It will be naturally inferred that any tendency in modern educational thought is toward the putting into practice rules deduced from these first principles.

We believe the present century will carry forward processes simplified during the past century, and elementary science has a place peculiarly and peremptorily its own in the general scheme of educational progress. More than this, we believe that most studies may be more advantageously pursued by making application of the methods employed in scientific instruction; that preliminary work in the training of the mind by the use of natural objects is the best preparation for most studies that are to follow.

A learner's introduction to the world in which he lives must come through the senses. He has a right to know about the earth and the living things it supports, since his well-being and his usefulness depend upon this knowledge; and the proper training in observation, sense-training, if you please, by personal contact and experience with the forms and forces which constitute and govern the universe is the only way in which he can acquire this knowledge.

One purpose accomplished in natural science study is the formation of habits of close observation. The senses become developed, acute and strong; materials for a comparison in future work are acquired; a spirit of inquiry and investigation is aroused; the laws of nature are discovered; the utilities of natural products are revealed.

A natural result is a gradual comprehension of the system and order prevalent in the universe, which in maturer work we know as scientific classification.

It is altogether in keeping with the results of such study to say that the mental powers make a steady, healthful growth, and there is satisfactory progress in the attainment of exactness and freedom in expression, a natural result of thoughtful consideration and an observant mind replete with facts.

It has been conclusively shown, too, that after preliminary science work, carried forward in a systematic way, advanced pupils have gone to the study of books with ease and profit.

It is not difficult to conceive that much pleasure and happiness may be the result of contact with the beautiful and the true, in both the organic and the inorganic, in nature; that this will have a tendency, through wise encouragement and direction, to keep out low pleasures during the formative period of childhood, and so foster, largely, an interest in pure and ennobling things which will extend into mature life. This is the testimony of those instructors who have tested the matter, and more than all, it is exemplified in the lives of many of the pupils who have had the advantages of such teaching.

The broad aim of science studies is stated by an excellent authority on this subject as "a responsive insight into nature, an interested understanding of the materials and activities of her great workshop, and appreciation of the variety, beauty, harmony and law of nature's handiwork." Another makes "the unity of science, with life the central study," the basal idea upon which his work has been prepared.

We quote from Joseph Payne ("The Curriculum of Modern Education," pp. 18, 19): "If science, then, is to constitute a real discipline for the mind, much, nay everything, will depend on the manner in which it is studied. In the first place, it is to be remembered that the pupil is about to study things, not words; and therefore treatises on science are not, in the first instance, to be placed before him. He must commence with the accurate examination of the objects and phenomena themselves, not of descriptions of them prepared by others. By this means, not only will his attention be excited, the power of observation previously awakened, much strengthened, and the senses exercised and disciplined, but the very important habit of doing homage to the authority of facts, rather than to the authority of men, be initiated. These different objects and phenomena may be placed and viewed together and thus the mental habits of comparison and discrimination may be usefully practiced. They may, in the next place, be methodically arranged and classified, and thus the mind may become accustomed to an orderly arrangement of its knowledge. Then the accidental may be distinguished from the essential, the common from the special, and so the habit of generalization may be acquired; and lastly, advancing from effects to causes, or conversely from principles to their necessary conclusions, the pupil becomes acquainted with induction and deduction—processes of the highest value and importance. It is no small advantage, moreover, that this kind of study affords, both in in its pursuit and in its results—both in the chase and the capture—a very large amount of legitimate and generous mental pleasure, and of a kind which the pupil will probably be desirous of renewing for himself after he has left school."

These are quoted as the words of a leader in educational thought who wrote and wrought for thinking, progressive teachers of the present generation; they are fraught with significance and replete in suggestion for the work we have in hand.

The outline of work which follows is arranged for the purpose of suggesting topics which may be used to advantage.

The subject of agriculture is so intimately connected with elementary science that a portion of each paper will be devoted to that particular phase of the study. It deals with living nature and all lines of elementary science may be easily studied in connection with it.

Peculiar circumstances or conditions will determine largely the development of any topic by each individual. The earnest teacher will be on the alert, always, to obtain other material, as well as to be thoroughly informed, not only as to the topic under discussion, but upon the devices adapted to the proper development of the topic, so that his pupils may be led to a solution of the problems for themselves. To this end the teacher should keep constantly in mind any necessary preparation on the part of the pupil, adapting the nature and amount of work done to the conditions, as well as to the age and capabilities of the pupils.

The pupils should be brought, as nearly as possible, in direct contact with nature, and only such work should be assigned as they can either do for themselves, or at least take the leading part in doing. It should be remembered that the principal object is to lead pupils to rely on their own powers; the teacher should furnish the proper opportunities and guidances, when such are necessary.

First Lesson.

Distinguish between plants and animals. Both are organic, i. e., made up of organs; both have life; both breathe; both require food; (What difference in the way they take their food?) Both are made up of tiny cells very much alike. (The chief difference between the cells of vegetables and those of animals is that vegetable cells grow together without any substance between them, and animal cells generally have a second substance connecting them). It is well, also, to develop the terms nucleus, and protoplasm in connection with the animal cell.

ANIMALS.

Birds.—Note what the birds are doing in your locality at this time, and in what respects the young birds resemble their parents as to appearance and actions. Observe what birds have disappeared that you noticed during the summer. Keep a memorandum of the times of migration of any birds and try to discover why the influence which cause some birds to migrate have no such effect on others.

Insects.—Watch the ant at work; the care of ants for young. Collect as many caterpillars as possible; watch their manner of eating, growth, moulting, spinning of cocoon at formation of chrysalides. Study insects especially with reference to their manner of eating. Different kinds of mouths different insects have. Learn chief differences between those which spend their time in the open air and those that live under stones, logs, etc.; ex., differences between butterflies and beetles. Find what insects must have liquid food, and what ones can take solid food. Learn all that is possible about the way the butterfly gets its food (how, and from what). Compare a butterfly's flight with that of a bird, and try to account for the difference.

Different kinds of beetles should be studied. They may be kept under stones in a box with dirt. The potato beetle is especially interesting for detailed study. Many beetles and their larvae may be found in old stumps or under the loose bark of trees. Study their structure and learn their life history in such a way that you may be able to give important facts in an interesting way to pupils when necessary to interest them or to supplement their work.

Study the lady beetle. Water beetles are also very interesting subjects of study. Obtain specimens and watch their manner of swimming, the way they breathe under water, adaptation of structure to habits, etc.

It is suggested also that the larvae of the milkweed butterfly and also the eggs are, in most localities, available for study. Examine the eggs with reference to form, color, etc. Watch closely for the appearance of the young larvae, note their growth, manner of moulting, etc. The ways by which larvae protect themselves from their enemies will make an interesting topic for a class lesson.

For a grade of class work above the primary, probably the fifth or sixth school year's work, it would be well to make a special topic of the relation of animal life to plants.

Several kinds of insect galls may be found on plants. A collection of as many kinds as possible should be made. Develop (a) the way galls are formed; (b) object of formation of galls, as protection, food; (c) different kinds of galls.

No opportunity should be lost from the very beginning to inculcate lessons with reference to animal protection.

In higher grades of work, the structure of some typical insect, as the grasshopper, may well be taken up, and some attempt at least may be made in classification. Life habits of typical insects should receive due attention and there should be frequent reviews on this point.

Collect caterpillars (larvae) of different kinds and place them in small boxes covered with light netting. Feed them with the leaves of the plant on which they were found. Study them and note their development.

Worms.—Observe how worms plug their burrows with leaves, etc. Why? Note any other interesting facts in connection with their actions and habits.

Tadpoles.—Note the different stages of development in which tadpoles are to be found; how they breathe; what they eat; what enemies they have.

Plants.—The plant as a whole. Study the plant, for the most part, out of doors. The subject is best introduced to children by means of stories as far as possible. The use of a plant, its work, etc., should be developed before the plant is studied in detail.

Parts of a plant:—1. Root—Use, (a) to feed plant; (b) to hold plant in position. Kinds, (a) Fleshy; (b) Fibrous. Functions—gripping, storage. (At this time do only elementary work in the study of plants.)

2. Stem—1. Use; 2. What it is made of; (a) woody material; (b) juicy material. Compare as to shape. Outside and inside growers—compare corn and maple.

3. Leaves—Kinds, shapes, parts.

4. Flower—Parts, use. Study fall flowers, simple and composite.

Study for special topic the spread of plant life—(1) by the scattering of seeds; (2) by growth of underground stem

1. Scattering of seeds—(a) seeds carried by wind; (b) plants carried by wind; (c) distribution by animals. Note in each case the locality in which the plant grows; whether the plant is solitary or social; the method by which it will be likely to be most widely distributed; what per cent of the seeds produced make new plants; differences in numbers of seeds produced by plants growing in wet and dry regions.

2. The underground stem. Differences between annuals and perennials should be explained by illustration. Roots of perennials may be examined and new buds seen. What conditions can a plant propagating by means of an underground stem meet more successfully than a plant propagating by seeds?

What is a weed? Why do weeds spread more readily than cultivated plants?

Conditions affecting the life of any plant; (1) water; (2) heat; (3) soil.

Study as many different kinds of flowers as possible, noting kinds of insects that frequent flowers and adaptation for fertilization. The form, colorization, etc., always have some significance.

Note adaptation for cross fertilization; ripening of stamens and pistil of the same flower at different times. Make list of insects that visit flowers—bees, butterfles, flies, beetles, ants, etc.

Study also in their adaptation for insects—1. (a) provisions of food; (b) attractive color; (c) odor; (d) form and position of parts; 2. contrivance for excluding unwelcome visitors—(a) hairs on stems; (b) sticky substance on stems; (c) arrangement of parts of flower to prevent entrance of creeping insects. Are any plants free from insects? Why?

Select a number of fleshy fruits for study and note in what respect they are alike. Learn the meaning, relations and structure of the following terms: Pericarp, epicarp, endocarp, mesocarp, sarcocarp, embryo, cell, ovary, dissepiments, placenta.

Note different colors of fruits and colors at different stages of development; appropriateness of color to the particular fruit; parts most highly colored.

Keep in mind the wild state of the fruits in accounting for the characteristics. Note parts developed by cultivation. What parts of the flower form the fruit in each kind of fruit studied?

Physics.—Make experiments in refraction of light, using a simple prism. Call attention to the changes the prism makes in the ray of light, breaking it up into a number of rays of different colors. The fact that the colored rays vary in their deviation from a straight line with the sunlight that enters the prism is due to their different wave lengths after entering the denser medium. Note which rays are nearest a straight line with the sunlight, and which are farthest from it. See how many colors can be distinguished.

Make simple experiments in magnetism, such as placing a magnet under a paper on which are placed some iron filings. Notice that each particle of the iron becomes a perfect magnet, also note the peculiar action of the filings when the magnet is moved beneath the paper. Magnetize a needle and by properly adjusting it upon a cork floating on water, or by thrusting it through a cork and suspending by a thread, show the properties of the magnetic needle. All the phenomena it exhibits, as well as practical applications of the same, may be developed as the occasion and the advancement of the learner admit, such as the direction it assumes; the fact that after magnetization it will not balance at the same point as before (the **dip** of the needle); the action of the magnet on each end of the needle; which pole of the needle is attracted by the north pole of magnet and which by the south pole; idea of compass; directions shown by needle; direction of wind; direction toward various places, etc., use in testing for iron and steel, etc.

Chemistry:—Study and observe phenomena of **fermentation.** This can be done by placing a small quantity of sweet cider in several bottles, placing these subject to different conditions, and noting which conditions are most favorable to changes which will thus be illustrated during fermentation.

Alcoholic fermentation produces what is known as "hard" cider. This change is due to the yeast plant which breaks up by its growth the sugar of the sweet cider into alcohol, carbonic acid gas, etc. Afterward, the change to vinegar is known as acetic fermentation.

Note the taste and color of the cider when first prepared. Some bottles should be left open, others corked; some in a warm, others in a cool place, etc. The bubbles which rise from the liquid during fermentation contain carbonic acid gas. The action of a flame, as from a lighted taper, when placed in a vessel partly filled with the fermenting liquid, or by forcing some of the gas into lime water and noting the change.

Meteorology.

A weather record should be prepared and kept throughout the year. The design is to draw attention to the climatic changes from day to day. The records should be kept in a book, using one page for each month. From the daily mean temperature compute the mean temperature for the month.

A convenient form for a weather record, suggested by the Illinois State Course of Study, is made by ruling one column of the page for the date; another section under temperature should be ruled into four columns, one to give the reading of the thermometer at 9 a. m., one at noon, one at 4 p. m. and the fourth the mean or average reading; a third section ruled into three columns should indicate the direction of the wind; another like section should be marked "Clouds"; and another "Rain or Snow"; in all of which data as to these particulars may be indicated for the three times of the day by an appropriate symbol.

GEOLOGICAL STUDIES.

Soils.—Influence on Vegetation; (1) by the character of food supply; (2) by the temperature afforded to the roots.

Physical differences of soil; (1) coarse or fine; (2) porous or compact. Which have greater food-furnishing power, fine soils or coarse soils? Why? Which are more easily cultivated, porous soils or compact soils?

What difference between these two kinds of soils as to moisture? As to heat?

Soils are formed by fine particles of rock mixed with decaying animal or vegetable substances, hence they vary in the proportions of plant food. Therefore, all soils are not chemically the same.

Clay soils are formed from decomposition of slate and various rocks, including volcanic rocks. The latter contains more or less of a mixture of sand and mica.

Marl is a soil whose mixture consists of carbonate of lime, clay and sand, in very variable proportions, and accordingly known as calcareous, clayey or sandy limestone. Soils are marly if sand is present, as are those whose base is sandstone if carbonate of lime was the cementing material as is usually the case.

Loam is a mixture of clay and sand with organic matter.

Soils are called **native** if their base is formed from the decomposition of the parent rock below them; **foreign** if they have been washed or drifted from the place of disintegration of the parent rock. Nearly all the soil of the Northern States is foreign.

Agriculture.—(L. **agri.** genitive of **ager,** a field, and **culture,** to till, to cultivate.) Culture of a field is the term applied to the business of raising farm or field products, including, of course, the disposition of the products in the markets. **Farming** and **husbandry** are terms used in the similar sense, although their use, usually, is restricted to the practical phase of this most fundamental of occupations.

Agriculture contributes to the well-being of the civilized world mostly in the way of food production. Although the general subject may be divided and subdivided into a variety of special subjects, we shall aim to give the essentials in a general way to cover the most important portions of it, dealing with the principles which govern in the practical application of the term **agriculture.**

The consideration of the subject must begin with the **soil,** as that is the source of the production of agricultural wealth which may be controlled or modified to meet required conditions. The other sources, not subject to control, are the atmosphere and sunlight.

Soil is composed of the fragments of rock, primarily mixed with organic matter, that is, the remains of plants and animals. It is evident that the nature of soil, then, depends upon the amount, the condition and the kind of rock which forms its basis, and the amount of moisture and organic matter it contains.

The process of weathering, by means of which rock waste falls from cliffs and other elevations, and rolls, washes and settles down to lower levels, depressions, etc., is a familiar one.

Most movements of land wastes are so slow that they are not noticed. Their importance is understood when we reflect that many land forms result from the removal of waste.

This rock waste is due to a number of processes, as, changes of temperature, the expansion of water as it freezes in the crevices of the rock, chemical changes under the action of water and air, erosion by streams, etc.

The action, both as to the formation and to the removal of waste, is greatest near the surface, since the agencies are obviously more effective here. Then again, on gentle surface slopes, such as plains, the waste may become deep, since its removal is slow, and the particles become finer because of longer exposure and the result is a fine deep soil of great advantage to many forms of vegetation. Examples of this class of soil are abundant in the alluvial "bottoms" of the Mississippi valley.

A contrast, too, in the fertility of soil weathered from limestone and that in which sandstone is the base, may be observed in certain regions as in Central Kentucky and in Western Tennessee. The limestone soil is fertile, while that on the sandstone is comparatively barren.

The value of farming lands, then, depends upon whether they lie on rocks that yield rich or poor soils, or whether they lie in a position to receive transported soils which have escaped the vigilance of the farmer who occupies the neighboring uplands.

There are some soils which have an almost purely organic origin. This is true of most swamps, peat bogs, etc., formed by decayed water plants. The little mineral matter contained in such soils is that which comes mainly from the plants which grow therein.

Growing plants facilitate the work of soil-making in several ways: (1) Their roots are sent between the layers of rock and into the crevices of the rocks themselves and their great expansive power crowds the rocks apart and breaks them to fragments. (2) The acids in the root glands also dissolve the rock and earthy matter. (3) The decaying plants, as well as the animal matter, form mold, also, which makes the soil mellow and renders it chemically fit for plant food while it aids in the retention of moisture, in the admission of the air, and in other processes.

In addition to this, bacteria have much to do with the decomposition and enrichment of the soil, for it is now known that they penetrate into the soil and exist there as well as upon its surface. (We shall discuss micro-organisms more fully in relation to other subjects.)

Thus the soil is prepared and the materials for plant food are made ready in nature. It remains for the husbandman to see that proper conditions for plant life are maintained, or in other words, to make successful application of human endeavor to the production of plant life without impoverishing the soil.

CHARACTER AND COMPOSITION OF THE SOIL.

Plants require food, and the soil is their great food store-house. This food is not always present in the soil in the form which the plants can use; sometimes there is none at all where it is most needed. The problem for progressive farmers is to supply these deficiencies where possible.

In addition to what has already been said as to the soil formation—the mixture of rock dust and decayed organic life—we must consider also, in the requirement for plant life, soil moisture and soil atmosphere. The atmosphere the soil provides; the plant contains more water vapor, more nitrogen, and more carbon dioxid than that required for the sustenance of animal life.

The plant receives from the soil plant-food containing from one per cent to ten per cent of its weight of the following elements: Phosphorus, nitrogen, iron, sulphur, potassium, calcium, magnesium, chlorine, silica and sodium. It also receives from the air, through its leaves, from ninety to ninety-nine per cent of its weight of carbon, hydrogen and oxygen.

It is easily seen that a proper preparation of plant-food that is taken in through the roots necessarily requires that there must be circulation of the atmosphere in the soil.

Most soils contain the necessary elements, but it is possible for plants to grow, in a partially starved way, in the soils where some of these elements do not exist, or where they are not in proper proportion. The favorable growth of plants depends upon the condition of the soil and the composition of the food elements.

These elements are not used by the plants separately, but are absorbed when in composition with other elements. For example, the plant absorbs ammonia and thus secures its most important food, nitrogen, in combination with hydrogen, which it also needs. Nitrogen is given to the soil by decaying organic matter through nitrifying ferments or bacteria, and by leguminous plants, as clover, alfalfa, cow-peas, etc. These plants supply nitrogen through the agency of bacteria, or germs, that live in the nodules of the roots and exract the nitrogen from the air and fix it in the soil as a compound.

The next most important element is phosphoric acid, which renders the plant fruitful and hardy. It is the most important mineral constituent of the soil and is used to a great extent by the cereals. It is supplied to the plant through decaying vegetation or through bones, etc., which have been prepared by acids to make phosphoric acid soluble (acid phosphate.)

Potash, which makes starch and woody tissue, hence needed by fruit trees and root plants, may be supplied by applying wood ashes to the soil. Barnyard manures also supplies potash in a soluble state.

Oxygen is found in a free state in the soil, and also in combination with nearly all the other elements.

Hydrogen is foud in combination in the soil. Combined with oxygen it forms water, absolutely necessary to plant life and growth.

Carbon is a part of the organic matter in the soil. It unites with oxygen and passes back into the air in the process of decay. It is obtained by plants mainly from the carbon dioxid of the air through the leaves and other green parts.

Iron exists in the soil both in a free state and in combination. It is quite abundant in most soils, and while it adds nothing to the plant tissue it is thought to stimulate plant growth. The disease known as "chlorosis", or the production of yellow foliage instead of normal green leaves, has for its most common cause the lack of available iron—either its absence altogether from the soil, or the failure of the roots to dissolve and absorb such compounds as may be present.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

[FIRST PAPER.]

1. How early in the world's history did science study receive consideration?

2. Name two prominent men among the Greeks who believed in science teaching. Two Romans?

3. What may be considered the first intro duction to elementary science study?

4. What were the ideas of Comenius on this subject? Of Fenelon?

5. How did German educational ideas take this tendency?

6. How were Pestalozzi's classes introduced?

7. What importance did Froebel attach to nature? Herbert Spencer?

8. Name some prominent American educators who recognize the importance of nature study?

9. What is sense training? How secured?

10. How does elementary science work contribute to the accomplishment of better work in other studies?

11. What is the broad aim of elementary science study? Some special aims?

12. How should this work be carried out?

13. How much of the work should be done by the teacher? By the pupils?

14. What are the main differences between plants and animals?

15. What is agriculture? Why should this subject be studied in schools?

16. Why does the consideration of this subject begin with the soil?

17. How do plants assist in soil making?

18. What can you say of bacteria in their relation to the soil?

19. What are the soil elements necessary to plant growth?

20. What is the function of iron in the soil?

Nature-Science and Agriculture.

[SECOND PAPER.]

"And the value of all things exists, not indeed in themselves, but man's use of them, feeding man's need."

SECOND LESSON.

Animals.

Birds.—Study for this lesson the migration of birds. It is interesting to note that some, as those which nest in the far northern portion of this continent, travel a very long distance to reach their winter abode in the Southern States. Others which nest in that region winter in the northern part of the United States, and still others, nesting in the middle and western states, are only summer residents spending their winters in the Southern States, and some even as far south as South America, then again there are others which have a permanent abode in the locality where they nest, adapting themselves to all the climatic changes, while still others which were at one time migratory, now remain throughout the winter. Some, hardy enough to remain throughut the winter, migrate, and others seem to indulge their fancy, going or remaining according to seeming whim. Robins and bluebirds are examples of the latter.

The cause of migration is explained in various ways. The first is to seek a change of climate, going south to avoid severe cold. Such birds return northward in the spring doubtless to separate themselves, to conceal their nest, during the time of nesting. In such cases the young birds especially would have a tendency to remain in their native region until driven southward by cold and famine, especially the latter. When food is abundant it is well known that many southern birds learn to endure the rigorous nothern winters.

Another theory of migration is based on the hypothesis that many birds north of the equator originated on the continents near the north pole at a period when that region was tropical in climate as it may be clearly proved to have been. As the conditions changed and the earth there became ice-covered, the birds could not temper themselves to the climate and the ice fields afforded them no food. They were therefore forced to flee southward. As the ice fields receded with the summer, the birds would move northward and build their nests as near as possible to their old location. In this way we may say the habit was established, and now, while climatic changes are more regular and conditions more permanent, many birds continue to follow it.

Still other causes of migration may be found in a necessity for new food fields, in the fear caused by the wholesale slaughter of certain species, in some localities, and a desire for variety or a roving disposition on the part of some birds.

Pupils should be encouraged to continue observations on the migration of birds in their particular locality and note the same with any peculiarities, as, (1) those peculiar to that region which migrate first in the fall; (2) those which remain longer than usual with probable reason for so doing; (3) those ordinarily migratory but now remaining throughout the winter, etc. We quote from a recent article by an authority on this subject of the migration of birds:

"The present international study of bird migration is not only in many particulars the greatest concerted scientific inquiry ever instituted, but it is the most baffling subject that naturalists have ever undertaken to exploit. Many of the most eminent among the current investigators reject all previous deductions in regard to the causes of migration. Fear of cold and hunger has been assigned as the motive that prompts birds to leave the north in wintertime; but contemporaneous ornithologists cannot accept this unqualifiedly, for vast multitudes are known to depart from regions in which no such contingency prevails. Moreover, species of the limicolae and other genera instead of stopping when they reach congenial north temperate latitudes press on and on, enter the tropics, cross the equator, and do not rest until they find in the south temperate zone conditions of climate and supplies of food exactly like those passed in north temperate regions. Longing for the old nesting-place has been assigned by many writers as the secret of the birds' return over seas and continents to the spot of their nativity, but this, modern naturalists point out, does not account for the amazing fact that nestlings of many species in the autumn migration leave the parental home months in advance of the old birds, and without a pilot, spread their young wings and start on voyages from two to nine thousand miles in length, arriving safely at the ordained winter home.

Neither can the love of birds for their mates be accepted as the dominating purpose of migration, for in the case of nestlings, in whom the instinct of world-journeying is so strong that they embark without a captain and when their wings are but a few weeks old, there is no lure of a tryst in the far corners of the earth to explain their amazing pilgrimage. Some French naturalists have decided that it is a craving for more light that prompts a flight toward the south when the days shorten in the north countries.

Another view is that bird migration is a proof of the polar origin of life. As the North Pole cooled, life developed, some of it evolving into bird forms, and there began to be a slight movement toward warmer areas in the winters. Gradually the earth cooled throughout, the bird migrations extending, and now, except in the case of certain acclimated species, there is spontaneous return in spring toward the primitive fountains of all world life. Inasmuch, however, as recent explorations indicate that certain birds summer in Antarctic regions, the North Pole theory would appear to be in need of revision.

After years of study devoted to the topic, Professor Alfred Newton, of Cambridge, stated in 1878 that without doubt, bird migration is the greatest mystery in the entire animal kingdom—"a mystery," he added, "that can be no more explained by the modern man of science than by the simple-minded savage of antiquity."

In spite of all their accumulated knowledge on the subject, the most progressive ornithologists confess that the facts of bird migration are as incomprehensible as if these restless wanderers had suddenly arrived from some distant planet. The latest theories overturn previous deductions, many of the observers now claiming that none of the visible marks of the earth's configuration guide the birds at the times of their migrations along aerial routes, sometimes three miles above the walks of man. Though Doctor Gatke takes the lead in setting forth many of these phenomena, he makes no pretense of solving the riddle. In regard to the problem of the altitude and velocity of bird flight Capt. F. W. Hutton says, in his Mechanical Principles Involved in the Sailing Flight of the Albatross, that in a perfectly calm atmosphere this bird with outstretched wings would drop, unless it were also executing a forward movement. Doctor Gatke, however, summing up his lifelong studies, says: "My observations are so much at variance with all explanations based on known mechanical laws that I am obliged to consider the question of migratory flight as yet an unsolved and perfectly open one."

Insects.—The grasshopper may be taken as a study of the typical insect for anatomical examination. Remember, we are studying life through its manifestations in the organic part of our work, and the teacher should lead the pupil to select data from which intelligent conclusions are to be drawn. One of the main ideas of this work is the comprehension of natural laws, phenomena, etc., and there is less danger of loss of time and energy if there is some attempt to study types with a view to preparation for classification.

The grasshopper should be studied first in the fields; his movements, his habitat, his food, his means of protection, etc., should be noted. Dead specimens should then be examined for the characteristic parts of insects. Eggs of the grasshopper may be obtained by putting some grasshoppers in a box containing moist dirt and fresh grass. The eggs will be deposited in the dirt.

Comparisons may be made between the grasshopper and the cricket, the katydid, etc. Try to account for contrasts in color of these insects.

BOTANICAL STUDIES.

Study plant stems. 1. Their functions; (a) To support the plant; (b) To supply the leaves of the plant with water. In connection with the study of the first function different plants should be examined and comparisons made as to the relative development of the woody tissue, color, thickness, etc., of bark, arrangement of leaves on the stems, etc. Collections of specimens of different kinds of stems in the locality should be encouraged. These may be sufficiently light to be conveniently and tastefully mounted, and while the main body of each specimen may show exterior characteristics, one extremity may be so trimmed as to exhibit cross section and the other longitudinal section of each stem.

Experiments may be made in connection with the study of the second function to show that water will rise in the stem: (a) Wrap the wilted leaf of a plant, as a twig of geranium, closely in tissue paper, leaving the lower part of the stem exposed. Place the stem in water and presently the expansion of the leaves, caused by the rise of the water through the stem, will burst the paper. (b) Place one end of a piece of cornstalk in colored water. After a time it will be seen that the coloring matter is diffused through the stem.

2. Study the structure of stems with relation to their performance of these two functions: (a) The use of woody tissue; (b) Different arrangement of fibro-vascular tissue; (c) Compare the cornstalk with the maple stem and note the different ways these stems increase in size, and lead pupils to understand that the one is outside grower (exogen), and the other an inside grower (endogen); (d) Call attention to difference in venation. (Do not hesitate to introduce technical terms after facts are learned.) (e) Study function of the bark and call attention to the rings of exogens.

Seeds.—Make also a special study of nature's methods and arrangements for the protection and dispersion of seeds. Show in this connection that the chief object in the life of a plant is to perpetuate its species, and to that end the perfecting of the seed is the principal necessity. Call attention to the protection the plant gives to its seed and carefully prepare a series of lessons on how how plants scatter their seeds, permitting the pupils to make their own discoveries as far as possible. Encourage pupils to make collections and after examination and comparison make lists and drawings of winged seeds, as the maple, feathery or downy seeds, as the thistle, and hooked seeds, as the cockle bur, sand bur, etc.

Show the scattering of seeds, first, as carried by the wind. Such seeds, it will be seen, usually have thin, downy attachments, or wings which serve as sails to waft them forward. Among the former are the familiar dandelion seeds, milk weed pods enclosing a silken mass, the thistle, the fireweed, the goldenrod, asters, wild lettuce, wild clematis, the cat-tail, etc. Among the latter will be found the seeds of the maple, the elm, the pine, the ash, etc.

Second, seeds scattered by water, may be discussed in an interesting and instructive way. Seeds of plants growing in the water should be examined, if possible; the seeds of the white and the yellow water-lilies, it will be noticed, contain air-bubbles which keep them afloat for a considerable length of time. Wild rice floats a long distance, but cultivation makes its seeds too large and heavy to travel far. Cocoanuts, seeds of the mahogany tree, etc., are carried long distances by ocean currents. Grass seeds, etc., are familiar examples of seeds that are carried in the soil washed by rivers and smaller streams.

Third, there are numerous familiar instances of seeds distributed by animals. Birds are among the most active agents in seed distribution. Crows, magpies, etc., in a seeming spirit of mischief, have been known to carry nuts several miles and bury them. The seeds of wild grasses cling to the feathers of birds and are carried long distances, and other birds, especially waders, carry lumps of earth containing seeds on their feet or legs to be deposited far away. Rye, oats, wheat, millet and clover seeds have been carried frequently in the crops of birds. Other seeds, protected against digestion, have been swallowed by birds for the sweet, fleshy part that surrounds them. Among these are the raspberry, cherry, blackberry, strawberry, etc. The hooked seeds, such as burdocks, cocklebursi, sand burs and the like, fasten themselves upon the coats of sheep, dogs, cows, horses and the clothing of man and are so disseminated. An interesting study may be made of their adaptation for this means of dispersion from their color, and mode of growth as well as from their being prepared with hooks, barbs, etc.

Studies In Physics.—Study the forms of water, calling attention first to that of water drop. Show that a frozen drop of water is a hail stone. The forces, gravitation, cohesion and adhesion may be illustrated with the drop of water, but the extent to which these are developed must depend upon the advancement of the class or their ability to understand. The shape of the water drop may be commented upon and explained according to the understanding of the pupils.

The formation of vapor may be shown by the use of the ordinary teakettle. Call attention to the similarity of the steam, formed when the vapor comes in contact with cold air, to clouds, and explain that clouds are formed in a similar way.

show that heat, as from an alcohol lamp, will cause the cloud of steam to disappear. Explain that clouds sometimes are dispelled by heat.

Illustrate evaporation by wetting some object as a cloth, piece of paper or a sponge, and place it in the sunlight or near the fire. Explain where the water has gone and why, and show how it may become condensed and visible. The formation of water drops on the outside of a vessel of cold water will illustrate the formation of dew.

Call attention to the uses of steam, as in heating dwellings, in the cooking, in furnishing power engines, etc. Show that frost is only frozen dew, that snowflakes are formed by the freezing of water vapor before it is under the influence of cohesion. Study the varied delicate crystals formed in snowflakes.

Study and discuss ice, showing the beauty and symmetry in crystallization, the uses of ice after it has been stored at the time of ice harvest, the manner of harvesting and storing, agency of ice in erosion, etc.

Meteorology.—Keep a weather record as suggested in first paper. Remember to determine the average temperature at the end of each month.

Geological Studies.—Study gravel beds, their origin, etc. Pebbles, their nature, origin, relation to life on the earth. Clay beds, and how they,are built.

Clay consists of hydrous silicate or alumini. (Aluminium is the metallic base of alumina, a white metal with a bluish tinge, and is remarkable for its resistance to oxidation, and for its lightness.) All clays seem to owe their origin to the decomposition of various rocks. While their chief constituent is aluminic silicate, they contain other ingredients varying with the nature of the rock to which they owe their origin. Common clay is a mixture of kaolin, or China clay, and the fine powder of some felapathic mineral which is not decomposed.

The most common varieties of clay are: China clay, or kaolin; pipe clay, containing a larger percentage of silica than kaolin; potter's clay, less pure than pipe clay; sculptor's clay, or modeling clay, a fine potter's clay sometimes mixed with fine sand; brick clay, a mixture of clay and sand with some ferruginous matter; fire-clay, containing little if any lime, alkaline earth or iron. Shale is a laminated clay-rock; clay-slate is an indurated cleaved clay-rock.

The relation of nutrition to the health of plants as treated by Albert F. Woods, Pathologist and Physiologist, Bureau of Plant Industry, in the year book of the Department of Agriculture for 1901, is so essential and so clearly in line with what should be taught in this connection that we have taken the liberty to draw freely from this paper on this subject, as embracing the results of the most recent investigations.

Plant Nutrition is one of the most important problems in agriculture. The most careful technical research is required in its study and every truth learned or process explained is of great practical value. Only a general outline, as based upon reports from experiment stations and the

Bureau of Plant Industry, can be attempted in a work of this kind. The discussion, however, will include the most important problem of nutrition and is intended to stimulate thoughtful investigation and experiment.

The simple elements we have named are obtained and organized into living tissue by the process called nutrition. It will be seen that while all plants may be resolved into the same primary elements, these elements have various combinations and relations to each other in the processes of organization, making the variety of organic materials and tissues.

We have different species or varieties of plants as a result of the fact that each living cell has a tendency to organize its simple elements after the manner of its own organization, thus giving a peculiarity of organization which is accepted as a natural course in the reproduction of all individuals.

However, variations in condition of environment and food will produce variation in the plant. This is evident from the comparison of a plant grown on poor soil with one of the same species grown on very rich soil. The difference is so great that they are scarcely recognized as the same.

The elements necessary to plant life and growth must be in combination available to the plant. As a whole, plants vary in their ability to obtain their food elements from different substances, but with the ordinary agricultural plants there is not so much difference. All absorb the free oxygen of the air through the roots, stems, and leaves, and obtain nitrogen, ammonia, etc., in the soils mostly by absorption through the roots, but none of the agricultural plants are able to absorb nitrogen directly from the air. Though about 75 per cent of the volume of the air is nitrogen, it is available to crops only through the agency of micro-organisms, as before stated, which convert it into nitrates, etc., and thus furnish it through decaying vegetation or from living roots or cells.

Water and the various salts, of calcium, magnesium, potassium, sulphur, phosphorus, etc., in solution are absorbed mainly through the roots from the soil. From 70 to 90 per cent of the weight of living plants is water.

The analyses of prominent investigators show that the quantitative composition of the ash of the same kind of plants varies according to the soil in which they are grown. Every plant requires a certain minimum of each mineral nutrient. Silicon and sodium are perhaps the only exceptions. An excessive amount may be fully as injurious, as in alkali soils, etc.

All practical farmers recognize the effect of soil conditions upon plant life and development. The greatest per cent of the substance of plants comes to them through the soil by way of the roots, and the texture and structure of the soil has a decided effect upon the availability to the plant of the soil foods with the air and water.

Much study has been devoted to the adaptation of plants to soils of certain texture, for an attempt to grow a crop on a soil not well adapted to it, will result at least in partial failure unless skill is able to modify the conditions of growth.

It has been found more difficult to maintain available food, not in too strong a solution in the soil water with the soil not so wet as to exclude the air, in light, sandy soils than in clayey soils. Perhaps the most favorable for management is a light clay soil with humus and fiber derived from decaying roots and plant tissues or manure. Such a soil can be most easily adapted, with proper drainage, to the absorption of soluble food without danger to roots or plants. It will not readily become too wet or too dry and air is easily admitted to the roots.

Importance of Oxygen.—Poor drainage and consequent excess of water and lack of air to supply oxygen brings on asphyxiation, weakening, and even death to the roots of plants growing in soils subject to such unsuitable mechanical conditions. Frequent illustrations of this are seen in crops growing in heavy clay soils, especially where there is impervious subsoil or hardpan, where the feeding roots are killed by suffocation during extended wet periods. Roots forming in a moist or dryish soil are often killed in two or three days if the soil becomes saturated with water as in the time of floods on low flat lands. In addition to the weakening of plants by the loss of feeding roots, there is development also of injurious products, as alcohol, etc., in the cells of the roots that are not killed.

If the surface of the soil becomes packed or hardened most plants will suffer for want of oxygen for the roots. This is one reason the farmer plows his growing corn or his orchard. The stunted condition or the death of shade trees along paved streets is due mostly to the fact that the open space left around the trunk of the tree is packed as hard as the pavement or that this space is entirely too small.

Chemical Condition of the Soil.—It has already been stated that plants will suffer starvation if there is not a sufficient quantity of any or all of the essential elements. The roots will also be injured if the soluble salts are too greatly in excess. The iron compounds, for example, cannot be dissolved and absorbed by the roots if an excess of lime is present. The absorption of iron and other difficultly soluble materials is also prevented by a lack of oxygen or by the presence of parasites which kill the root hairs and feeding roots. The addition of iron, sulphate or other soluble iron salt, to the soil, will usually correct the trouble due to the lack of iron.

Recent investigations have shown that magnesium is a poison to many plants if unaccompanied by a readily available calcium compound. Too much magnesium and insufficient lime give plants a stunted growth. The remedy is to apply lime free from magnesium. Soils poor in magnesium, however, receive benefit from a magnesium lime and injury from a lime free from magnesium.

It must be remembered that magnesium is necessary to plant growth. It is especially important in the formation of seeds, and while a comparatively small amount is generally sufficient for plant growth up to the time of flowering or fruiting, a sufficient amount must be available then or the flower buds will not form or will wither before maturing. This, and other symptoms caused by lack of this important element, may also be procured by other causes which must also be taken into consideration.

Magnesium occurs in the soil in a natural way from disintregating rocks, chiefly as magnesium carbonate and sulphate.

If there is not sufficient lime or calcium it is first indicated in plant development by stunted growth and small, yellowish leaves. Chlorophyll or leaf green bodies do not normally develop, and the starch they make does not readily change into sugar. It is thought that this latter difficulty is due to the failure of the nucleus of the cells to manufacture diastase, the ferment necessary for transforming starch to sugar in plant nutrition.

Calcium owes its chief importance to the fact that it is a necessary constituent of the compounds entering directly into the composition of the nucleus and of the chlorophyll bodies, while it serves also the purpose to a large extent of neutralizing free acids developing in the nutrition of the cell.

Calcium is also important in serving to combine acids produced in the soil in various ways, i. e., by decomposition brought about through the action of roots, etc., upon soil particles, and also by strictly chemical decompositions. The roots of plants would be injured if these free acids were not neutralized. The presence of lime also favors nitrification in the soils.

Potassium.—All agricultural plants require large quantities of potassium. It is estimated that a wheat field requires about thirty pounds per acre annually; clover field, about eighty-three pounds; potato field, about one hundred pounds.

One of the first indications of a lack of potash is a cessation in growth without any apparent disturbance, the plants having their normal green color but making very little starch or sugar, and little, if any, protein or nitrogenous matter.

Potash is apparently indispensible in connection with protein formation and it is an important factor in the formation of starches and sugars. Proteins, or the related nitrogenous compounds, are the main source of food in the growing cells, hence the importance of potassium is easily recognized.

One of the most important physical requirements of plant growth is turgescence, or water pressure, in the cells. Potassium is necessary to this condition, while it also increases the water-absorbing power of the plant as a whole and the water holding power of the soil. Plants are more readily matured and perfected by a ready supply of potassium.

It has been estimated that clay soils, especially clay loams, contain from 5 to 8 per cent of potash, lighter loams, about 3 per cent and deeper sandy soils about 1 per cent. Even this smaller amount is equivalent to 3,500 pounds per acre, assuming that one acre of land one foot deep weighs 3,500,000 pounds.

Function of Phosphoric Acid.—Phosphorus enters largely into the nutrition of the nucleus of cells. The nucleus is not only the controlling center of every living cell, but its most highly specialized portion. It is evident, then, that without phosphoric acid the nucleus can neither grow nor divide for the production of new cells, hence plant growth ceases. Phosphoric acid is also an important constituent of chlorophyll and of chlorophyll bodies. Without these, the formation of sugar and starch from water and carbon dioxide cannot be accomplished. The lack of phosphoric acid, as well as of iron, lime or magnesium, is indicated by a yellowing of the chlorophyll.

Chemical investigation has shown that as a plant nears its flowering or fruiting period, phosphoric acid, magnesium, proteins and carbohydrates pass rapidly into the younger parts of the plant, preparatory to being stored in the seeds of fruits to meet the requirements of rapid growth at these periods. In case of scarcity, these materials are even forcibly withdrawn from the lower leaves and the roots when the reserves are used up. The living substance of the cells in the lower leaves is dissolved and absorbed after the carbohydrates, the fats and other reserve foods are gone. The chlorophyll disappears, then the chlorophyll bodies (chloroplasts), the nucleus, and the rest of the valuable constituents of the cells are absorbed by the younger parts. The elements thus obtained serve to feed the tuft of young leaves for a considerable time.

It is noted that a similar transfer of valuable food constituents takes place before the fall of leaves in autumn in practically all deciduous trees.

Nitrogen is necessary to the formation of albumen and of various constituents of the protoplasm. As has been stated, it is absorbed from the soil by the plant largely as nitrates or ammonia.

The lack of nitrogen is usually manifested by reduced leaf and stem growth and the tendency to the production of flowers and fruit at a very early period, though the amount of fruit produced is correspondingly small. Again, an excess of nitrogen, like an excess of water, stimulates the production of a vegetative growth at the expense of flowers and fruit.

Wheat and other cereals have not only soft leaves and weak stems under such conditions, but the plants are more subject to rust and mildew, and other parasitic diseases. This is true, practically, of all ordinary plants. Common salt is of great value when applied to light soils too rich in nitrogen. It reduces the excessive vegatative growth, thus permitting the formation of more grain in proportion to the straw and preventing the lodging due to rank growth. English farmers use it on very light lands at the rate of two to three hundredweight per acre, applied usually before the land is plowed.

Nitrogen assimilation also appears to be involved in some obscure diseases, such as the mosaic disease of tobacco, winter blight of toma toes, peach yellows, etc.

The dilute solutions of nitrates are absorbed by the roots of the plants and pass up through the stems to the leaves, where, through the aid of the chlorophyll, the nitric acid unites with the sugars to form the more highly organized compounds, amides and proteids, which serve as food for the growing cells. If anything interferes with the process of proteid organization nitrogen starvation will result, even in the presence of large quantities of nitrates, for the young cells cannot use the original soil nitrates.

Sugars are required for the organization of proteids, and sugar cannot be produced unless the chloroplasts are in good working order and exposed to light and heat of the proper intensity. There is no proteid formation in albino leaves or those devoid of chlorophyll, neither is there any where there is not sufficient light or heat. In such cases, therefore, nitrates accumulate in the plant. When the activity of the chloroplasts is renewed this accumulation of nitrates is gradually worked up into proteids, except in albino leaves, where the chloroplasts have lost their functional activity.

Experimental investigation has shown that a large excess in nitrates may in themselves cause a yellowing in the chloroplasts and so prevent nitrate assimilation. At first, plants overfed with nitrate of soda or other strong nitrogenous fertilizers, become brighter green and grow rapidly, but as their nitrates accumulate in the cell faster than it is used, the leaves begin to turn yellow on the edges and along the vascular bundles, and growth is checked and the plant dies back. This is especially likely to happen in plants that are not gross feeders. Yellowing and death of the edges of the leaves is caused by an over application of almost quickly soluble salt (potash, sodium, chloride, etc.

Organic manures are likely to stimulate vegetative growth at the expense of fruit, the fruit produced with organic nitrogen being coarser, thicker skinned and of poorer quality than when mineral fertilizers are used. Muck acts in this respect like organic manures, and it often contains iron pyrite, which, when exposed to the air, oxidizes to iron sulphate or copperas. Free sulphuric acid often forms in such cases, especially in the presence of decaying organic matters. The injurious action of muck on plants is often due to these causes rather than to any peculiarity of their nitrogen. Thorough compositing with lime is a remedy for these conditions.

In the use of organic nitrogen, especially fresh organic manures, there is a possible danger of the production of nitrites during decay and fermentation in the absence of a ready supply of oxygen. The acid juice of the roots of plants would convert nitrites into nitrous acids, which would, of course, quickly kill the feeding roots. This may be one reason why fresh manures often act injuriously on crops, especially in soils not well aerated.

If the solid matter in a solution in a soil exceed one part to five hundred of water, it is nearing a limit beyond which many plants are likely to suffer; the leaves turn yellow on the edges, become spotted and drop off, or growth is checked, shortened and compacted; the leaves often become puckered and twisted, owing to the weak development of the vascular tissue ("veins") as compared with the soft cells of the leaf. The roots and root hairs are also shortened, thickened and deformed. This refers, of course, to conditions to where concentration is not sufficient to kill the roots outright. It is understood that the strength of solution varies for different species of plants, some requiring a weak solution of nutritive matter while for others a highly concentrated solution is best. As a general rule plants with leathery leaves, with hard and narrow leaves, and with hard wood, require more dilute solutions than those with large, soft and expanded leaves. It is well to note that during the period of leaf formation plants can do with the greatest amount of nutritive matter.

Water.—An insufficient supply of water causes a hard, stunted growth, while an excess of water causes a soft, watery growth, subject to the attacks of various plant and animal parasites and easily injured consequently by drought. As has been previously stated, an excess of water in the soil excludes the air and produces asphyxiation of the roots. Most annual plants require the greatest amount of water during the rapid development of new shoots and leaves, and again at the period of flowering and fruiting. During to dormant or resting period which most plants require at some stage of their development, very little water is required, as well as very little food of any kind. Many evergreen plants, if watered during the resting period, drop their leaves, after which, if the soil is not brought promptly to the proper degree of dryness, the feeding roots decay and the plant may die. In the case of bulbous and tuberous plants the natural ripening and resting periods of the bulbs and tubers must be regarded or the bulbs will either rot or produce plants of very low vitality.

Most plants store up their reserve food immediately following the period of vegetative growth and fruit production. In perennials it is stored in the roots and stems and in the bulbous and tuberous plants in the bulbs and tubers. Here it undergoes slow changes, varying for different species, preparatory to a renewed period of growth. Many seeds also have to go through a similar resting period in which these nutritive materials become available for further growth. While plants, bulbs and seeds may often be forced to grow without this period of rest, it is evident that the reserve foods may not be in the right form to properly nourish the early stages of growth, and a weak, diseased plant is the result. No amount of nutritive salts or fertilizers applied to the roots of such plants can help them out. They will eventually starve to death in the presence of an excess of food. The pathological conditions in the cells are the same as described under the head of nitrogen.

Carbon forms about one-half (44 to 60 per cent) of the dry organic matter of plants. (The same proportion holds true in animal life.) It has been noted that the absorption of carbon dioxid from the air is one of the fundamental conditions of nutrition. Though the amount in the air is quite small, viz., only .03 per cent. (or 3 volumes in 10,000 volumes of the air) the air is the direct source of supply.

The transformation of carbon dioxid into carbohydrates (starch, sugar, etc.) takes place only in cells containing chlorophyll, and these are located, of course, mainly in the leaves. Hence anything which interferes with the normal development of the chlorophyll bodies in the leaves or the development of chlorophyll will interfere indirectly with carbon assimilation.

Heat and Light are very important factors, and different species of plants vary in regard to requirements in these respects. Some plants require to be shaded. When leaves are even slightly withered the stomata, or breathing pores, through which the principal interchange of gases (carbon dioxide, hydrogen, etc.) between the leaf and the air takes place, close in order to prevent the further loss of water. In this withered condition carbon dioxide enters the leaf with difficulty and the sugar production is greatly reduced or altogether prevented.

When leaves are exposed to sunlight, as Prof. Wood has determined by experiment, their internal temperature becomes several degrees warmer than the surrounding air. If the external temperature is very high, tender leaves may get so hot as to be actually scalded. It is observed that plants growing in hot deserts and places exposed to the sun are, as a rule, covered with a dense coating of hair or scales. This prevents the excessive heating of the tissues and consequent excessive evaporation.

Observations of investigators have been confirmed by Prof. Wood to the effect that spraying foliage with Bordeaux mixture or lime reduces evaporation, since the applications act like a hairy or scaly covering. Hence, during hot, dry periods spraying, apart from the fungicidal value, has a beneficial influence in promoting assimilation by preventing excessive absorption of heat and light rays by the leaves, and crops so protected might be able to withstand a droughty season that would otherwise greatly injure them. It also suggests the inadvisability of spraying heat-loving plants during the cool weather of early spring.

When plants are exposed to too strong a light the fact can usually be determined by the effort on the part of the suffering plant to place the surface of its leaves more or less parallel to the light rays, thus reducing absorption. When there is too little light the leaves present their upper surface as nearly as possible at right angles to the light rays, thus increasing light absorption. In very strong light the chloroplasts move to the side walls and turn their edges to the light, and the leaves thus have a lighter green color and less light and heat are absorbed. When the light is weaker the chloroplasts present their largest surface and the same leaf becomes a darker green and more light is absorbed. If the light is too weak, however, the plant finally becomes yellowish and starved.

Reserved Food of Plants.—A mature seed of any plant contains not only the embryo plant, but more, less reserve food—starch, sugar, oils and protein materials. In some cases these materials are directly available to the germinating seedling, even before the complete maturity of the seed. In other cases, after the seed is mature it has to go through a "resting" period, in which internal changes take place preparatory to germination. Ferments are formed ready to cause the solution of the reserve food during the process of germination. If germination is forced before these changes are complete a weak and poorly nourished growth is the result. Often these preparatory resting period changes take place only when the seeds are exposed to certain natural conditions of environment, such as heat or cold, moisture or dryness, etc.

During the early stages of growth of herbaceous plants, after the reserve food in seeds or tubers has been used up, the young plant must manufacture its own supply. For this reason the first leaves must begin work early in cases where the reserve food in the cotyledons or other storage tissues is small, and they should therefore be carefully protected against injury.

In most plants we have first a root development, requiring a warm, moist soil and cool air, then a development of the stem and leaves. If during the first stage of development conditions favor leaf instead of root growth, the young plants soon suffer for water and soil food, and even if not killed may never fully recover and produce a normal growth. The amount and nature of reserve food should always be considered in the various operations of propagating and pruning, if the health, vigor and productiveness of the plants operated on are to be kept up to a high standard.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

(SECOND PAPER.)

1. How is the cause of migration of birds explained?
2. Which explanation do you think most plausible? Why?
3. What have you learned of the food of the grasshopper? Of his means of protection?
4. How or in what are the grasshopper and the katydid alike? How are they unlike?
5. What are the functions of plant stems?
6. How would you teach these functions to a class of children considering them for the first time?
7. How does a corn stalk differ from a maple in its manner of growth? In venation?
8. What is the function of bark on stems?
9. What is the chief object in the life of a plant?
10. What animals are the most active agents in seed distribution?
11. Of what does clay consist? Name common varieties?
12. What is meant by plant nutrition?
13. What causes different species or varieties?

14. Discuss the importance of oxygen to plant life?

15. Why does packing of the soil about roots of plants cause the plants to suffer?

16. What chemical conditions injure growing plants?

17. Of what importance is magnesium to plant life?

18. In what particular is calcium important?

19. Which elements are the source of food in growing cells?

20. How is lack of nitrogen usually manifested in plants?

Nature-Science and Agriculture.

[THIRD PAPER.]

"I pity the man who can travel from Dan to Beersheba and say ''Tis all barren'; and so it is; and so is all the world to him who will not cultivate the fruit it offers."—Sterne.

THIRD LESSON.

Plant Study.

It will be well to begin this study with a kind of anatomical study of familiar plants as types of plant life. Note first the variety in form and size and make distinctions, as, **trees, shrubs** and **herbs.** Call attention to the almost universal green coloring and explain the importance of this color. As examples of plants which are not so colored, refer to mushrooms and lichens. The latter may be found in abundance on the trunks of trees, or on walls, etc. Interest may be varied and intensified by exhibiting also a few microscopical specimens of plants. Taking any familiar tree, studying its parts, as roots, stem (trunk), branches and leaves. The principal study of the roots at this time should be a comparison with the stem, showing their similarity—sometimes, notably, in the case of the chestnut tree, etc., when a portion of the root is uncovered for a considerable time, it appears very much like the stem, and even sends shoots or branches bearing buds, into the air. Consider types of roots, as soil, water, air, clinging and **prop** roots. Call attention, also, to different kinds of stems, as subterranean, procumbent, floating, climbing, erect, etc. Study the three distinct parts, **pith, wood** and **bark,** in a cross section of the trunk. Notice that the pith does not increase in area of cross section as the tree grows older. Notice, too, the difference in color, smoothness and thickness of the bark, by comparing a young tree with an old one, and observe that the growth of new wood is between the old wood and the bark. Thus it can be seen that the growth is from the outside. The older wood is the "heart wood," the newer growth the "sap wood."

Compare the relations of the branches to the trunk, in the pine, fir, etc., and apply the terms, **excurrent** and **deliquescent.**

Consider next the leaves in their relation to the branch, as to whether they are petiolate (having a stem) or sessile (without a stem).

Call attention to the importance of the blade of the leaf and notice the arrangement of the leaves on the stem, as opposite, alternate, etc. Other interesting studies will be in comparing leaves as to their venation, their surfaces, their classification into simple, compound, etc., their margins, their outlines, bases, apexes, etc.

Observe that new branches are formed always in the angle between the leaf and the branch or stem on which it grows. Some of these branches, usually shorter than others, end in a flower bud.

Study the parts of a flower; the **calyx,** with its separate leaves called **sepals,** the **corolla,** whose leaves are called **petals;** the **stamens,** composed each of a **filament** and an **anther** (the latter producing the **pollen,** or flower dust, whose use should be explained); the **pistils,** whose stalks are called

styles and the ball at the base an **ovary** which will grow or develop and form the **fruit** when the other parts of the flower have fallen away or have disappeared. From a variety of specimens it should be shown that some are **incomplete,** that is, they have not all the parts just named, and that those are **perfect** flowers, so far as fructification is concerned, which have both stamens and pistils. It should be explained, or discovered, that some flowering plants do not produce fruit because they do not bear both these essential organs. Willows, hemp, chestnuts, hops, etc., may be studied as examples of this class, and the discovery made that plants bearing these organs, each on a different plant, must grow near each other in order that there may be fruit. Sometimes, as in the case of a certain weeping willow, new plants must be produced from slips or cuttings, since only one kind, that bearing pistils, has been imported to this country. Distinctions should be made also as to the length of life of different plants; as, annuals, biennials and perennials and the pupils should be led to name examples of each. Note that some plants are perennial, as to the root, but annual as to the stem.

Do not close this study until there is a clear idea of the parts of a plant and their functions as well as ability to give a good definition of all the parts and terms discussed. The relation that flower, fruit, seed, root, stem, leaf and bud bear to each other should be shown, as adapted to the ability of the learner. Also the different organs in which plant food may be stored should be discussed, together with the sources of plant food.

There is an abundant opportunity, too, to distinguish the organic and the inorganic in these studies and researches, and the relations of the different groups of natural objects to one another may be discussed. Sketching or drawing should not be omitted as it serves an important purpose in bringing out the characteristic features, as the pupil sees them, of organs, structure, etc., under investigation; but avoid going too much into detail and make no attempt to be "artistic" in this respect.

ANIMALS.

Frogs, Toads and Salamanders.—Examples of as many kinds of frogs and toads as possible should be compared as to size, color and markings, habits, etc. Their notes, manner of feeding, season of spawning, etc., should be observed. Observe also their eggs and compare them. Note that frogs have teeth in the lower jaw, while toads have none. It may also be learned that none of them are venomous and that nearly all are valuable insect destroyers and for that reason they should be protected, not abused and despised. Distinction should also be made between salamanders and lizards. The former have a smooth skin while the latter are always covered with horny scales, There are no common lizards in the northern portion of the United States. Examples of these, as the "horned toad" and the chameleon are frequently brought from Texas and other southern states as curiosities. Salamanders belong with frogs and toads in the class known as Batrachia. Mud puppies resemble salamanders in shape. They live altogether in water and have external gills. Salamanders have no external gills when full grown.

Turtles also afford interesting study as to habits of feeding, etc. Their nests, containing eggs often in great numbers, may be found hidden in the sand in the banks of streams or ponds. The actions of the newly hatched young will be observed also with great interest. It will be observed that most turtles are aquatic or semi-aquatic.

Studies in Physics.—Compare natural objects as to their common properties, as, impenetrability, dvisibility, compressibility and expansibility, etc. Experiments may be made showing that the several objects compared possess these properties although in different degrees.

The Three States of Matter:—Solid, liquid and **gaseous,** may be represented easily and definite ideas concerning them may be shown.

Experiment.—Plunge an inverted tumbler into a vessel of water and note that the surface of the water in the tumbler is lower than that of the water in the larger vessel. Burn a small piece of paper in the tumbler and while it is warm invert and plunge it quickly again partially into the vessel. Notice that the surface of the water in the tumbler is now higher than that in the larger vessel. What does this prove about the air? Show the change of a liquid into gaseous form by the two processess, ebullition (boiling), and by evaporation. The experiments may be carried further and the process of distillation shown by simple means.

The expansion and compression of liquids and solids by the application of heat or cold, or by the observation of natural phenomena, etc. It may be shown that solids increase in volume by being reduced to the liquid form, and that a still greater increase in volume results from sufficient addition of heat or reduction of pressure to bring it to a gaseous condition. The notable exception to this general rule should be shown in the case of freezing water or melting ice. Illustrations or observations showing the importance, and the utility of the great force developed in this way should be insisted upon. The principle of the expansion of the solids by heat and their contraction by cold can be understood readily by the observant minds and its importance, in the utility of nature and in the mechanical world should be suggested by proper means; as, in the bursting of vessels when water is frozen in them, or the breaking or splitting of rocks by the same process, (proving the exception spoken of above); in the space left between the ends of the rails in constructing railway tracks; in the illustration of the principle in "setting" wagon tires, etc.

A portion of this study may be spent in discussing **Temperature**, what it is; in learning that **heat** and **cold** are relative terms; that cooling an object consists not in adding cold, but in taking away heat; that we speak of an object as being very **warm** when its temperature is higher than that of our body, and **cold** when its temperature is lower; but in either case we cannot accurately determine the degree, hence, the body, or rather the sense of "feeling" or touch is not always a reliable guide in determining temperatures of objects and for this reason instruments called thermometers (from the two Greek words, **thermos,** heat, and **metron,** measure), are used; these instruments should be studied and the fact determined that they are constructed upon the principle of expansion and contraction; discover why liquids are used for this purpose generally instead of solids. The graduation of the thermometer will also make an interesting study if desired at this time.

Studies in Chemistry.—The first effort in this study should be directed toward an understanding of the difference between physical and chemical phenomena. It should be clearly shown and understood that in any chemical change a complete change in the nature of the body is made, i. e., the object loses itself in giving rise to other bodies; in a physical change the body does not lose its nature, although it may appear in another form, as changed from solid to liquid, or from liquid to gaseous, or it may be mixed with other substances.

Simple bodies, or **elements,** that is, bodies that cannot be decomposed, of which there are about seventy, including the metals, should be distinguished from **compound bodies,** or those composed of two or more simple bodies. The different kinds of matter of which a substance is made are called its **constituents.** All the natural compounds are made out of the seventy elements or simple bodies. These rarely occur as pure compounds, for two or more substances are mingled so completely that they seem to be but one, although each posesses all its properties unchanged. For example, in syrup of sugar the water and sugar are mixed without change of properties. It is the same with water and salt as in brine. Such are called mixtures, purely physical phenomena. Use other illustrations. All substances are either simple compounds or mixtures.

The work of chemistry is to decompose compound bodies, called analysis, or to combine simple elements and thus form compound bodies, which process is called **synthesis.**

It will be observed by every chemical action it is a source of heat or cold; a change in temperature accompanies every change in the nature of a substance.

Experiments.—1. Place a piece of chalk in a glass of strong vinegar, or, better in dilute sulphuric acid. Note that a quantity of gas will escape from the chalk and rise to the surface. Does it not show that the gas was combined with something else in the chalk?

2. Mix some powdered sulphur, "flowers of sulphur", with some very fine iron filings. The **mixture** can be easily separated, the sulphur from the filings, since it is lighter, and there is no combination of the two substances. Now mix with warm water and soon the mass will grow larger and hotter and become somewhat blackish in color. The two substances are now combined

and have formed a new substance called sulphide of iron. This is a good opportunity to call attention to the fact that in its native state sulphur is found mixed with earthy impurities from which it must be separated. This is affected by evaporization, as sulphur vaporizes more readily than the substances with which it is mixed, and the vapor on being cooled in sulphur and is practically pure.

Sulphur is also found combined with metals in the rocks and soils. These compounds are called **sulphides.** Example, sulphide of iron, or **iron pyrites**, known also as "fool's gold."

Many experiments could be suggested illustrative of mixtures and of combinations to stimulate the powers of observation. It should be kept in mind that love of observation should lead to that which is of more importance, love of explanation. Enough has been said to suggest that **experiment** is the key to a real knowledge of nature.

Studies in Geology.—Distinguish between **Calcareous** and **Silicious** rocks. **Calcareous** is from the Latin **Calx.** Lime, chalk, limestone and marble are examples of calcareous rocks, since by the action of heat they become lime; they are also affected by acids, dissolving and giving off gas by their action.

Silicious rocks are such as are not affected by acids, as clay, flint, slate, etc. These resist the action of heat.

Minerals are frequently seen in crystalline form. These crystals are either calcareous or silicious. The former are comparatively soft and are of little value. Quartz and precious stones, such as rubies, sapphires, etc., are much more valuable. Diamonds are crystallized carbon, not stones. Granite is composed of three different minerals—quartz, mica and feldspar.

Quartz is the mineral composing flint rock, and is the hardest of all the common minerals. A bowlder composed entirely of quartz is called a quartzite. There are many quartzites. One composed of distinct grains, as white and gray, is called a **granular quartzite.** One having the grains almost completely melted together is a **vitreous quartzite.** One containing pebbles is a **conglomerate.** One having some of its pebbles red is a **jaspery conglomerate.** Quartzites are exceedingly abundant and grains of quartz are found in many other rocks than quartzites. In fact, quartz is the most abundant of all minerals.

Mica is a rock with shining scale-like mineral fragments. It splits into leaves of indefinite thinness. The leaves of one species are transparent; of another black; another varies from dark brown or smoky to transparent.

Feldspar is a mineral not so hard as quartz; and, also, when compared with quartz, it presents a more regular surface, which casts a comparatively unbroken reflection, and in other ways, by study and comparison they may be distinguished. Feldspar is not always white or cream-colored; very frequently it is pink-tinted; often almost red. All these three different minerals are found in the granite bowlder. There are several varieties of granite, according to the species of mica; according to the colors of the quartz and feldspar; according to coarseness of the constituents; according to the relative portions of the three ingredients. If, however, the minerals are not uniformly mixed; if they are ranged in courses, the rock is stratified, and it is not a proper granite, though often called granite. Properly it is a **gneiss** (nice). If the mica is almost or completely wanting in a granite-like rock, it is **granulite.** When a gneiss-like rock contains very little feldspar, it is called **Mica schist** (shist).

If a bowlder contains quartz and feldspar with **horneblende** (a dark mineral, nearly black, or greenish black, or dark green, not scaly) instead of mica, it is not granite but **Syenite.** The "Quincy granite," near Boston, is a syenite.

Studies in Astronomy.—The following topics are presented:

1. The **Horizon.** (a) The visible or sensible horizon; (b) The real horizon. Show that each observer has his own horizon, but that the **real** horizon is the line in which the plane passing through the center of the earth parallel with its visible horizon meets the sky. The distance between the visible and the real or astronomical horizon is too small to be perceived on a surface so far away as the apparent surface of the sky.

2. **The Sky.**—Note that the observer is always at the center of that which is called the sky. What does the sky seem to be? What bodies seem to move on its surface?

3. Learn concretely the meaning of **sphere,**

circle, axis, point. Then try to conceive these in the abstract.

4. Deduce several facts proving that the earth is spherical in form.

5. Size and motions of the earth.

Agriculture.

[THIRD PAPER.]

WHEAT.

The early home of the wheat was in Central Asia and by the Mediterranean Sea. It has been claimed that the Chinese cultivated wheat 2700 B. C. The Egyptians attributed its origin to Isis; the Greeks to Ceres. The early lake dwellers cultivated it in Switzerland, the people of Hungary used it in the Stone Age, and a grain of wheat has been found in an Egyptian pyramid which dated 3359 B. C.

Wheat belongs to the family of grasses. It is an annual plant, with hollow, erect, knotted stems, and produces, in addition to the development from the seeding plant, secondary roots and secondary shoots (tillers) from the base.

Varieties of Wheat.

The classification usually adopted is based, in the first instance, on the nature of the ear; when mature its axis or stem remains unbroken, as in the true wheats, or it breaks into a number of joints as in the spelt wheats.

1. True wheats.
    1. Soft wheats.

The chaff scales are boat-shaped, ovoid, and more or less of the consistence of parchment. The seed is opaque, white and easily broken.

2. Turgid wheats.

The glumes have long aures; the seed is turgid and floury.

3. Hard wheats.

The outer glumes are keeled, sharply pointed; the seed is elongated and of a hard, glassy texture and difficult to break, owing to its toughness. The seeds are richer in nitrogen than those of the soft wheats.

4. Polish wheats.

Rarely, if ever, cultivated in this country. Large, lanceolate glumes and elongated glassy seeds.

Further subdivisions are also made depending upon the presence or absence of aures, bearded or beardless wheat,—the color and texture of the ears, etc.

2. Spelt wheats.

The distinctions of this variety lie in:

1. The presence of aures.
2. The direction of the joints of the glumes.
    1. Straight.
    2. Bent outwards.
    3. Turned inwards.
3. The form of the ear as shown on cross section.
4. The axis or stem breaks into a number of joints.

The division into a spring and winter wheat is an agricultured one solely. Any variety may be a spring or a winter wheat depending on the time at which it is sown.

GENERAL STRUCTURE OF THE WHEAT PLANT.

1. Stalk.
    1. Grows to a height of from three to four feet.
    2. It contains much woody fibre, being largely composed of silex, a hard flint like material.
2. Leaves.

    Each have a long sheath encircling the stem, and at the junction of the blade or "flag" with the sheath a small whitish outgrowth of "ligula."
3. The ear.

    Sometimes called the inflorescence consists of a central stalk or zigzag forming a series of notches, and bearing a number of flattened spikelets, one of which grows out of each notch and has its inner or upper face pressed up against it.

    At the base of each spikelet are two empty boat shaped glumes or "chaff scales," and then a series of flowers, two to eight in number. Each flower consists of an outer or lower glume, called the flowering glume, which terminates in a long or short awn or "beard."
4. The seed.
    1. Oblong or ovoid in shape, with a longitudinal furrow on one side.

2. Closely surrounded by chaff or scales.
3. Microscopical examination of a longitudinal section.
   1. The outer layer consists of epidermal cells, of which the uppermost are prolonged into short hairs to cover the apex of the grain.
   2. Two or three layers of cells inside the epidermis constitute the tissue of the ovary, and overlie somewhat similar layers which form the coats of the seed.
   3. Within these cells is a layer of square cells which contain the gluten or nitrogenous matter upon which the nutritive value of the seed depends. This thin layer of gluten cells contain the albumen or perisperm, composed of numerous cells containing starch granules.

The season for wheat sowing depends upon conditions in different parts of the country, and somewhat upon the kind or variety to be propagated. Varieties of winter wheat are sown in the fall, usually the latter part of September or during the month of October, as they require a sufficient time to become firmly rooted before the soil is frozen.

Spring wheat is sown as early as possible after the frost is out of the ground in the springtime. For this reason the ground is plowed in the fall, usually, and then made fine and loose by means of discs or harrows.

The harvest time for wheat varies from May, in Texas to August in Manitoba and Quebec, Canada. That of California, Oregon, Alabama, Kansas, and most other states, is June; of Minnesota and Nebraska, July: Sweden, Norway and Holland harvest their crops in September; Northern Russia and Siberia, in October; Peru and Southern Africa, in November; New Zealand and Chile, in December; Australia and Argentine, in January; India, in February; Upper Egypt, in March; Lower Egypt, Mexico, Turkey, Persia and Asia Minor, in April.

It is generally conceded that the value of wheat for milling and bread-making purposes, depends more largely upon its nitrogen contents than upon any other. While starch is the most abundant constituent of wheat and offers the largest amount of nutritive food, the protein, representing the principal part of the nitrogenous bodies, is the substance which gives the wheat its characteristic properties for bread-making, for in it are found those constituents, together known as gluten, which give wheat flour its superiority for bread-making purposes.

The length of the period of growth is one of the principal influences affecting the composition of the wheat grain. There seems to be a marked relation between the content of protein matter and starch and the length of the growing season. The shorter the period of the growth and the cooler the climate the larger the content of protein and the smaller the content of starch, and vice versa. For this reason, the spring wheat should be cultivated in regions where it is possible.

In southern countries the intense heat, also, affects the composition of the grain when it occurs, as it is apt to do, about the time of ripening, and so hastening the ripening process. The result is a lowering in the production of starch.

The amount of seed wheat that should be used per acre depends somewhat upon the manner of sowing as well as the time. This amount is usually about two bushels per acre for the sowing made late in September or early in October and by increasing this quantity at the rate of half a peck per week until three bushels are reached, which may be held as the maximum. These are the quantities to be used in broad-cast sowing; when drilling is resorted to, two-fifths less seed will suffice.

Soil Requirements.

In order to yield a crop of thirty bushels of wheat to the acre, the amount of the demands made upon the soil may be approximately expressed as follows:

Nitrogen	134 lbs.
Phosphoric acid	54 lbs.
Lime	36 lbs.
Magnesia	17 lbs.
Potash	170 lbs.

Use of Wheat.

1. Flour.

2. Straw plaiting and braiding—hats, mats and baskets.

3. Manufacture of paper.

4. Macaroni.

A preparation of wheat, originally peculiar to

Italy, in which country it is an article of food of national importance. The same substance in different forms known as vermicelli, paste, etc. These substances are prepared from the hard, semi-translucent varieties, these wheats being not only much richer in gluten and other nitrogenous compounds, but their preparations are more easily preserved, to which conditions their suitability for the manufacture of these preparations is due. Macaroni and other forms are prepared in a uniform manner from a granular meal or hard wheat, which is thoroughly mixed and made into a stiff dough with boiling water. While in the hot condition it is placed in a strong metallic cylinder, the end of which is closed with a thick disk, pierced with openings which correspond with the diameter of the article to be made. By means of an accurately fitting plunger which is introduced into this cylinder powerful pressure causes the stiff dough to squeeze out through the openings in the disk in continuous threads or sticks as required. Macaroni is dried rapidly by hanging it in long sticks or tubes over wooden rods in stoves or heated apartments through which currents of air are driven. True macaroni has a soft yellowish color, is rough in texture, hard and breaks with a smooth glassy fracture. On boiling it swells up to double its original size, without becoming pasty or adhesive, always maintaining its original tubular form.

Experiments with macaroni wheats in this country have been made recently by the Department of Agriculture and it has been found that they are well adapted to a wide extent of territory in the West and Northwest. In some instances they have yielded from one-third to one-half more per acre than any other wheats grown side by side with them, and a good yield with grain of excellent quality, has been produced when other varieties have failed. They have also been successfully grown in Kansas and Nebraska.

The demand for carload lots of macaroni wheat for seed, as well as for milling, is on the increase, and the factories in this country are awakening to the importance of their use instead of the ordinary bread wheats.

The seed-bed for wheat is best when one or two inches of the surface soil is fine and loose with the soil immediately below it fine and compact. This condition is secured by plowing some time before seeding. Following with the harrows, then with the roller. After a week or two the soil should be surface-tilled with disc or heavy, sharp-toothed harrow. In this way, the manure, which should have been spread upon the freshly plowed soil, will be divided and covered, the soil will be compacted, and the last cultivation will pulverize and loosen the surface. This preparation causes the roots of the young plant to spread horizontally near the surface so that they may adapt themselves to the alternate rising and falling of the soil as it freezes and thaws so that they are not seriously injured. As the roots grow during the warm summer months they naturally penetrate to the firmer, more compact soil for the moisture they cannot obtain nearer the surface.

RYE.

It is claimed that rye is a native of the Island of Crete in the Mediterranean Sea. It is also said to be growing wild in the regions near the Caspian Sea and in certain regions of Crimea.

1. Stem. Tall, slender, smooth and somewhat branched at the bottom. When fully matured the stem is very rich in silica.

2. Leaves. Narrow, ribbon-like and bluish green in color.

3. Spikes. Erect, terminal and solitary. three to four inches in length.

4. Kernel. When ripe the grain is of an elongated oval form, with a few hairs at the summit. It is smaller and less nutritious than that of wheat.

BARLEY.

The early home of barley was in Western Asia. It was cultivated in Syria over three thousand years ago.

1. The Stalk. Varies in length in different localities. When fully matured the stem becomes yellow in color and the head droops.

2. Seed. Is not quite as large as that of wheat. Has a fine brush which is rough. The aures are long.

Barley is the most hardy of all cereal grains, its limits of cultivation extending further north than any other; at the same time it can be cultivated in subtropical countries.

The following is the composition of barley meal:

Water	15 per cent
Nitrogenous compounds	12.98 per cent
Gum	6.74 per cent
Sugar	3.2 per cent
Starch	59.95 per cent
Fat	2.17 per cent

OATS.

1. Stem. From two to three feet in height. It turns yellow when the seed is ripe.

2. Flowers. Are arranged in loose panicles, and are thus unlike the spikes of barley, wheat and rye.

3. Seeds. Smooth, with single bent aures. The calyx is two-seeded. The branches of the panicle are erect when green, but droop when the seeds ripen.

Smut in Oats.—The presence of smut in the oat crop can easily be detected by observing the blackened, imperfect heads where perfect heads of oats should be found. Two distinct smuts have been described:

1. Loose smut.
2. Closed or covered smut.

In the loose variety the smutted head is of a dusky olive brown color and is easily blown off the stalk by the wind, leaving the stalk bare. The closed variety is of a blackish brown color, is covered by the hull of the original oat kernel, and consequently in many cases the heads of smut are not noticed.

These two varieties of smutted heads are made up of spores or seeds of a fungus plant which grow inside the oat plant. The growth of this fungous plant, which consists of a colorless thread-like structure, is as rapid as the growth of the oat plant. As the oat plant develops and heads out, branches of this invisible smut are sent out into the kernels of oats. These branches develop seeds of the smut plant where the kernels of the oats should be produced.

This fungous disease may be transmitted from crop to crop through the seed oats, but it has been found by experiment that heating the seed oats to about 140 degrees F. the life of the smut seed in the oat kernel will be destroyed while the vitality of the oat kernel will not be affected. This heating and the consequent destruction of the smut seed is done practically by dipping the seed oats in hot water just before sowing.

LEGUMINOUS FORAGE PLANTS.

1. **Cow Pea.**—The cow pea is a plant of warm weather and long season, so that with some exceptions the varieties do not produce seed, or at least cannot be depended upon to produce seed north of the Ohio river. The crop is grown and seed produced in almost every Southern state and upon most every farm.

Cowpeas are allowed to become well ripened before harvesting, which is usually done with a mower. The vines are piled in small piles and frequently turned until dry. Thrashing is best done with a bean thrasher, though in some places the flail is resorted to or the peas are tramped out by horses on the barn floor.

2. **Soy Bean.**—The soy bean has a more northern and western range than the cow pea. The pods grow close to the ground and the ordinary harvesting machine cannot be successfully used. For small areas a "knife cutter" is used; for large areas special harvesting machines are recommended. Care is needed in keeping the seed; it should be stored in loose woven bags, which are only partially filled and kept dry. If put in close bags or in deep bins in large quantities the seed may heat enough to injure its vitality.

Canada Field Pea.—The Canada field pea is grown in the Northern states and in Canada. This is a genuine pea, while the cow pea is not.

There are many varieties of beans and peas, and notwithstanding the fact that they differ to some extent, yet they are very similar in their nature and growth. The most prominent characteristic of the order to which the pea and bean belong is the seed pod. In reality the pod is a transformed leaf; in other words, when a pod is broken open, laid out flat, and the seeds removed, its resemblance to a leaf is especially noticeable. The long, tough fiber situated along the back of the pod corresponds to the central vein of a leaf; the line along the front of a pod is the union of the two edges. The fibers of the pod are called "strings."

Beans and peas may be considered good examples of the two cotyledonous plants, i. e., the seeds are in two parts, and in the process of germination these two halves rise above the ground to aid in the capacity of both leaf and store house of supply, till the plants have enough roots and leaves to make a living for themselves. Observation will show that as soon as the two halves of the seed reach the light and air they turn green, which means that they are endowed with chlorophyll and can manufacture protoplasm as well as supply it ready-made. As soon as the true leaves are developed the cotyledons are absolved.

Beans and peas require but from six to ten weeks for growth and maturity, consequently they are planted from early spring till the middle of summer. Root and stalks die as soon as the seeds are developed.

The seeds of both peas and beans need but a thin covering of soil for germination, springing up in a day or two when planted in moist, warm soil. Decay results when covered too deeply.

Clover, cow peas, soy beans, etc., are grown not only for forage, but principally as leguminous crops to restore nitrogen to the soil.

HEMP.

The original home of the hemp plant was doubtless in some part of Asia. The hemp plant is dioecious, that is the male and female, flowers are borne on separate plants. The male plant is smaller than the female, and ripens and dies earlier in the summer. In addition to these distinguishing features the foliage of the female plant is darker and more luxuriant than that of the male.

The leaves of the hemp plant consist of from five to seven leaflets, the form of which is lanceolate-acuminate. The margins are sharply serrated. The height of the plant varies according to the season, soil, etc., the average being from eight to ten feet.

Hemp is grown for three products.

1. The fiber of its stem.

2. The resinous secretion developed upon its leaves and flowering heads, especially in hot countries.

3. Its oily seeds.

Hemp fiber is long, soft and very strong, being especially adapted for use where strength is required. It is used in the manufacture of fine twines, carpet thread, sail cloth and different grades of woolen goods. The tow is used for thread and for yarns to be woven into carpets, linen goods, etc., and the refuse fiber combined from the two is used as oakum for calking ships.

The ripe seeds contain about 34 per cent of oil and 16 per cent of albuminoids. The seeds are about one-eighth of an inch in length and of a dark gray color.

They are much used as a food for singing birds.

Hemp as a drug or intoxicant for smoking and chewing occurs in the forms of bhang, ganjah and charas.

An ideal hemp soil must be rich in fertilizing elements, especially nitrogen and potassium; it must be deep and sufficiently loose in texture to permit the development of the root system and also to allow good drainage. But few farm crops require so much water about its roots. The time of harvesting varies from eighty to one hundred and forty days from the date of seeding, the rate of growth depending upon the variety, moisture, condition of the soil and temperature. If cut too early the fiber will be fine, but lacking in strength; if allowed to become too mature the fiber will be coarse, harsh and brittle.

After the hemp is cut it is allowed to lie on the ground from four to eight days to dry. When dry the hemp is usually bound in small bundles and set up in shocks. In stacks, properly built, the hemp will remain uninjured for a period of from two to three years, in fact it is claimed that the quality of the fiber is improved.

"Ratting" is the process in which the vegetable gums surrounding the fiber are dissolved and the fiber is at the same time freed somewhat from the woody interior portion of the stalk and also from the thin outer cuticle. These gums are not soluble in water, but they are dissolved by a kind of putrefaction which takes place when the stalks are immersed for some time in soft water or are exposed to the weather.

Breaking is the process by which the fiber is separated from the stalks and roughly cleaned. It prepares the fiber for market as rough hemp. The name has also been extended to various fibers resembling the true hemp, as, the Sisal Hemp of Mexico and Yucatan, whose product is well known in this country, especially in the form of twine for harvesting machines, as is also that of Manila Hemp.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

(THIRD PAPER.)

1. What is the difference between a tree and a shrub?

2. What is the importance of the green coloring in the foliage of plants?

3. What three distinct parts of the stem are shown in a cross section?

4. What difference in the relation of the branches to the trunk, comparing a pine tree with an oak?

5. What is the stem of a leaf called? That of a flower bud?

6. Where are new branches of a tree formed?

7. When is a flower complete? Perfect?

8. What is the distinguishing feature between the eggs of a frog and those of a toad?

9. What do frogs eat? Toads? Salamanders?

10. What are the "three states of matter?" Do you know any substance that cannot exist in all three states?

11. What is the difference between a physical and chemical change?

12. Of what is granite composed? Limestone?

13. Where did wheat originate?

14. Why is wheat classed with the grasses?

15. Upon what does the value of wheat for milling purposes depend?

16. What are the soil requirements for wheat?

17. Where is the native home of rye? Of barley?

18. What is smut in oats?

19. In what way are leguminous crops of primary importance?

20. What are the products of the hemp plant?

Nature-Science and Agriculture.

[FOURTH PAPER.]

"It is only through the morning gate of the beautiful that you can penetrate into the realms of knowledge; that which we feel here as beauty, we shall one day know as truth."—Schiller.

FOURTH LESSON.

Plant Studies.—Topic for special study.

Evergreens.—Notice the peculiar structure of the wood, without ducts, with aromatic, resinous juice; the awl-shaped or needle-shaped leaves; the flowers destitute of floral envelopes; the catkin-like spikes of the staminate flowers and the ovule-bearing scales of the pistillate ones, arranged in spikes, which finally ripen into cones. Different varieties should be studied, including pines, spruces, firs, larch, cypress, cedar and even the hemlock, and their characteristics and differences noted. Study and germinate the seeds.

Air Plants.—These are so called because they receive their entire sustenance from the air, having no connection with the soil.

The most of these are small and not readily noticed, although they grow in profusion. Examples of the most familiar ones are the lichens and mosses growing in great abundance on rocks, decaying walls, fences and the trunks and branches of trees. But there are large flowering plants which live in the same way, growing only where is abundance of warmth and moisture. Among these are large handsome flowers belonging to the Orchis family.

Parasitic Plants.—These plants not only grow upon other plants, the **hosts,** but they feed upon their juices by striking their roots, or **haustoria** (from Latin, **haurire,** to drink), into them. Moulds and blights are only the lowest forms of the plants that live in this way. Some of the false fox-gloves, the painted cup and some species of bastard toadflox, are partially parasitic on the roots of other plants; that is, they absorb the soil-water from the roots of the host, but they are not wholly parasitic, since they have chlorophyll in their leaves, and hence do their own starch-making. The mistletoe is a half-parasite, whose seed germinates on the boughs of trees. The haustoria become imbedded in the bark and engrafted into the growing wood until the mistletoe is as firmly united to the host as a natural branch.

The wholly parasitic plants are absolutely dependent upon other plants, as they are destitute of the power of assimilation. The cancer-root is a root parasite of this class, as are also the beech drops and the pine-sap. The dodder is a common parasitic herb. One species, the flax-dodder, can live on only one kind of host.

Wheat rust, so common on wheat and other grains, and even on grasses, is an excellent and interesting example of parasitic fungi. There are three kinds of spores in wheat rust. The first is the **cluster-cup** stage, and in this stage the spores are carried by the wind, usually from some other plant, as the barberry, and deposited upon the wheat. They germinate here and soon produce the **red rust.** The black spores of the **black rust** are soon developed upon the stem or the sheath. These different kind of spores may be examined with a magnifying glass and their number, position, form, size, color, etc., determined.

A lichen is known to be a combination of two plants. The green cells belong to a species distinct in itself, and the remainder, which is the larger portion of the growth, is a fungus parasitic upon it. The relation seems to be of mutual benefit, both having a vigorous growth. "Reindeer moss" and "Iceland moss" are lichens.

Leaves.—Study the many forms under which leaves exist, namely, as **scales,** where they are small and thin, as in quick-grass, or large and thick, as in all bulbs; as **seed-leaves,** or **cotyledons;** as in **bud-scales.** These may be considered as special forms of leaves in comparison with what we call leaves in the foliage of a plant. A careful examination of these forms should be made in order to determine why they shall be considered leaves.

Leaves also appear as spines in several plants, as in the barberry. By careful examination in summer nearly every gradation between ordinary leaves with sharp, bristly teeth and leaves which are reduced to a branching spine may be seen on a single shoot.

In some plants, too, as the pea, the upper part of each leaf becomes a tendril for the climbing plant.

There are other interesting forms of leaves which may be discovered by close observation; they may also be discovered, in some instances.

to serve a double purpose; that is, they serve as foliage, to prepare nourishment, and also to perform some special office or use, as that of a tendril, or to store nourishment, etc.

In winter, buds of hickory, buckeye, elm, catalpa, etc., may be studied carefully by dissections and drawings. These should be contrasted and interpreted by comparison with development of leaf buds of early spring.

Weeds.—Make a special study of what are commonly called weeds—"plants out of place"; plants that persist in growing where they are not desired; their insistency, their tenacity, their multiplicity, their great power to effect distribution in a variety of ways, and their ability to crowd out more desirable plants.

At the time of ripening there should be a collection of the worst seeds of the neighborhood. Later these may be planted in flower pots or earthen vessels and their vitality tested; care should be taken to note differences in amounts of heat and moisture, etc.

Another interesting experiment may be arranged by having pupils fill vessels with soil from different localities or sources, as, from different levels in fresh excavation; from some spots known to have been kept free from weeds for several years; from a corner of the cellar under an old house, etc. Keep these in a warm place, not permitting the soil to dry out, and watch the different plants as the seeds germinate and develop. How did the seeds get into the soil? How long have they remained there? Why are weeds said to be the farmer's friends? Why do state legislatures make weed laws? (In other words, why may not a farmer or a gardener permit certain weeds to grow?)

Algae (plural of **Alga**, from the Latin, seaweed). These are mostly aquatic, and are most familiar as seaweeds and green-pond slimes. The velvety growths or the incrustations on the glass of aquaria are also examples. One of the plants, Spirogyra, commonly known as pond-scum or "frog-spit," is found in ponds, springs and even in clear streams.

Algæ have been classified according to color: (1) The blue greens, slimy patches on damp wood or stones, or in shallow fresh water; (2) the green algæ, found chiefly in fresh water; (3) brown algæ, such as kelps and rockweeds, chiefly marine; (4) red algæ, the seaweeds or sea-mosses, also mostly marine. There are altogether nearly 1,500 species.

Float a little spirogyra, pond-scum, in a white plate, on water just sufficient to cover the bottom of the vessel. By the aid of the microscope observe the green color of the threads and their length compared with their thickness. Notice whether the filaments are about equal in diameter. If the power of the microscope is sufficient, study their structure; discover the shape of the cells; count the bands of chlorophyll as the number of bands characterizes the species.

Place some fresh pieces of water weed (Elodæ, common in ponds) under a funnel in a deep glass jar or other vessel filled with spring water or water from the brook. Invert over the end of the funnel a test-tube filled with water.

Bubbles of gas will be seen to rise in the tube. Test for oxygen. (The carbon dioxid used is in solution in the water.)

As an experiment to illustrate the importance of oxygen to the roots of a plant, select a thrifty plant, not aquatic, growing in a flower pot, and exclude all air from the roots by keeping the soil saturated with water, or by keeping the bottom of the plant standing deep in water. Note how the growth is checked and that the plant finally declines.

Black Mould.—This may be found abundant in decaying fruits, as apples, peaches, etc., or by putting portions of damp bread in a warm place for several days, taking care to keep them moist and warm until patches of mould make their appearance. Study them under a good microscope at different stages of growth, both in fruit and in the bread. The slender threads which form the network covering the bread surface are called **hyphae,** and the entire network the **mycelium.** Note the delicate threads rising at intervals from the mycelium which terminate in small globules. These globules are spore-cases, Compare spore cases in different specimens, as well as in the same specimen, and note the change of color as they approach maturity. This study may be continued by experimenting with the spores to observe the development of hyphæ, etc.

ANIMAL STUDIES.

Frogs.—Collect frogs' and toads' eggs and keep them in shallow vessels of water. The bottom of the vessel may best be covered with clean sand and gravel. A stone should also be placed in the vessel rising to the surface. Spirogyra and other water plants should be put into the water. The plants not only keep the water supplied with oxygen, but they also furnish food for the tadpoles. Bread and small bits of meat may be added for food, but the uneaten portions should be removed before they make the water impure. Watch the tadpoles. Note how they breathe. Compare with fish. Study their development in every way. Notice that the eggs of toads lie in single rows, inclosed in transparent jelly. At first they are about the size of a small pin-head, black above and light on the lower surface. The whole mass, after contact with the water, becomes eight or ten times as large as the body of the mother toad. The number of eggs at a single laying, by actual count, has been found to be, in some instances, more than 10,000.

As the egg is sufficiently large to be observed without the aid of the microscope, the development may be observed readily. The egg becomes somewhat elongated, then the tadpoles hatch and begin feeding upon their gelatinous envelope. When this is gone they eat the slimes in the water, on the sides of the vessel, and on everything in the water. They grow quite rapidly; the hind legs appear then the fore legs, the tail is absorbed and the little toads come from the water upon the stone that has been placed for the purpose. The work the tadpoles do in the water as scavengers should be emphasized. In ponds their feeding habits may also be observed, and it will be seen that matter that would otherwise pollute the water is taken up by them. This will be a revelation to those who have believed water impure because of the presence of tadpoles. The value of toads in the extermination of insects, etc., should also be observed and emphasized.

Bees.—Study bees as types of a useful and important class of insects. They should be studied as individuals and by comparison. Note that the abdomen is thrown forward upon and intimately united with the thorax; the large head, large compound eyes and three ocelli. The mouth parts are well developed, both for biting and feeding on the sweets of plants, the ligula being especially developed for lapping nectar. Note also that the wings are adapted for powerful and long-sustained flights. The metamorphosis of each insect of this division of insects is most complete. Study the larvæ, observing size, shape and feeding. Compare cocoons of pupæ. Notice the division into three classes, males, females and workers, and the division of labor among them. The antennæ are short and filiform, the mandibles large, stout, toothed, and the maxillæ developed into three subdivisions. (1) the palpi, usually six-jointed, (2) the labial palpi, generally four-jointed, and (3) the prolongation of the ligula, which is highly developed, being furnished with a secondary pair of palpi, the paraglossæ, while in the pollen-gathering species the ligula is of great length. If possible observe the manner in which the bee gathers pollen, first collecting it with its mandibles, where it is gathered by the tarsi, from whence it is passed to the intermediate legs with many peculiar scrapings and twistings of the limbs, then similarly passed on and deposited, according to the nature of the bee, upon the posterior tibiæ and tarsi, or upon the under side of the abdomen.

The abdomen in the larva state consists of ten segments, but in the adult bees there are six complete segments in that of the females and seven in the males.

Bees secrete wax in thin, transparent, membranous plates on the under side of the abdominal segments. The honey is elaborated by an unknown chemical process from the food contained in what is known as the crop, from which it is regurgitated into the honey cells.

The nests of bees, as well as those of wasps, etc., should be collected with the young in various stages of growth, and in such numbers as to show their different stages of construction. The cells of honey bees are hexagonal in shape, except in the case of the queen cells, which are flask-shaped. The drone cells are one-fifth larger than the worker cells; honey cells are larger than brood cells.

Compare the honey bee with other insects, as hornet, wasp, bumble bee, house fly, etc., to discover points of resemblance as well as points of difference.

Follow a honey bee for a short time and note what it does, how many flowers it visits, the kinds of flowers and the flowers they seem to like best.

Study a hive of honey bees to discover if you can distinguish the three kinds in the hive, the workers, the queen and the drones.

Interesting experiments may be made as to the value of bees in cross-pollination, by covering a clump of buds of plants, or the branch of a fruit tree before the buds are open, and comparing the fruit with that produced by buds of a similar kind left uncovered. Note the activity of bees as compared with other insects in the matter of cross-pollination and their relative efficiency in this important work.

It will be a matter of interest to collect statistics of the yield of honey in a neighborhood or locality, and what influences affect the yield when there is a material difference in colonies.

Under ordinary condition honey bees collect all their honey within a radius of two miles, but they have been known to travel twice as far under peculiar circumstances to find flowers.

While the bee industry has grown to great proportions in this country, the honey bee is not native to America, having been imported from Europe. There are only a few races of bees that excel in those points that are desired by bee-keepers: 1. The black or brown or German bees, which have been here about 200 years and have become the common wild bees of the country. Their defects are principally their bad temper and their failure to resist attacks of the bee moth. 2. The Italian bees, whose principal defect is their failure to winter well in the colder parts of the country; otherwise they are deservedly popular. (3). The Carniolans, whose fault is excessive swarming. 4. The Cyprians, or Syrians, imported from Cyprus. These bees fill their cells so full of honey that it gives the honey a dead or "watery" appearance, which injures its sale.

It is interesting to know that in addition to honey bees it is estimated that there are some five thousand different kinds of bees. None of these have the perfection of organization or the stability in this respect that the honey bee has.

The Bumble bees are an interesting study, and are valuable because of their services in the fertilization of flowers, especially red clover. The queen having hibernated during the winter, collects honey and pollen in the early spring and, having selected a home, usually a deserted mouse nest, builds cells and deposits eggs in them, and feeds the young until the larvæ emerge. The first bees, which are small workers, then take the place of the queen in the labor of collecting honey and pollen and building cells. Broods that follow are large workers, who continue the work and increase the store of honey. Queens and drones hatch out usually in August, desert the nest and scatter over the fields. The workers and drones die later and the queens alone live through the winter to begin the same process the following spring.

There are also many species of wasps and hornets. Most of these burrow in the ground and make their nests there, feeding their young insects, spiders, etc., instead of pollen and honey. The common mud dauber (mud wasp) is easiest obtained for study. The most useful to orchardists and gardeners as an insect destroyer is the white-faced hornet. They are injurious, however, to grapes, peaches and even to pears, as they gnaw holes in the fruit which may lead to great injury to the crop. Like the bumble bee, the queen alone lives over winter. She begins alone to build her nest in the spring, making cells in which she lays eggs, then feeding the larvæ on finely chewed insects. As soon as the first brood emerge from the cells they begin to assist in the work of nest building and the bringing of food for the larvæ of the larger workers which follow them. A last brood of males and females are brought forth in the early fall, after which the workers and males die and the queens hibernate to begin all over the next spring.

Studies in Chemistry.—Prepare and examine the nature of the following gases: Oxygen, hydrogen, carbon dioxid, nitrogen.

Studies in Physics.—The lever classes and action of each. Different classes of machines.

Studies in Geology.—Collect specimens of rocks, clays, sand stones, shales, etc., of locality. Examine and test for limestone. Study structure, formation of clay beds, the work of pebbles.

Studies in Astronomy.—Note the changes from week to week of the time of the rising and the setting of the sun. The sun as the source of all heat on the earth. Phases of moon. Explain reflected light of moon.

AGRICULTURE.

Corn.

Indian Corn, or Maize, belongs to the family of grasses. Observation will show that the veins of the leaves run parallel and that the stalk is jointed like that of grass. Cross sections of the stalk will show it to be tubular, its different portions being readily demonstrated.

1. The outer body, or shell, is hard and tough, giving great strength to the stalk.

2. The inner portion is made up of a soft, pithy, cellular mass which, upon closer examination, is found to consist of parallel fibers running lengthwise from joint to joint.

The corn plant grows from six to fifteen feet in height, its color varies from a yellowish green to a dark green during the growing season, depending upon the character of the soil and the amount of moisture. When the period of the ripening of the grain begins, the color changes to yellow and brown, with sometimes a tinge of orange and red.

Closer inspection and the study of the plant as a whole will show:

1. One central shaft, there being no branches.

2. The leaves are arranged alternately on the stem and are attached to it directly, without any petioles.

The study of the leaf:

1. They are long and ribbon-like.

2. A heavy midrib extends through the center from the base to the tip.

3. The veins run parallel.

4. The leaves arch upward in a graceful curve, the inner part sloping downward to the shaft and the outer part sloping downward and away from it.

5. The attachment around the base is such as to give them a trough.

3. The blossom of the corn is divided into two parts—

a. The tassel is situated at the very top of the plant. It is the pollen-bearing or staminate part.

b. The second portion is the pollen receiving or pistillate part. It is situated lower down on the stalk. Sometimes there are two or three of the latter, but usually only one. They are called the **ears.**

4. Aerial roots, which appear just before the plant is full grown. They grow out in circles near the base of the stalk, and they brace the stalk of corn materially against the force of the wind.

5. The ripened ear—

1. The kernels of grains are arranged in rows.

2. The cob is a long, cylindrical, rough, woody core.

3. During the early stages of the ear the cob is green and soft, and connected with it are long white or green threads, commonly called silks, but which in reality are the pistils of the blossom.

4. These pistils receive the fallen pollen and carry it back to the points of attachment of the cob, at which place it produces the seeds or grain of the corn.

5. After the maturity of the grain the pistils or silks die and turn brown.

6. The whole ear of corn is covered completely by large, tightly-fitting leaves called the husk, which must be removed before grains can be shelled from the cob.

After the seeds or grains of corn have been placed in suitably prepared soil they germinate in a few days. But a single blade is sent up as all grasses do, the seed consisting of but one cotyledon. As the plant continues to grow it puts out leaves, first one side, then on the other, so that in the mature plant there are two rows of leaves up the stalk on opposite sides; these being arranged alternately on the stem, as has been said before.

The tassel and the ears appear last of all; and as soon as the grains in the ear are fully developed the whole plant dies.

Cultivation of Corn.

1. Preparation of the soil.

In the central states corn is usually planted in the months of May and June. The plowing and harrowing of the soil is usually done just before the time of planting. In speaking of this subject, an authority says: "Experience has proved that plowing the ground late in the fall helps to catch and retain water. The plowing leaves the ground loose, rough and open, so that winter snows and rains are caught and retained in the small cavities due to the plowing. It is often in a better condition, too, for early spring working than ground not plowed in the fall, and an early and successful crop can be started under more favorable conditions than would otherwise be possible. When it is dry enough to work, a good harrowing generally will reduce it to a smooth, mellow condition, giving it the power to retain the largest amount of heat and moisture."

2. Planting of the seed.

After suitable preparation of the soil the seed is planted in rows about four feet apart, the plants being from two to four feet apart in the row. It is planted with a hand planter or with corn drills drawn by horses which plant one or two rows at a time.

3. Relation and necessity of moisture.

But a small percentage of the weight of the dry plant is obtained from the soil through the roots. Immense quantities of water are taken up through the root system, but it does not enter into the composition of the plant. After passing through the plant it is given off to the atmosphere through minute pores or openings in the leaves of the plants. Just as in the human body the sweat pores open when a man becomes warm, perspiration collects on the skin, evaporates and cools the body—so in the case of plants the transpiration of water cools the plant and prevents it from wilting on a warm day. If for any reason the root system cannot supply the moisture for this transpiration the plant wilts.

4. Plowing of the corn.

Incessant cultivation is necessary to destroy weeds which soon spring up on account of the plants being so far apart. This cultivation not only destroys the weeds, but keeps the soil in a better condition for holding moisture and supplies necessary aeration to the soil. It may be said that corn should be plowed four or five times during a season, best while the plants are small—after the plants have become large enough to shade the ground further cultivation is unnecessary.

5. Harvesting.

Corn is gathered in the late autumn or at any time during the winter. By some it is husked in the field; others cut and gather it, leaving the husking till the corn is needed. Fodder makes a good, rough feed for cattle and horses during autumn and winter—the stalks, being tough and coarse, are not eaten, usually, unless prepared by shredding machines, etc.

Results of study and investigation as reported through the Department of Agriculture from which we quote, show that there is apparently the same average amount of ash, oil, and albuminoids in a corn wherever it grows in this country, with the exception of the Pacific Slope, where, as with wheat, there seems to be no facility for obtaining or assimilating nitrogen. It maintains about the same percentage of albuminoids under all circumstances, and is not affected by its surroundings in this respect.

Our conclusion must be, then, that corn can supply itself with nitrogen under varied circumstances, but that it rarely is able to assimilate more than a certain amount, nor will it fall far below this amount. The bushels of corn may vary, and the size of the grain, but the quantity of albuminoids is practically unchanged."

We quote also from a report of the University of Illinois Agricultural Experiment Station:

"Aside from the hull which surrounds the kernel, there are three principal parts in a grain of corn:

1. "The darker colored and rather hard and horny layer lying next to the hull, principally in the edges and toward the tip end of the kernel, where it is about one-eighth of an inch in thickness.

2. "The white starchy appearing part occupying the crown end of the kernel and usually also immediately surrounding, or partially surrounding, the germ.

3. "The germ itself which occupies the central part of the kernel toward the tip end.

"The horny layer which usually constitutes about 65 per cent of the corn kernel contains a large proportion of the total protein in the kernel.

"The white starchy part constitutes about 20 per cent of the whole kernel, and contains a small proportion of the total protein. The germ constitutes only about 10 per cent of the corn kernel, but, while it is rich in protein, it also contains more than 85 per cent of the total oil contents of the whole kernel, the remainder of the oil being distributed in all the other parts."

These facts are of value in the selection of seed corn, as, if one wishes to select those ears of high protein content he has only to choose those whose kernels show a relatively small proportion of the white, starchy part surrounding the germ. If corn is to be propagated for the oil content, it is only necessary to select those ears whose kernels have a larger proportion of germ, etc. It is not the absolute, but the proportionate, size or quantity of germ or of white starch which serves as a guide in making these selections.

"The price of corn varies, say, from one-half to one cent per pound.

"The cost of protein in the principal stock-feeding states varies from 3 to 5 cents per pound. In other words, protein is several times more valuable than corn itself, consequently stock-feeders want more protein in corn.

"The price of corn starch varies from 2 or 3 cents to even 10 cents per pound, depending upon the wholesale or retail nature of the sale. The manufacturers of starch and glucose sugar, glucose syrup, and other starch, want more starch in corn."

A bushel of ordinary corn, weighing 56 pounds, contains about 4½ pounds of germ, 36 pounds of dry starch, 7 pounds of gluten, and 5 pounds of bran or hull, the balance in weight being made up of water, soluble matter, etc. The value of the germ lies in the fact that it contains more than 40 per cent of corn oil, worth, say, 5 cents per pound, while the starch is worth 1½ cents, the gluten 1 cent and the hull ½ cent per pound.

"It can readily be seen that a variety of corn containing, say one pound more oil per bushel, would be in large demand." These statements and suggestions appeal to the commercial side of the question.

It has been estimated that a crop of 50 bushels of Indian corn per acre, with the stalks, contains about 64 pounds of nitrogen, 24 pounds of phosphoric acid and 36 pounds of potash. Estimating one-half of this plant food returned to the soil after being fed to animals, this means a loss of 32 pounds of nitrogen, 12 pounds of phosphoric acid and 18 pounds of potash per acre. The most of the lost nitrogen may be restored if clover is in the rotation.

Corn is the most useful, the most productive, and the most easily raised and harvested of all plants.

POTATO.

The potato plant belongs to the night shades, a family of plants which contains poisonous principles. The potato is a native of Mexico and Central America, but has been introduced into and cultivated in many countries and climates.

The potato owes its value to the peculiar habit of developing underground slender leafless branches, which differ in character and office from the true roots, and which gradually enlarge at the free end, thus producing the tubers. In its native state the tuber is no larger than the plum or cherry, but by cultivation it has increased in size to its present dimensions.

Scattered over the tuber are a number of buds, commonly called eyes, and from these buds new plants grow. Starch and other matters are stored up in the tubers, and in due season are rendered available for the nutrition of the young shoots when they begin to grow. The young shoots derive their nourishment from the parent tuber until development of roots and leaves enables them to obtain sufficient nutrition and then take care of themselves. The potato tuber consists for the main part of a mass of cells filled with starch and encircled by a thin, corky rind. A few woody fibers traverse the tubers.

2. The following may be given as the average composition of the potato:

Nitrogen matters	2.1 per cent
Starch, etc	18.8 " "
Sugar	3.2 " "
Fat	.2 " "
Saline matter	.7 " "
Water	75. " "

From the above it will be noticed that the value of the potato as an article of diet consists for the most part in the starch it contains. The quantity of nitrogen it contains is small.

The potato plant grows from two to four feet in height and has a tendency to vine or run along the ground. All of the nutritious substances of the upper portion of the plant are withdrawn and stored in the tubers as soon as blooming is over. The vines wither quickly and in the course of a few weeks scarcely a trace is left.

Potatoes are planted in rows about four feet apart, so as to readily admit of cultivation; the hills in each row are from two to three feet apart. The time of planting varies according to the variety; from the time of the last disappearance of frost from the ground until July. The early varieties mature about the first of July, the late varieties in September and October.

The usual manner of keeping potatoes during the winter is to place them in a cellar or bins, or to cover them in the field in large heaps. This later method is best accomplished by first covering the potatoes with a layer of straw and then with earth of sufficient depth to keep out frost and to shed rain.

SWEET POTATO.

The sweet potato is cultivated for the most part in tropical countries for its tuberous root which is an article of diet greatly in request.

The leaves are cordate, entire and borne on slender twining stems. The flowers are borne on long stalks in loose clusters, they have a white or rosy funnel shaped corolla.

The edible portion of the plant is the root which dilates into large club shaped masses filled with starch.

The plant is not known in a truly wild state.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

(FOURTH PAPER.)

1. What peculiarity is there in the structure of the wood of evergreens? The flowers?

2. What is the difference between air plants and parasitic plants?

3. What is wheat rust? What are its stages of development?

4. What peculiarity is there in the composition of lichen?

5. What are some of the peculiar forms of leaves?

6. What are weeds? What are some of their peculiarities?

7. What are algae? Give examples.

8. What is black mould? Where found?

9. Why are water plants kept in an aquarium?

10. How does the size of honey cells compare with those of drones and workers in the hives of a honey bee?

11. Why are spiders often found in the nests of wasps?

12. Give practical examples of the different classes of levers.

13. Why is Indian corn classed with the grasses?

14. Name all the food products of corn.

15. Why is the corn crop cultivated during growth?

16. What are the three principal parts of a grain of corn?

17. What portion of a kernel of corn is starch?

18. What elements are taken from the soil in the production of a crop of corn?

19. What is the principal food content of the potato?

20. What gives the sweet potato its value as a food?

Nature-Science and Agriculture.

[FIFTH PAPER.]

"Great Nature spoke; observant man obeyed."

FIFTH LESSON.

PLANT STUDY.

The Propagation of Plants.—The natural method of plant propagation is by two general ways—by seeds and by buds. If we wish to obtain correct ideas as to how plants grow, etc., we must begin at the beginning. Previously, perhaps, we have observed, in a general way, the plants we have studied. We have become familiar with them—with their organs, with their general appearance, with some of their phenomena, etc. A few familiar seeds should now be studied as to structure; then they should be sprouted and their growth observed closely.

It is scarcely necessary to say that the seeds must be good, that is, well matured, in order that they shall germinate. Their condition in this respect will depend upon their age, for if preserved too long they may lose their vitality; upon the healthful condition of the plant which produced them, and upon the conditions in which they have been stored and preserved. Of course, seeds vary in the length of time they retain their vitality with the kind of plant and somewhat with the conditions of both plant and seed development. Tests with seeds of the same kind but of different ages, etc., will be interesting experiments in this connection. Do this if possible.

It must be taken into consideration that proper conditions as to air, moisture and temperature must exist in order that seeds shall germinate.

Experiments: 1. Place soft, wet paper in the bottom of four or five vessels (glass tumblers will answer) to the depth of about one inch. Put the same number of soaked peas in each vessel, cover the vessels and place them where they will be subject to different temperatures, say from 35 to 90 degrees. Keep the temperatures as nearly constant as possible, and the moisture in each equal to that of the others. Note the rate and extent of germination in each.

2. Arrange the vessels as before, except as to amount of moisture in each, placing in one dry seeds on moistened paper; in another place seeds that have been thoroughly soaked on paper a little moistened; in another, place on thoroughly soaked paper seeds that have been soaked; in another have sufficient water to nearly cover the seeds, etc. Place the vessels where they will have the same temperature and note the times of germination.

3. Prepare in a similar way vessels containing seeds with conditions favorable as to moisture and temperature, but with different provisions as to the admission of air, and note results.

An interesting experiment, showing effect of germinating seeds upon the surrounding air, may be made by removing some of the air in one of the tightly closed vessels in the last experiment by means of an "ink-filler" or "medicine-dropper." Force this air through clear, filtered lime water and note the result. Is it the same as when the breath is blown through lime water by means of a tube? (Carbon dioxid renders lime water a milky color.) These are familiar experiments which will suggest others equally familiar and interesting.

Considerable technical work might be done in this connection, but it is thought best to restrict the experiments somewhat as to amount of work done, and to limit the extent to which we enter into detail. Do not try to have children learn the names of any but essential parts, etc., of each seed studied.

Seeds should be studied both dry and after several hours' soaking. Observe the **plumule,** or first bud, in each of several kinds of seeds, as bean, pea, squash, etc. Split the seed into its two halves, observing their attachment, the thickness of these halves, each of which is a **cotyledon** or seed leaf. Do not fail to have sketches of cotyledons, etc. Compare the bean and the pea as to points of difference. Compare also the peas with corn at different stages of germination, noting the formation of roots, development of plumule, etc. Observe that the corn has but one cotyledon and the fact that it remains nearly altogether in the buried grain, acting as a digesting and absorbing organ through which the food stored without the embryo is tranferred to the growing plant after it is changed to liquid form, as in the case of most seeds.

The plumule, or first bud, with its abundant supply of plant food stored about it, in all seeds is more than able to preserve the stock from which it sprang and to increase the number of plants. For instance, a farmer may produce the same stock, and even the same variety, of corn, wheat or garden vegetables year after year by planting seed of the previous year's crop, and harvest much more than the original amount planted. This is not true of all plants, especially of fruit trees, vines and shrubs, in respect to variety, neither can new varieties be secured in this way.

In order to maintain varieties as well as to produce new ones, such means as layers, cuttings, grafting and budding are used. Quicker results, as well as the production of dwarf varieties of trees, are also obtained in some instances by grafting.

A **layer** is formed by bending to the ground a vigorous young shoot and covering it with three or four inches of earth. Roots will form at the covered portion and leaves and branches from the the tip. Layers are generally allowed to lie one season before they are severed from the parent stem. The best results from this means of propagation are obtained from plants which have soft wood. Fall is the best season for layering, although good results may be obtained from beginning in the spring.

Cuttings are detached shoots of plants inserted in soil or in water. If the cutting is of soft wood, there are usually several joints. In hard wood cuttings there should be two or more buds. Grapes, currants, and such house plants as geraniums, etc., are propagated by cuttings.

In grafting, a plant, or part of it, is made to grow upon another plant. The **stock** is the stem into which the graft is transplanted. The part which is transplanted is called the scion (cion). There are many methods of grafting, but all are only different ways of matching the line between the bark and wood of the scion to that of the stock, then fastening them together until the cambium layers of the two grow together.

There may be one bud or more in the scion, and in the most common method of grafting the scion is inserted in a split in the wood of the stock, taking care to make close contact between the living part of both scion and stock (cleft grafting); or the stock may be cut off at the junction of root and stem with a smooth, slanting cut about one inch in length, placing this cut in contact with a similar one of a scion of the same size (whip grafting); or by preparing stock and scion as in the latter method, then splitting both a little way near the middle and carefully sliding them together, the "tongue" of one within the cleft of the other (whip-tongue grafting). Grafting wax usually prepared from resin, beeswax and tallow, is used to cover the wound so that parts may be prevented from dying out. Light bandages are necessary to hold parts in place, and are put on before the wax is applied.

Budding is only one form of grafting. It is performed by slipping a bud with a small portion of its own bark under the bark of the stock. A "T" cleft is made in the bark of the stock, the angles are carefully lifted up and the bud is slipped beneath and tied firmly with a strip of cloth or a withe of coarse, tough grass. Budding is usually done in the fall, that the bud may be ready to begin growth in the spring. As soon as it begins to shoot the stem of the stock is cut off a few inches above it.

Buds are always grafted on plants of the same kind or in some closely related tree, and care should be taken to select only those buds or scions whose varieties it is desired to perpetuate.

Common cleft grafting is employed if new varieties are to be added to an old tree. Whip-grafting in some form is employed in grafting scions on young stocks, as seedlings used in nursery stock for apples, pears, etc. Budding is usually done in propagating peaches, cherries, plums, etc.

Animal Studies.

Fishes.—The following points are suggested, which may be varied to suit conditions and advantages for observation: Habitat absolutely aquatic. Discuss results if a fresh water fish were transferred to salt water, etc. Call attention to the fact that certain species, as salmon, sturgeon, shad and some others, ascend rivers to spawn, while others, as the eel, pass from the rivers to the sea for the same purpose.

The respiratory organs, gills, are delicate fringes or laminæ, supported on bony arches. In most species these are covered by a kind of lid composed of three pieces, the **operculum** (L. **operire,** to cover), the sub-operculum and the inter-operculum. This three-coated gill-cover plays on one called the **pre-operculum.**

The gills are constantly bathed with water through alternate openings of the mouth and gill covers, and the necessary oxygen is thus obtained from the air which is mingled with the water.

The locomotive organs are called **fins.** Those corresponding to the anterior locomotive organs of higher vertebrates are named **pectorals,** and those corresponding to the posterior, **ventrals.** The vertical fins on the back are called **dorsal,** those beneath the tail **anal,** and that at the end of the tail **caudal.** Which are used in swimming? Which in balancing and directing?

Discuss the swimming bladder and the functions that have been ascribed to it; also study the vertebræ, their structure and shape, and note the fact that the spinal column bends freely laterally but not vertically.

Notice the one large complicated muscle on each side extending from head to tail, and the fact that these furnish the principal motive powers.

Observe the smallness of the brain and determine whether it fills the cavity in which it is situated.

The eye has no motion (a few exceptions) and the iris has no power of contraction or dilation apparently.

Most fishes reproduce by means of eggs, that is, they are oviparous. The spawning season and habits of those that are accessible should be closely observed.

Studies in Physics.—Diffusion or transference of heat—Illustrated by as simple means as possible the three processes of diffusion of heat,—**conduction, convection** and rediation. 1. Conduction,—By means of an iron wire or rod show how heat gradually travels from the end placed in a flame toward the end held in the hand. Note also the different degrees of heat between the two ends after one end is heated. The medium through which heat passes in this way is called a **conductor.** Test the conductivity of several metals by arranging wires of iron, brass, copper, etc., so that an end of each is in the same flame at the same time, and noting how near the fingers can approach the flame along each wire at the end of about a minute.

Why does water seem colder than air when they have both been subject to the same temperature for a considerable length of time and when the thermometer marks the same degree of temperature in both? Why does marble seem colder than wood under the same conditions? Observe that clothing keeps the body warm because the fibres of which the cloth is composed are poor conductors of heat, and because the air which is between the different parts of the clothing is not a good conductor and the heat of the body cannot readily escape. Make a list of materials that are good conductors of heat.

Show that the diffusion of heat takes place by convection when the body moves or when there is relative motion between its parts, as in the heating of water. Do this by illustration.

The explanation of diffusion of heat by **radiation** should be deferred until the subject can be taken up in a special way in connection with other forms of radiant energy.

Light.—Illustrations should be given showing that light always moves in a straight line. The reflection of light should also be illustrated and in this connection, the refraction of light which has been previously considered as an interesting phenomenon, should be taken up and explained. Familiar experiments such as placing a stick or a straw obliquely in a vessel of clear water and noting its broken appearances, or by trying to locate correctly a coin placed in a deep vessel of clean water, will demonstrate that rays of light are bent in one direction when entering a rarer medium and in another when entering a denser substance.

Interesting and instructive experiments may also be made with simple lenses, as reading glasses, eye glasses, etc., and explain how microscopes and telescopes are formed. Consider also in this connection the seven colors of the solar spectrum and the fact that bodies are **colored** only when all the colors except that by which each is known are absorbed and this particular color is reflected.

Studies in Chemistry.—In connection with the germination of seeds to show that carbonic acid gas (carbon dioxid) is given off, fill a small fruit jar about half full with beans or peas that have been soaked twenty-four hours; add a little luke warm water and cork the jar. Let it stand for twenty-four hours and test for carbon dioxid by inserting a lighted taper. If the taper is extinguished it will show that carbon dioxid has taken the place of oxygen in the jar.

Test for starch in a potato tuber, a grain of corn, etc., by spreading a drop of tincture of iodine on the cut or exposed surface. The presence of starch will be indicated by change to blue or violet color.

To show that starch is formed only in the green part of leaves, take a leaf of geranium, or other plant, variegated with white, that has been in sunlight. Place in hot alcohol to disolve out the chlorophyll, until the green color disappears, and then stain with iodine. Note that the parts of the leaf which were green are now violet-brown indicating starch, while the white parts are not colored by the iodine.

Geological Studies.—We spoke especially of quartzites in our last lesson. There are some rocks that **appear** to be composed wholly of one mineral, and yet they are not quartzites. They are mostly dark-colored, slate-colored or blackish or greenish in appearance. If these are banded in different colors, or are capable of splitting into sheets, they are **argillites.** Roofing slates and most other hard slates are included among them. If a rock is very fine, blackish and harder than slate, it may be an **aphanite.** It is a **porphyry** if it consists of a very fine hard, uniform reddish or greenish base having crystals of feldspar scattered through it.

Bowlder rocks are all hard, crystalline, and generally foreign to the region where they lie. Sometimes fragments of rocks are found that are not hard and crystalline and far fetched, but which come from ledges appearing at the surface not far away. The most familiar uncrystalline ledges are of sandstone, limestone and shale. Sandstone is composed chiefly of grains of quartz. They are like those in a granular quartzite but not so brilliant or so firmly compacted together.

A grindstone is a fine sandstone.

It should be shown by experiment how sand grains may be cemented together by lime or iron. A rusty nail left for some time in damp sand will cement sand grains.

Studies in Astronomy.—1. The names of the planets. 2. The difference between planet and star. 3. The zodiac, the twelve parts, or signs. 4. Eclipses—their cause, in a general way. 5. Tides—what they are; their cause; flood tide; ebb tide; springtide; neap tide.

AGRICULTURE.

(FIFTH PAPER.)

Farm Animals.

No study is of more pleasing interest than that of the domestic animals about us. To know them, to understand their life, to minister to their well being, is but to make us closer and better observers, and better and more intelligent in every way. To do this it is not necessary to pet or to pamper animals, but to attempt to make them comfortable and to develop them in every way that they may be the best types of animals of their kind.

All farm animals existed at one time in a wild state. They were tamed by man to serve him in some useful capacity. By commencing with wolves when young, the American Indians taught them to assist in the hunt, and in this way dogs have originated wherever wolves were found in those regions inhabited by man. The domestic turkey came from wild ones captured in the earlier times and tamed in this, its native home.

It is known, too, that if left to themselves, all our farm animals will become "wild," as did the horses and cattle which escaped from the Spanish settlers in this country in early days, stocking the western prairies in this way. Such are called **ferae.**

We also know that there are many wild animals very similar to our domestic ones, so similar in fact, that we are quite sure they are close relatives and that our own have either come from them or from others similar to them.

It is interesting to try to learn the origin not only of the different animals but of the different kinds or species of the same animal. We feel certain that some of them came from more than one wild species, having originated simultaneously, or nearly so, in different parts of the earth. This seems the case, for instance, with dogs. So many kinds, so much unlike, must have originated from more than one kind of wolf. The same is true of cattle, sheep, etc.

Not the least striking feature of the domestication of farm animals, is the fact that each was made submissive to man for a definite purpose,—for hunting, for burden bearing, for clothing, for food, etc.

Only those necessary to man have been domesticated, hence different animals have been domesticated in different countries, for two reasons, first, because they had different classes of wild animals, and second, because their requirements or uses are different. Of course it is to be supposed that only the best types of each kind were selected, and we know that better food and care in domesticity has made them improve greatly.

The relation of the number of domestic animals to the human population does not change rapidly. Quoting from an authority who compiles the information from the latest census returns, the average for each family, estimating the number at sixteen million families consisting of five persons each, is—

One horse or mule,
One cow,
Two other cattle,
Poultry equal to one cow,
Two and one half hogs,
Two and one half sheep.

Of course it must be evident that some families must keep and raise these animals for those who live in the cities and elsewhere who do not keep any. The families living on the farms in most instances have more than the average. The most of these animals are raised for food. In fact nearly all except horses and mules, eventually are eaten, and these are eaten in some countries.

It is estimated that a horse at work will eat, on an average, 100 bushels of oats, or their equivalent, and one and one half tons of hay or its equivalent in pasturage or other "roughness" in a year. There is some tendency to feed horses too much grain. It is thought that the proper allowance of food per day for every one thousand pounds live weight of animals should be 20 to 25 pounds, half of which should be grain.

One estimate of food for a working horse is an average of 22.5 lbs., dry matter for each 1000 lbs. live weight per day. This should contain one and eight-tenths lbs. of digestible protein and eleven and eight-tenths lbs. of digestible carbohydrates and fats, a nutritive ratio of about one to seven.

With cows it should be about the same as for horses, except that the nutritive ratio should be about one to five and one half. This suggests the enormous amount of food necessary to maintain the animal population and the large area of land required to produce it. No other nation in the world does it, or could do it.

The Horse.—It must not be inferred that our horses are descended from the "wild horses" of our western prairies or from those of other countries. These so-called wild horses have descended from those that have escaped from man. Within historic times no real wild horses have been known.

Investigations in comparative anatomy have demonstrated that their structure is but a modification of the same general plan upon which the tapirs and rhinoceroses are formed, and the discovery and restoration of the characters of extinct species, especially that conducted comparatively recently in the fossiliferous strata of North America, have revealed numerous intermediate stages through which the existing horses appear to have passed in their modifications from a very different ancestral form.

The remains of an animal has been found that seems certainly to have been a horse, much like the present horse except that he was much smaller and in place of one toe and hoof on each foot he had three. In deeper strata has been found a similar one with five toes upon each foot. The splint bones, the slender bones on either side the long bone just below the "knee" (really the wrist) joint, are all that is left of the two outside toes of the three-toed horse. These bones are jointed at the top to help form the knee, and run to a point before they reach the fetlock joint below.

The only relations to the horse now in existence are the domestic ass, the wild ass of Abyssinia and the Zebra and the Quagga of South Africa. This relationship may be inferred not from resemblance only but also from the fact that both the horse and the ass occasionaly show dark stripes down the sides of the shoulders and frequently bars on the sides and back of the legs.

These colors and markings come out when there has been some mixed breeding; when strains of blood have been brought together that do not harmonize; when the characters of the improved strains "cancel out," leaving the opportunity for the appearance of these ancient characters long since "bred out" except when "reversion to type" brings them back again.

We can imagine the original wild horses inhabiting the same general regions as the wolves, and, since the principal means of defense lies in running, and the wolf is also fleet of foot, horses developed into the fleetest and most enduring of animals, making them of special value to man in hunting, warfare, and later, as the civilization of man progressed, the usefulness of this most useful animal increased until we note that the size, style and action became as various as their various uses and we have different breeds of horses for different purposes. "The attempt to produce a type of animal to fill a certain use gives rise to a breed." When this attempt is made simultaneously in different countries we have more than one breed designed for the same service, differing only in unimportant respects.

Thus we have the different breeds of draft horses, each excellent, for each of the countries, England, Scotland, Belgium and France. We have also, for example, the Percheron and the French Draft two types of France, as the result of different ideas of breeders in the same country with regard to the draft horse.

The modern draft horse traces directly back to the large horse of the middle ages found only in "Flanders" (now Northern France and Belgium). The demand for a heavy horse came because of the increase in weight of armor, so a "charger," able to carry a knight and full armor for both man and horse was bred up from this "Flanders" stock and became the favorite wherever chivalry flourished in Western Europe.

Fully as interesting is the history of the thoroughbred, beginning with the crusades in the twelfth and thirteenth centuries, and having its origin in the Arabian horse "bred for a thousand years and more for speed, endurance and faithful, ness to his master." The trotting horse of to-day- an American "creation," has for a foundation the best blood of the Arabian and the old English horse.

The modern Percheron represents the French use of its Arabian blood which becomes fused into the common blood of the country largely in use upon its farms. This is why the Percheron has more and better action than all other draft breeds which have descended more directly from the original heavy horse without the infusion of Arabian blood.

The Belgian, the Shire and the Clydesdale represent the old original stock of heavy "Flanders." The French Coach is the blood of the thoroughbred upon the best of the lighter horses of France.

In America we have bred all these breeds in line with their original purpose, and we have all of them Americanized, so to speak, and there are no better horses in the world. The draft horse is the one the American farmer can produce most successfully from a marketable point of view.

Some of the most important breeds of horses are as follows:—

Draft Horses or Heavy Breeds.—1. The Percheron, (from the province of Perche where they were developed,) France; 2. French Draft, also developed in France; 3. Belgian Draft, Belgium, developed by Belgium farmers; 4. Clydesdale, Scotland; 5. Suffolk Punch, Eastern England; 6. English Shire, also Eastern England.

Carriage or Coach Horses.—1. French Coach, France; 2. Cleveland Bay, England; 3. German Coach, Germany; 4. Hackney, England.

Roadsters and Light Breeds.—1. The Thoroughbred, England; 2. American Trotter; 3. American Saddle Horse, bred in Kentucky and Virginia.

Cattle.—The origin of our common cattle is not certainly known, but it is thought the original wild stock was found in Western Asia or Southern Europe. Whatever their source, our present breeds are descended from European stock.

The nearest approach to cattle in this country at the time of its discovery were the bison.

The so-called "wild" cattle of the western plains were, like the "wild" horses, really ferae, having escaped from the Spaniards in the early attempts at colonization.

Our present breeds are supposed to be not more than one or two thousand years removed from wild animals, and the longest record of any breed is not yet one hundred and twenty-five years old.

It is more than likely that all modern European and American breeds of cattle have descended from the auroch, or European bison, once widely distributed but now nearly extinct, except when protected in the Lithuanian forests, etc.

Out of this original stock, if this is correct, and whether of one or more species, Europe has produced all the modern breeds of cattle. This country has not produced a variety sufficiently improved or important to be called a distinct breed. To Western Europe, especially to England, belongs the distinction not only of improvement in breeds, but of the production of new breeds.

The four great beef breeds are the Short Horns, the Herefords, the Aberdeen Angus and the Galloway. The first two came from England and the last two from Scotland. To these, among important beef cattle, may be added the Sussex, from the country of Sussex, England.

The Herefords were known in England one hundred and fifty years ago, as Longhorns. They were spotted red and white with mottled faces and long horns. They were used for labor, but came to be much used for beef about the time of the American revolution. By improvement they gradually assumed their present beautiful red color, with clear white faces and full white breasts and came to be called Herefords from the shire where they had been developed. No breed excels them on the range, that is, for making beef principally from grass.

About the same time, in the shire of Durham, England, and along the river Tees, there progressed an improvment of a large kind of cattle, better milkers than the Longhorns, locally known as Teeswater cattle. These cattle received the best attention of a number of the best farmers of Durham, and so the Teeswater cattle improved and became popular over England, gradually becoming known as Shorthorns to distinguish them from the Longhorns.

When these two breeds afterwards came to America, the Longhorns were called Herefords, after their native shire, and the Teeswater cattle were called, first Durham, after their native shire, but afterwards Shorthorns.

While these breeds were being improved, and during our war for indepencence, a half-wild, black, shaggy, hornless lot of cattle were feeding on the hills of Galloway in Southwest Scotland. They were rough and uncouth but thick meated, and by improvement have come to be among the best beef cattle of to-day. These are the hardy, hornless Galloways.

The Aberdeen Angus, named from their home, Aberdeen and Angus, two shires of Southeast Scotland, are the last, the youngest and the finest finished of all the beef breeds. They excel as yard and stall feeders, and as show-ring cattle. They are shiny, black and hornless, with bright intelligent faces and erect ears, a distinct breed that will never be confused with others, not even the shaggy, black hornless Galloways.

The dairy breeds are the Jersey, from the Isle of Jersey; the Ayrshire, from Scotland (the shire of Ayre;) the Holstein-Friesian, from Holland and Denmark; and the Brown Swiss, from Switzerland.

Other and minor breeds are the Devons, the bright, quick red cattle from Devonshire, England; the Dutch-Belted; the Red-Polled, the red and hornless Norfolk and Suffolk, of England; the Kerry, from Ireland; the Pembroke, huge cattle from Wales; and the West Highland, fierce shaggy looking cattle from Scotland.

The typical beef cow is squarely built, back and loins full, stomach line parallel with the back line which is straight. The legs are thick and full, hips evenly fleshed and neck full and short. The face is short, the bones of fine texture, the skin soft and the eyes should be bright.

The dairy cow presents a decided wedge-shaped appearance, from whatever point of view. The back line is crooked, hip bones and tail bone prominent, the thighs are thin and bearing little flesh, and there is little flesh on the back and shoulders. The neck is long and thin. The udder should be full but not fleshy, attached well behind and extending well forward. The skin should be soft and pliable and the bones should be of fine texture.

A good sire is necessary to the improvement of a herd of cattle. The improvement from common stock upward is,—the first generation is one half pure; the second is three-fourths pure; the third is seven-eights pure; the fourth is fifteen-sixteenths pure, etc.

Sheep.—It is thought the sheep was the first animal domesticated by man. From the earliest times the lamb has been the symbol of innocence.

The nearest wild relatives of our domestic sheep are the Big Horn of the Rocky Mountains and the nearly related species scattered all over the mountain region of western North America and Central Asia, etc. The camel of Western Asia and Northern Africa, and the Llama, Alpaca, Vicuna, etc., of the Andes regions of South America, are more remote relatives. Goats, both the common and the Angora, are near relatives.

While the true origin of the sheep is not known, there is reason to suppose that their wild progenitors were of a dark color; first, because an occasional black, or rather brown, sheep appears in our flocks and second, because these dark sheep have coarse, inferior wool and appear in every way more primitive and unimproved than the general average of sheep.

In any case it is almost certain that the progenitors of our sheep were inhabitants of the hills of Western Asia and of the region round about the Mediterranean Sea. They have left four distinct types of sheep, as follows:

1. The Persian Sheep, which is large, heavy and with a tendency to lay on fat at the rump and often on the tail itself—the so-called fat-tailed sheep. Most of the "fiddle strings" of commerce are made in Germany from the small intestines of these sheep.

2. The Fezzan Sheep of Northern Africa with their long legs, bulging foreheads, pendulous ears and heavy mane.

3. The Merinos, or fine-wooled sheep, coming originally from Spain. They are generally heavily horned, except as the horns have recently been

bred off, are much the smallest sheep in the world and carry the finest fleece known.

4. The coarse-wooled sheep, of uncertain origin but of many breeds are characteristic of England and are extensively bred in this country.

As has been said, the Merino sheep originated in Spain; from thence they spread north into France, northeast into Saxony and also across the Atlantic into the United States. A few were sent by the king as a present to a friend in Australia, whence they spread to New Zealand.

Those that spread into France developed into a long-legged, plain sheep with a somewhat lighter fleece, carrying less oil, or "grease" than the original Spanish Merinos. They were imported into this country a generation ago under the name of French Merinos, and recently they have commenced to come over under the name Rambouillet (pronounced ram boo lay).

Those Merinos that spread to Saxony became very much reduced in size and in vigor, but developed a fleece of the finest wool ever seen by man. This wool came into great favor, especially for yarn, but the growing cheapness of silk finally ruined the call for the Saxon fleece and this type of Merino is almost extinct.

Under the hand of our breeders those brought to America flourished and the fiber became longer and finer and was given a lustre not found in the original Merino. One peculiar fact in this connection is that this was accomplished only with enormous development of wrinkles and immense quantities of "grease," the yellow, oily gum so characteristic of fine-wooled sheep.

Those Merinos sent to Australia flourished and the climate proved especially favorable to the best development of the Merino fleece. Australia, New Zealand and neighboring islands rapidly stocked themselves with Merino sheep. The Spanish supply was soon practically exhausted and the Australians soon learned that the best available Merinos were to be found in America. Prices became almost fabulous, and this trade became so extensive that Vermont and New Hampshire, then almost the only sheep raising states, could not supply the demand, and with the rise in prices the raising of Merinos spread westward until Australia became not only full from our makets, but she discovered she could not only produce her own breeding flocks, but that she could grow a better Merino and produce a better grade of fine wool than any other known region. She has been so extensively in the business ever since as not only to control the market in fine wools, but even to lead to the building of ships for the "Australian frozen meat trade" with Europe.

But all this time a very different class of sheep were extensively bred in England where the Merino never succeeded and where sheep are bred for mutton rather than for wool.

There is no evidence of any relationship between these and the Merinos, since the origin of both is unkown. There is little resemblance, for the English sheep are much longer and coarser than the Merino, generally destitute of horns, with a longer, coarser fleece.

From these English sheep have developed the modern breeds of coarse wooled sheep. These may be divided, however, into two classes, the long wools and the medium wools.

The three classes of sheep comprise the fine-wooled breeds,—American Merino, Delaine Merino and Rambouillets; the medium wooled breed,—Southdowns, Oxford Downs, and Cheviot; the long wooled breeds,—Leicester, Lincoln and Cotswold.

Sheep serve three purposes: They make a good quality of meat; they make our most useful clothing, which no other animal can do; and they improve the land on which they are pastured.

Swine.—The domestic pig is descended from either the Peccary of Central America, the Wart Hog of Southern Africa, the Wild Boar of Western Europe, or the Malay Hog, or Deer Hog of Southeastern Asia.

From whichever he may have come, we are indebted to the Chinese for our swine. These people succeeded in developing a very quick growing, early maturing, but a small if not delicate animal. Neither Europe, Africa, nor America domesticated its wild hog, but Europe, thinking the Chinese pigs too small and delicate, improved them by crossing with the larger and coarser wild boar.

In this way the English breeds were produced, especially the Berkshire, which had the largest amount of wild blood of any, and also the

"White" breeds of various sizes, all of which, and especially the smaller ones, contain a comparatively high per cent of Chinese blood.

All our breeds either came to us from England or else have originated here out of English stock.

The early European colonists in this country soon learned the value of Indian corn as feed for the pig, and so corn and the pig developed together in America.

The first great corn growing region of America was in and about Chester County, Pennsylvania, and here developed the strain of white hogs, founded upon English stock, and now known everywhere as "Chester Whites," the first American breed of hogs.

Later on when the Miami Valley became the great corn growing region, another breed of hogs was developed. At first a strong-boned, coarse, upstanding spotted hog, it has developed into a fine finished, truly American hog of fine form and of a uniform black color. It was called at first McGee, Warren County, Poland and finally Poland-China. The bulk of refining blood for its formation was furnished by the American Berkshire, the original of which had long before been imported from England.

The most important large breeds of hogs are, Chester White, Improved Yorkshire, Tamworth, Duroc-Jersey, Cheshire; among medium breeds are Berkshire and Poland-China; and smaller breeds, Victoria, Suffolk, Essex and small Yorkshire.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

(FIFTH PAPER.)

1. What are the natural methods of plant propagation?
2. What is necessary to the germination of seeds?
3. What is a plumule? A cotyledon?
4. What is a layer? A cutting? A cion? A stock? What is budding?
5. What salt water fish ascend rivers to spawn?
6. What are the respiratory organs of fish?
7. What functions are ascribed to the swimming bladder of fishes?
8. Describe the eye of a fish.
9. What are the processes of heat transference?
10. Illustrate each process of heat transference.
11. What is meant by the refraction of light?
12. What is an argillite? An aphanite? A porphyry?
13. What are tides? Their cause?
14. How have all farm animals originated?
15. What is the meaning of **Ferae?**
16. For what purpose are farm animals used?
17. How much will a horse eat in a year? A cow?
18. From what did the horse originate? The cow?

19. What are the characteristics of the beef cow? A dairy cow?

20. Trace the origin of the sheep? The pig?

Nature-Science and Agriculture.

(SIXTH PAPER.)

"Oh, world, as God has made it! all is beauty."

SIXTH LESSON.

Plants.—A study of the characteristics of flowers, their likenesses and their differences, by comparison, in other words, the identification of plants, necessitates some effort at simple classification at least.

The best divisions, and those determined upon by botanists generally are based on the structure of the flowers, and the fruit or the seeds. Some references are also made to the form and arrangement of leaves. Technical works on this subject have formed series of great groupes, bringing together under a common head plants quite different in appearance but whose flowers are very similar.

In the plants of the common Pulse family the flowers, fruit and seed are in all formed or arranged in the same manner, or nearly so, as we find by careful examination, although some are trees, as the redbud, the honey locust and the black locust; others are shrubs, as the wisteria; and still others are herbs, as the peas, beans, vetch, clover, etc. Notice in the flowers of this family the sepals are more or less united, the five points alone being free, inside of which is the corolla, with its five very unlike petals. The stamens, too, are arranged peculiarly; the ovary is simple and free from the calyx; the fruit is usually a one-celled pod. These points may not be so readily discovered in the flower of the clover, but patience and close investigation will reveal that it is similarly arranged. This family is also known as **leguminosae,** from the Latin, **legumen,** vegetables, pot-herbs; this name is given because many of the plants of this family are food products.

In like manner, it will be found that the plants of the rose family have flowers with no important difference except in the ovary, and consequently in the fruit. The calyx is five-lobed, the petals five inserted with the stamens on a disk that lines the calyx-tube, and the stamens are usually numerous. The fruit is a pome, a stone fruit or a group of stone-fruits, or one to several akenes or follicles, seldom a berry or capsule. Example of flowers to study are those of the quince, pear, apple, crab-apple, American and European mountain ash, service, red haw, raspberry, blackberry, rose, plum, peach, cherry, etc. These plants are all classed in the rose family because their flowers have the same structure as that of the rose.

The **Composite** family is important also and its members are easily recognized. The flowers are in a dense head, on a common receptacle, surrounded by an involucre composed of many bracts. There are usually five stamens inserted on the corolla and the anthers are united into a tube surrounding the style. The flower heads vary not only in appearance but in size. The corolla is either strap-shaped or tubular. The fruit is an akene.

Three divisions may be made of this family, according to the shape of the flower, some have both strap-shaped and tubular flowers. Among these are: Golden-rod asters, dasies, sunflowers, elecampane, daisy, fleabane, golden ragwort, yarrow, Black-eyed Susan, blue spring daisy, etc. Others have only strap-shaped leaves, as dandelion, wild lettuce, chicory, etc. The third division consists of those which have only tubular-shaped blossoms, as thistle, tansy, iron-weed, boneset, trumpet flower, blazing star, white snake-root, salt-marsh fleabane, etc.

The blue spring daisy is the only one of these which appears in the spring. The Black-eyed Susan comes in July and the others in August, September and October, mostly in September.

The golden-rod is a very popular and familiar flower. It should be studied as an illustration of a composite flower, as should also others nearly as familiar, as the sunflower, chicory, the thistle and Black-eyed Susan. Note the character of the petals; the insect visitors of each; their purpose.

Call attention to the generic name of golden-rod, **solidago**, a word taken from the Greek, meaning "to make whole," referring to the healing properties attributed to the plant. About eighty species of golden-rod are native to the United States.

The **mustard** family is distinguished as consisting of herbs with pungent, watery juice, having four sepals and four petals, their upper part spreading in the form of a cross, hence also the name **gruciferae.** The flowers have six stamens, the two outer ones shorter than the four inner ones and a single two-celled pistil with two parietal placentae forming the kind of pod called a silique.

The flowers are arranged in racemes and are so nearly alike that an examination of the fruit and seed is necessary, usually, to determine the genera and species. The following are among the plants that may be studied as examples of this family: Pepper grass, tongue grass, horse-radish, mustard, water-cress, toothwort (two-leaved), crows foot, shepherd's purse and sweet alyssum.

The plants of the **lily** family are mostly herbs with regular symmetrical flowers, perianth free from the ovary; stamens, nearly always six, one before each division of the perianth; ovary usually three-celled fruit, a pod or berry. The divisions of the perianth are colored nearly alike, with one exception. Plants of this family which may be interesting study are: White hellebore, Indian poke, garlics, wild onion, lilies, tulips, adder's tongue, dog-tooth violet, hyacinths, asparagus, Solomon's seal, lily-of-the-valley, trillium.

The **mint** family comprises mostly herbs, with square stems with opposite leaves, more or less aromatic. It will be noticed that the leaves are without stipules, and the flowers are generally in cyme-like clusters, auxillary, and often grouped in terminal spikes or racemes. The calyx is tubular, usually two-lipped. Corolla also usually two-lipped. Stamens, four, two long and two short, or sometimes there are only two stamens. The fruit consists of four nutlets, corresponding to the four deep lobes of the ovary. The plants for study comprised in this family are horehound, catnip, motherwort, garden sage, garden thyme, mint, etc.

The **grass** family consists mostly of herbs with usually hollow stems closed and enlarged at the nodes. The leaves are alternate two-ranked with sheathing bases split open on the side opposite the blade.

The flowers are nearly or quite destitute of floral envelopes, solitary, and borne in the axile of scaly bracts called glumes. The fruit is a grain. They should be distinguished from sedges which have usually solid, triangular stem, and three ranked leaves whose base, when sheathing is not slit. Examples of grasses, Wheat, Indian Corn, Timothy, etc.

In the study of all these families their usefulness to man and their utility in the economy of nature should be kept in mind and emphasized as occasion presents itself. For example, in the consideration of the Pulse or Leguminose family, in the growing season a clover plant should be dug up. The little swollen points or places in the roots called nodules or tubercles are the home of the bacteria, which in their development take the nitrogen from the air. At their death, which occurs in a short time, this nitrogen is available for common plants which need large amounts of nitrogen. Not being able to get their own supply from the atmosphere, they are dependent entirely upon the soil supply which is never large and which is soon exhausted by growing crops and by rains. It is necessary then that the same supply of soil nitrogen be kept up in some way. It is too expensive to do so by supplying it in the form of Commercial fertilizers, since it is estimated that in this form it will require about four pounds at, say, fifteen cents per pound to grow a single bushel of wheat. By growing clover or other leguminous crops, thus securing nitrogen from the air through the root tubercles it can be obtained for nothing. Plants may be classified as nitrogen producers and nitrogen exhausters. Only those plants whose roots have nodules or tubercles produce nitrogen.

Animal Studies —Interest in these studies will not be lessened by selecting types whose activities are known and can be studied from a practical standpoint. We shall now study a few insects, both injurious and beneficial.

Injurious Insects.—The **Hessian Fly** derives its name from the probability of its having been introduced into this country with the bedding straw of the Hessian soldiers during the Revolutionary War. It has two broods as the flies appear in the spring and in the autumn. At each of these times the fly, a minute, two winged insect, lays twenty or thirty eggs in the crease of the leaf of a young plant. In about four days in warm weather, they hatch, and the pale red larvae crawl down the leaf working their way in between it and the main stalk, passing downward, till they come to a joint just above which they remain, a little below the surface of the ground, with the head toward the root of the plant. Two or three larvae are sufficient to weaken a plant by sucking the sap and by embedding themselves, by simple pressure of the body, in the side of the stem. In five or six weeks the larvae are full grown. Their skin hardens, becomes brown, then turns to a bright chestnut color. This is the puparium or flax-seed state. In two or three weeks the semipupa becomes detached from the old one. The larvae remains through the winter in this puparium. Towards the beginning of May the pupa becomes fully developed and about the last of May it emerges from the brown puparium "wrapped in a thin white skin which soon breaks and is then at liberty." The flies lay their eggs on the young wheat for a period of three weeks, and then disappear. The larvae from these eggs take the flax-seed form in June and July and most of them are thus left on the stubble at harvest time. The best preventative against their attacks is to burn the stubble. There are four known parasites on the Hessian Fly, one of which preys on the eggs, another on the larvae, and the other destroys it in the flax-seed state.

The **Chinch Bug**, while it does most damage, perhaps, to the wheat crop, infests also oats, corn, sugar cane, in fact all kinds of grain. The young bug is at first wingless and of a bright red color, changing with age to brown or black and are marked with a white band across the back. It is said that the female is occupied about twenty days in laying her eggs, about 500 in number.

The larvae hatches in fifteen days and there are two broods in a season, the first maturing from the middle of July to the middle of August and the second late in the autumn. The eggs are laid in the ground usually at the depth of an inch or more. It is also stated that some of them continue alive in concealment during the winter. Long continued, wet, cloudy, cool weather is not farvorable to their development. The early sowing of small grain in the spring and the burning of all straw, weeds, stalks, etc., on or near the ground to be cultivated discourage their multiplication.

The **Corn Worm**, or Boll Worm, is the insect whose larvae are found in the tips of corn ears. In some portions of the country as in parts of Southern Kansas, scarcely an ear of corn is free of it. It is an enemy to cotton also, and attacks even beans, peas and other garden vegetables. The larvae grows to a length of about one and one-half inches, then buries itself in the ground where it becomes a brown chrysalid, and emerges as a clay-yellow moth in three or four weeks.

The **Cabbage Butterfly** was introduced from Europe into Quebec about 1859 and soon became abundant in the United States. It is now our common white butterfly, and perhaps the only one we are justified in destroying. A single one of these butterflies has been known to contain between 400 and 500 eggs.

The **Colorado Potato Beetle** reaches the adult stage within a month after hatching from the yellowish eggs. The larvae are pale yellow with a reddish twinge and a lateral row of black dots.

The adults pass the winter in the ground, emerging late in the spring, just in time to lay their eggs upon the young potato leaves. The larvae devour the leaves to such an extent as to sometimes cut off the entire crop in some localities. The loss to this country alone from the ravages of this beetle is enormous each year. There are various beetles, hemiptera, and a species of Tachina Fly which prey upon the larvae. A mixture of one part of Paris Green to twenty of flour or plaster sprinkled upon the potato plants the first one or two weeks after they come up will practically destroy the beetle for the season.

Aphids or Plant Lice.—Among the most troublesome insects are those which live upon nearly every useful plant, puncturing the plant and sucking the sap. That which infests the corn, the corn louse, attacks the roots; the grape phyllaxera lives on both the roots and leaves and even on the bark. Most species, however, attack the young fruit, leaves and the buds, as the peach tree aphid, the green apple tree aphid, and the aphids which infest the rose. the elm and other shrubs and trees.

All these aphids make interesting and profitable study. Many species excrete a sweet fluid through a minute pair of tubes on the back. This fluid, called honeydew, is injurious to trees, etc., since it makes various mildews possible. These are the aphids cared for by ants for their excretion. Many kinds of aphids produce also a white, powdery, downy growth as a means of protection by concealment or by rendering themselves unpalatable to birds.

Aphids have antennae with from five to seven joints; beak three-jointed and developed in both sexes; legs long and slender with two-jointed tarsi; males and females are winged and also the last brood of asexual ones, but the early summer broods are wingless. Of the many species whose life story is practically the same, local conditions and interests will determine largely which shall be studied.

Cutworms are the caterpillars of the different species of the owlet moths. These are the caterpillars which cut off the very young plants of field and garden even with the earth. The larvae feed at first upon the tender grass roots and the roots of other plants, but they are ready for their destructive business early in the spring when they have attained a growth of about one inch in length. They are not known to have any insect enemies, but plants are somewhat protected from their ravages by placing a cylinder of stiff paper or tin about six inches in length about the plant, so that it enters at the lower end about an inch into the earth. No poisonous preparation has proved effective in their destruction. Robins and toads assist in their destruction, but these assistants are not usually sufficiently numerous in a locality to retard their multiplication materially.

Tent Caterpillars.—The moths of this insect lay their eggs on the slender twigs of trees, mostly of the apple and wild cherry, in the month of July. The very small black caterpillars are develeped during the summer and remain curled up within the egg shell during the winter and fall, after hatching just as the leaves are unfolding and forming a web under which the colony lives. They feed on the tender buds, etc., and build their tents. They may be destroyed by previously searching for the bunches of eggs on the twigs before the tree is leaved out, and the caterpillars may be killed with a brush or mop dipped into strong soap-suds, or a weak solution of petroleum. The larvae are about two inches long, hairy, with a dorsal white stripe, with numerous fine crinkled black lines on a yellow ground; united below into a common black band, with a blue spot on the side of each ring. The moth which appears in July, is reddish brown, with two oblique, dirty white lines on the fore wings.

The **peach tree borer** has been destructive to practically all peach trees in nearly the whole United States within the past twenty years. The moth resembles a species of wasp and appears from the last of June to the first of September during which time it deposits its eggs on the trunks of peach and plum trees within a foot and a half of the ground. These eggs are quite numerous, are glued to the bark, and hatch out in about a week. The larva crawls under the outer bark and bores into the juicy inner bark where it remains feeding, except in freezing weather, for about ten months. It then emerges, makes its cocoon close to the ground on the tree trunk, and in about three weeks emerges as a moth to begin its life story over again.

The **Codling Moth**, or **Apple Worm** was imported from Europe, and it is estimated that it now causes a loss of from 25 to 75 per cent of the apple crop alone in this country and Canada, as well as causing great loss of other fruits, as crab apples, pears, quinces, and even plums, apricots and cherries. The cocoon may be found from October to May under the bark scales of apple or pear trees, etc., or in crevices about places where fruit has been stored. The moths emerge late in May or early in June and they may be known by a horse shoe of copper-colored scales on the front wing. Very soon they begin to lay their eggs on the growing fruit or on the leaves near by. The larvae hatch in a few days, burrow into the core from the blossom end, and mature in three weeks, when, if the apple does not fall, they spin to the ground after eating their way out through the side of the apple and crawl to the trunk of the tree, or they may crawl down the branches after eating their way out, and make their cocoons again under the bark.

The most effective means for their extermination used by fruit growers is to scrape all loose bark from the trees early in July and fasten a wisp of straw or a band of burlap or heavy paper around the trunk; then remove these bands and collect and destroy all larvae at least once a week during the month of July.

Beneficial Insects.—The **ichneumon** flies, which are parasitic upon other insects, comprise several thousand species. The eggs are laid by the parent either on the outside or within the caterpillar or other larva on which the young is fed. When hatched it devours the fatty portion of its victim which gradually dies of exhaustion. The ovipositor of some species is very long and is fitted for boring through very dense substances. When about to enter the pupa state the larva spins a cocoon, consisting in the larger species of an inner covering and escapes as a fly through the skin of the caterpillar.

The principal study of these insects should be in the observation of their habits and mode of life and the part they play in Nature's great plan.

The **braconids and chalcis flies** are only subdivisions of ichneumons and are among the most important of these valuable insects.

The **syrphus** flies owe their importance to the fact that their larvae prey upon plant lice and other soft bodied insects. There are more than three hundred different species of them.

The **tachina** flies resemble house flies in form. They have a stout bristly appearance and their larvae are parasitic upon almost all insects. The white, oval eggs are deposited upon the body of a caterpillar, or even of some insects, where they stick as tightly as if glued. On hatching, the maggots burrow into the victim, feeding upon the tissues and juices. The larva spins no cocoon, but the outer skin hardens into an oval case called the pupa case or puparium where the larvae change into pupae from where they emerge as full grown flies in about ten days.

"**Lady birds or lady beetles** are well known from their hemispherical form; generally red or yellow color, with round or lunate blackspots. The species, numbering more than one thousand, are difficult to discriminate. The yellow long oval eggs are laid in patches, often in a group of plant lice which the larvae eagerly devour. Both larvae and adults feed upon the plant lice, eggs and larvae of other insects.

It will be profitable also to study other beetles serviceable in destroying injurious insects, as **lion beetles, tiger beetles** and **bombardier beetles.** The first feed upon caterpillars, corn worms, and one species devours corn worms.

Dragon flies, damsel flies, and **caddis flies** will also amply repay observation and study.

Agriculture.

(SIXTH PAPER.)

BACTERIA.

Scientists have had some difficulty in deciding whether bacteria are plants or animals. Their food and what little structure they possess would indicate that they are plants closely related to the fungi.

They exist by millions everywhere, or rather, they may exist anywhere, in the air, in the water and most other liquids, in the soil or on the surface of objects. They are so small that the aid of a microscope is necessary to distinguish them. In form, some are spherical, others are cylindrical some are spiral, and many are bent and twisted, the elongated forms, into queer shapes. It requires several thousand, laid side by side or end to end, to make a line an inch in length.

Their discovery is attributed to Anton van Leeuwenhoek in 1683. It was left to Robert Koch and Louis Pasteur, in 1880 to demonstrate their power to cause disease. Bacteria are so small they are thus taken into dust particles in the air and thus taken into the body with the breath, or with water or milk.

Not all bacteria are harmful. Some are very useful indeed and not enough is known of others to determine whether they are harmful or useful to mankind.

The single bacteria consists of a single cell, and, small as it is, this simple cell carries on all the processes of life.

They multiply by division. That is, the simple cell divides into parts, making two cells instead of one. This process continues, each of these two cells after growing for a short time dividing and thus making four cells. These four in like manner produce eight, the eight produce sixteen, and so on. It has been found that some kinds divide at intervals as short as half an hour while others require a longer time. It may thus be seen how very rapidly they may multiply. Too great an increase, however, may soon exhaust the food supply in any one place, or they may be poisoned by effect of too many living in a small colony.

Moisture is necessary for their propagation and growth. As spores they are on all dry substances, and in that state they are dormant, just as we have in seeds or bulbs dormant life in higher plants. In this condition bacteria may exist for a considerable time, in some instances for years, to become active when the necessary moisture is supplied.

It is in the spore state that bacteria are carried in large numbers everywhere in the dust of the air, because of their light, dry condition and their minuteness.

They are also carried by clothing, the hands, etc., from contact with surfaces on which they exist, and disease germs are thus scattered, soon to find lodgement where conditions are more favorable to their development and multiplication.

They may be carried in various ways, from place to place, after the stirring up of dust from the street, or in the house or barn; they do not rise and float away from a moist or liquid surface.

While a certain amount of heat is necessary to the developement of bacteria, too much heat will destroy them. Freezing will stop their growth but will not destroy them; when a sufficient amount of heat is afterwards added, they renew their activity.

Certain chemical preparations called germicides mostly poisons, are prepared to destroy them, but a preparation that kills one species frequently has no effect upon others.

The food of bacteria must necessarily be in a liquid condition. When the temperature is suitable the bacteria flourish and cause decomposition in dead animal or vegetable matter in a moist state. In case of the lowering of the temperature to a certain degree, their action ceases but it begins again with a rise of temperature to a proper degree. It will be noted that living, healthy plants and animals have power to resist their attacks. Decay of dead animal or vegetable matter is always due to the growth of bacteria.

Bacteria, since they form part of the dust, may enter the body with the air during respiration. Nature has provided the nostrils with mucous membrane, one function of which is to prevent all particles of dust from entering the lungs. If air is breathed through the mouth, dust may be taken into the lungs and with it the germs of diphtheria, grippe, pneumonia. tuberculosis, etc., may be communicated. These germs get into the air mainly through sputum, which after drying may be taken up by the wind. Hence we have regulations by the authorities with regard to spitting in public places. These are established for the safety of the public and should be carefully heeded.

Germs that enter the system with food or drink are those of typhoid fever, cholera and other intestinal diseases. For this reason care should be taken to destroy all those germs to prevent their gaining access to drinking water, etc.

The cleanliness and the proper ventilation of all public buildings, which are nearly always centers of infection, cannot be too strongly emphasized.

We have already spoken of the relation of bacteria to the soil in the leguminous plants. It must also be noted the decomposition of both plants and animals, due to bacteria, returns to the earth as much substance as has been taken from it in their growth, besides preventing the accumulation of the bodies of dead plants and animals. Permitting a piece of land to "rest" by permitting it to grow up in weeds, is nothing more than affording bacteria an opportunity to decompose the weeds, which have served as forage and breeding places for innumerable insects and other small animals, as well as these creatures themselves, in order that they may enrich the soil.

It is well known that bacteria live also in the soil, helping to decompose the organic matter mixed with it. They exist at a depth not greater than five or six feet, however, decreasing downward to that depth.

Low, wet soil, because of the acids held in solution, prevent the growth and action of bacteria. Drainage and a good circulation of the air in such soils is the remedy, since the washing out of the acids gives the bacteria an opportunity to work.

The farmer stores his grain and hay in dry condition to prevent the action of bacteria, moulds and fungi. Apples and other fruits, as well as meats, are dried in order to preserve them, for the same reason, since moisture encourages and promotes the development of bacteria, etc.

Low temperature prevents bacteria from growing and multiplying, hence fruits, vegetables and meats are kept in cold storage except when the temperature is naturally sufficiently low as in winter.

Salt and sugar are also good preservatives of fruit and meats, since bacteria cannot live in them when properly prepared. The sugar must be dry, usually, and the fruit with which it is used must be cooked to drive out the water they contain.

Bacteria in the Dairy.—When milk leaves the udder of the cow, the gas which is predominant, carbonic acid gas, begins to pass from the milk and gases of the air takes its place. This is brought by the natural diffusion and solubility of gases. As soon as milk leaves the udder of the cow it comes in contact with germ life; it is the germ life which is controlled largely by the conditions of the milk; in it there are germs of many kinds, some of which flourish readily where there are traces of oxygen only, and others where there is an abundance of oxygen. These germs produce the various fermentation of milk, consequently it makes a difference in the character of the fermentation whether there is an abundant supply of oxygen or not. Bacteriologists have shown that where only traces of oxygen are present in a fermenting substance as milk, there is more likely to result from the fermentation products which are really detrimental to the body. Hence the matter of methods of aeration of milk for the addition of oxygen when not properly done naturally is engaging the attention of dairy men.

The agitation of milk aids aeration, and since during the few moments immediately after milking the interchange of gases between the air and milk is greater, it follows that where milking is in process the air must be pure, otherwise the foulness of the air must be incorporated in the milk. What must be the condition of the air in a stall where all sorts of fermentation are going on and in which are odors of diverse kinds. These obnoxious substances are in the air and must pass into the milk with the air. It is well known that the souring of milk is caused by bacteria. These bacteria are in the air, on the hair of the cow, in the dust that may rise from the floor, from the feed, and they may even be on the milker's hands. When these bacteria fall into the milk they begin to grow and soon change the sugar of the milk to an acid, provided the milk is of the proper temperature. A moderate degree of heat is all that is needed.

Milk kept in a deep well, in a spring house, or on ice may remain sweet for some time. The cooling process does not destroy the germs, but simply retards their action. The germs still are there and will cause the milk to sour when a sufficiently high temperature is restored. Boiling from a few minutes to an hour will destroy bacteria, and this is resorted to when disease producing germs are suspected to be present. The boiling, however produces a flavor that is objectionable to some.

Bacteria are important factors in the making of butter and cheese, since upon them depend the flavor. Before cream can make butter of good flavor, it must "ripen," that is, it must be kept at a proper temperature until it sours. We have learned that bacteria brings out the souring process, and upon this the flavor depends. When several species of bacteria work in the same cream, the butter made from cream is poor in quality. Each species produces a flavor peculiar to itself. Expert butter-makers are able to control the species and growth of the bacteria they wish to use to produce a high flavored article. If any bacteria survive after the butter is made, they cause the butter to become rancid. To keep well, butter should have the water well worked out and considerable common salt mixed in to discourage any remaining bacteria.

Cheese making is dependent in the same way upon growth of bacteria. Except in the mechanical process of preparation and the time required to mature, the conditions are not essentially different from those of butter-making.

In most instances, also, vinegar is produced by the direct action of bacteria. The action of the bacteria is upon the sugar in the liquid used. The necessary conditions of temperature and moisture being present, they change the sugar to carbon dioxid, which passes off in bubbles from the surface of the liquid, and alcohol, which later becomes oxidized by the action of other bacteria, make a weak solution of acetic acid, or vinegar. The "mother of vinegar" is only the vast colonies of bacteria grown into a slimy mass. Boiled cider keeps sweet, since the heat killed the bacteria it contains, if kept sealed so that no others can enter.

Fire blight of apple and pear trees, one of the most injurious of fruit diseases, is caused by bacteria. They grow and multiply in the cambium layers, hence the tree suffers, as is shown by the blackened twigs and the withered blackened leaves. The only remedy is to cut away the twig about a foot below the blackened portion. Sometimes it becomes necessary to cut down and destroy the entire tree. After pruning such twigs or limbs as have been thus afflicted, it is best to sterilize the knife blade by dipping it into a solution of carbolic acid, in order to prevent spreading the disease by cutting into the healthy wood of other trees. The germ may also be harbored in the crab, the quince, the hawthorne, etc. They gain access to the tree through the blossoms or through some wound in the bark.

It is difficult to distinguish bacteria from yeasts and moulds without the aid of the best mircroscopes. The study of these micro-organisms is very interesting and highly important. Enough has been given to at least create a desire for further study and experiment.

Nature-Science and Agriculture.

OUTLINE QUIZZES.

(SIXTH PAPER.)

1. Upon what is the best classifications of plants based?
2. What is the form of the fruit in the pulse family?
3. Why are leguminous plants so named?
4. Name the principal plants of the Rose family.
5. What characterizes the flowers of the composite family?

6. What distinguishes the flowers of the mustard family?

7. How would you distinguish the grasses?

8. How are plants dependent upon bacteria?

9. Why is the Hessian fly so called? Where do these flies lay their eggs?

10. Upon what plant do they live? In what way do they injure the plant?

11. What plants are injured by chinch bugs? In what way?

12. Where does the chinch bug deposit its eggs?

13. How long has the cabbage butterfly existed in this country?

14. What are aphidae?

15. Are bacteria plants or animals?

16. Where do bacteria exist? What is their form?

17. How do bacteria reproduce themselves?

18. What is necessary to the development of bacteria?

19. In what condition must the food of the bacteria be supplied?

20. In what ways are bacteria beneficial? In what ways are they injurious?