

NEW ELEMENTARY AGRICULTURE

AN ELEMENTARY TEXT BOOK DEALING WITH THE
PROBLEMS OF THE FARM

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INTRODUCTORY

This is an agricultural nation. The products of the soil are the basis of her industries and her prosperity. The children of our great Commonwealths should be familiar with our crops, our grains and grasses, our flowers and fruits, our trees and shrubs and weeds, our domestic animals and birds and insects. Our children should have a practical knowledge of the management of a farm, of the composition of the soil, and of the adaptability of the farm and its soil for the cultivation of certain plants and the counter effect of such plant growth upon the soil. They should love nature, they should be taught nature's ways and means, taught to observe her phenomena closely and in such a manner that they will learn to love her. Nearly all industries of mankind have their origin in the soil, and children should be led to see the relation between farm labor and its products and the marts of trade and commerce.

Much of the work of the school, including instruction in geography, arithmetic, science, and literature might be correlated profitably with instruction in agriculture and nature study. A school garden with the actual work intelligently directed might prove an inspiration to honest toil and better living. As the effect of teaching vocal music daily in the schoolroom is felt in the church, the Sabbath school, in society, and in all public

gatherings, so the teaching of agriculture and nature study will affect and improve every farm and garden and lawn and flower-box in the neighborhood. The attractions of farm life may be thus enhanced and the exodus to the city diminished.

Instruction in agriculture, properly presented, will increase interest in school life and in farm life. The care of stock, the protection of insectivorous birds, the preservation of game, the engineering of the farm, the great physical universe, will appeal directly to the boys, and the domestic science, including preservation of fruit and dairying and rural economy, will interest the girls. The farm is the groundwork, the backbone, the sinew, of our health, our wealth, our happiness. It must remain so. Keep close to nature for physical, intellectual, and spiritual strength and growth.

The school laws of Nebraska require teachers "to pass a satisfactory examination in the elements of agriculture, including a fair knowledge of the structure and habits of the common plants, insects, birds, and quadrupeds," for second-grade county certificates and all grades above the second. This book has been prepared and published in answer to the direct demand resultant from the law quoted above. We believe that the art of thinking, of reasoning, and of higher and better living can have no higher source and no more pronounced results in any line of school instruction than where children are taught to look "through nature up to nature's God."

The manuscript has been prepared by Dr. Charles E. Bessey, Professor G. D. Swezey, Professor Lawrence

Bruner and Professor H. R. Smith of the University of Nebraska, and Professor R. W. Thatcher of the Washington Agricultural College. Dr. Bessey and Professor Swezey prepared the copy on the "Plants of the Farm." The chapters on the "Weather of the Farm" were prepared by Professor Swezey. Professor Bruner prepared the chapters on the "Insects and Birds of the Farm," Professor Smith the chapters on the "Domestic Animals of the Farm," and Professor Thatcher the chapter dealing with the "Soils."

The illustrations have been drawn from various sources, credit being especially due several government publications and the work of C. V. Riley. Credit is also due to Gray's "How Plants Grow," and to Todd's Astronomy, both published by the American Book Company, for cuts which have been reproduced.

WILLIAM K. FOWLER,

State Superintendent of Public Instruction.

LINCOLN, NEBRASKA, August 1, 1903.

DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

Superintendent W. K. Fowler, Lincoln, Nebraska:

In reply to your letter I have to say that your proposition to have a book written along the lines of elementary agriculture for the use of the public schools is well timed. It will meet a want that has been very pressing. If we could have school-teachers informed along these lines it would be a great pleasure to them and a great benefit to their pupils, and would train young people in the direction of the studies that will control

their life work. There should be a universal demand for such a publication. The gentlemen who are to write it are well known to the educators and scientists of the country, and stand high in their respective specialties. I bespeak a very cordial reception for the publication when it is issued.

Very truly yours,

[Signed] JAMES WILSON,

Secretary.

PREFACE TO THE REVISED EDITION

The demand for the New Elementary Agriculture has grown so fast that it has become necessary to publish new editions from time to time. The few errors in the first edition have been corrected, and all the plates have been carefully revised.

A number of teachers and superintendents have suggested that exercises and questions would add greatly to the value of the book as a text. These appear in the revised edition. They are intended to help the student and also the teacher, who will use many other exercises and questions to add to the interest and value of the class work.

The questions and exercises are the work of Dr. G. F. Warren, Professor of Agriculture, Cornell University; President W. M. Kern, Ellendale, No. Da.; Professor J. W. Searson, Manhattan, Kans.; President C. A. Fulmer, Wesleyan University; Miss Anna E. Caldwell, Kearney; and Professor Goodwin D. Swezey, University of Nebraska.

TEACHERS' MANUAL

SUGGESTIONS FOR THE TEACHER

The following list of U. S. bulletins have been chosen with reference to their use in the public schools of this country and the Iowa and Nebraska bulletins have also been listed with special reference to the needs of those states. These state bulletins may be secured for use in other states when desired.

Agriculture is so comprehensive a study that the best a teacher or text can do is to arouse an interest in the subject, and give the pupils such direction that they can follow up their study in later life, along lines most interesting to their particular community.

This book was designed to bridge over the space between every day life and technical Agriculture and to arouse and stimulate a personal interest in scientific farm methods. It contains that elementary knowledge of Plants, Insects, Weather Conditions, Soils, and Animals which must be thoroughly understood by the pupil before he can intelligently study the various problems that Agriculture presents to the farmer. Since it is impossible to study intensively all of these problems in a short term of school, the authors of this book believe, that rather than to give a bare smattering of everything, the best plan to pursue is to give in the text all necessary, essential elements and to depend upon the teacher, by the use of these bulletins, to bring the subject directly home to her community.

The successful teacher will select two or three bulletins from this list bearing on subjects of particular interest to the children of her school and will supplement the text with these bulletins. In this way she will not only arouse the child's interest by satisfying his curiosity on those two or three subjects, but will also be training him to call on the National Department of Agriculture and his own state institutions so that his work will be of practical future value.

For example: if the community is pestered with the Canadian thistle, enough bulletins concerning this pest should be ordered so that each pupil could have a bulletin. Then when the subject of weeds is studied, the teacher can hand these bulletins around for an intensive study, specimens can be collected, and the methods of extermination suggested by the bulletin put into practice.

The teacher must be prepared, and should select those bulletins which she thinks will be of special interest to her school, and send for them as soon as this course is started. If she explains the purpose for which she wants them she can secure one for each pupil in the class free of charge.

If she should find the children interested in some subject upon which she has no supply of bulletins it is never too late to send.

For the U. S. Bulletins, address,

Department of Agriculture, Washington, D. C.

For the Iowa Bulletins, address,

Iowa College of Agriculture, Ames, Iowa.

For the Nebraska Bulletins, address,

The University Farm, Lincoln, Nebraska.

Every school should order *United States Farmers' Bulletin* 408.

More advanced classes will need *United States Farmers' Bulletin* 409 and *United States Experiment Station Bulletin* 195.

SUPPLEMENTARY MATERIAL BY CHAPTERS

CHAPTER I

Plants, and How They Grow.

(Exercises 1 to 10, also 15 and 16, and 24 to 27 inclusive, and page 11 U. S. Farmers' Bulletin 408).

Bees (U. S. Farmers' Bulletin 397).

CHAPTER II

Seed Testing (U. S. Experiment Station Circular 34)

(Exercises 11 to 14 inclusive, U. S. Farmers' Bulletin 408) (U. S. Farmers' Bulletin 409).

Dodder in Farm Seeds (U. S. Farmers' Bulletin 306).

Fanning Mill used for Selecting Seeds (Nebraska 104).

Cultivation (Exercise 43, U. S. Farmers' Bulletin 408).

Eradication of Weeds (U. S. Farmers' Bulletin 28)

(Iowa 105).

Wheat Grass and Quack (Iowa 11 and 83).

Canadian Thistle (Iowa 12).

Dropseed Grass, Cocklebur, Foxtail, Squirrel Tail,

Mustard, Butter-print, Wild Morning Glory (Iowa

13).

Weeds used in Medicine (U. S. Farmers' Bulletin 188).

The Lawn (U. S. Farmers' Bulletin 248).

CHAPTER III

Gardening.

School Gardening (Send to State Superintendent of Schools, Lincoln, Nebraska, for Bulletin 1, Series IV).

Garden and Potato (Iowa Course 4, Circular 2).

Beans, Peas, etc. (U. S. Farmers' Bulletin 121 and 289).

Melons, etc. (U. S. Farmers' Bulletin 231).

Potatoes (U. S. Farmers' Bulletin 35).

Tomatoes (U. S. Farmers' Bulletin 220).

Asparagus (U. S. Farmers' Bulletin 61).

Mushrooms (U. S. Farmers' Bulletin 204).

Cucumbers (U. S. Farmers' Bulletin 254).

Celery (U. S. Farmers' Bulletin 282).

Trees.

Windbreaks (Nebraska 48).

Planting (U. S. Farmers' Bulletin 134).

Insect Enemies of Shade Trees (U. S. Farmers' Bulletin 99).

Plums (Iowa 114).

Apples (U. S. Farmers' Bulletin 113) (Iowa 1, Iowa Extension 5).

Cedar Apples and Apple Rust (Iowa 84).

Grafting (Exercises 17 to 23, U. S. Farmers' Bulletin 408).

Pruning (U. S. Farmers' Bulletin 181).

Preventing Fruit Diseases (U. S. Farmers' Bulletin 243).

Strawberries (U. S. Farmers' Bulletin 198).

Raspberries (U. S. Farmers' Bulletin 213).

CHAPTER IV

Crops in Western Nebraska (Nebraska 118).

Corn (U. S. Farmers' Bulletin 409).

(Iowa Course 1, Circulars 2, 3, 4, 6, 7, 8.)

(Iowa Course 2, Circulars 1, 3, 4) (Nebraska 25 to 112).

Silos and Silage (U. S. Farmers' Bulletin 32) (Iowa 117).

Wheat (Iowa 16) (Nebraska 89 to 118).

Oats (Iowa Course 3, Circular 3) (Nebraska 113) (U. S. Farmers' Bulletin 395).

Loose-Smut (U. S. Farmers' Bulletin 250).

Plant Diseases (Iowa 104) (Nebraska 113).

Grain Smuts (U. S. Farmers' Bulletin 219 and 250).

Alfalfa Seeds (U. S. Farmers' Bulletin 194 to 339).

Millet (U. S. Farmers' Bulletin 101).

Sorghum and Syrup (U. S. Farmers' Bulletin 135).

Sugar Beets (U. S. Farmers' Bulletin 52).

CHAPTER VII

Grasshoppers (U. S. Entomology Circulars 22, 74, 89)
(Iowa 22) (Nebraska 70).

Corn Root Aphis (U. S. Farmers' Bulletin 59). (Iowa 21).

Pear Slug (Iowa 15) (U. S. Entomology Circular 26).

Spraying Calendar (U. S. Farmers' Bulletin 127). (Iowa 89).

Insect Enemies to Shade Trees (U. S. Farmers' Bulletin 99).

Insect Enemies of Wheat (Nebraska 96).

Codling Moth (U. S. Entomology Circular 171) (U. S. Farmers' Bulletin 283) (Nebraska 51).

Hessian Fly (U. S. Entomology Circular 70) (Nebraska 19).

- Bark Beetle; Fruit Tree (U. S. Entomology Circular 29).
Borers, Apple Tree (U. S. Entomology Circular 32).
Ants (U. S. Entomology Circular 36).
Moth; Clothes (U. S. Entomology Circular 36).
Squash Bug (U. S. Entomology Circular 39).
Cabbage Worms (U. S. Entomology Circulars 60 and 62).
Chiggers or Mites (U. S. Entomology Circular 77).
Fleas (U. S. Entomology Circular 108).
Usefulness of Toad (U. S. Farmers' Bulletin 196).

CHAPTER VIII

- Birds, Useful and Harmful.
 (U. S. Year Book Reprints 197, 443, 486).
 (U. S. Farmers' Bulletin 54).
Poultry (U. S. Farmers' Bulletin 41 and 141).
Chicken Lice (Iowa 18).
Chicken Mites (Iowa 19).
Eggs (U. S. Farmers' Bulletin 128) (Iowa 17).
Standard Varieties of Chickens (U. S. Farmers' Bulletin 51).
Turkeys (U. S. Farmers' Bulletin 200).
Ducks and Geese (U. S. Farmers' Bulletin 64).

CHAPTERS X TO XIV

Send to Department of Agriculture, Washington, D. C.
and ask to have daily weather maps sent you free.

CHAPTER XV

- Soils (Exercises 28 to 46, U. S. Farmers' Bulletin 408) (Iowa 2). (Pages 2, 44, 83, 91, 107, 157 *Condra's Geography of Nebraska*, for sale by *The University Publishing Company, Lincoln, Nebraska*).
- Nitrogen Cultures (U. S. Farmers' Bulletin 315, 316, 318) (Iowa 2).
- Manures (U. S. Farmers' Bulletins 44, 77, 192) (Exercise 46 U. S. Farmers' Bulletin 408) (Iowa 1) (Nebraska 114).
- Drainage (U. S. Farmers' Bulletin 187) (Exercise 45, U. S. Farmers' Bulletin 408) (Nebraska 41, Article V) (Pp. 43, 44, 52, 53, 55, 89, 163, *Condra's Geography of Nebraska*, for sale by *The University Publishing Company, Lincoln, Nebraska*).
- Rotation (U. S. Farmers' Bulletin 337).

CHAPTER XVI

- Horse Feeding (U. S. Farmers' Bulletin 170).
- American Carriage Horses (U. S. Animal Industry Circular 113).
- Glanders and Farcy (U. S. Animal Industry Circular 78).
- Loco Weed (U. S. Farmers' Bulletin 380).
- Lumpy Jaw (U. S. Animal Industry Circular 96).
- Horseshoeing (U. S. Farmers' Bulletin 179).

CHAPTER XVII

- Dairy Cows (U. S. Farmers' Bulletin 55 to 106) (Iowa 3) (Nebraska 101).
- Milk (U. S. Farmers' Bulletin 42, 63, 413).

- Butter (U. S. Farmers' Bulletin 201) (U. S. Animal Industry Circular 56).
Cheese (U. S. Farmers' Bulletin 166).
Growing Feeder Steers (Nebraska 105, 117).
Feeding Cattle (Experiments Nebraska 85).
Beef Production (Nebraska 90, 93, 100, 116).
Dehorning Cattle (U. S. Farmers' Bulletin 350).
Loco Weed (U. S. Farmers' Bulletin 380).
Black Leg (U. S. Animal Industry Circular 23, 31).
Foot and Mouth Disease (U. S. Animal Industry Circular 38, 141).
Scabies (U. S. Farmers' Bulletin 152).
Ticks (U. S. Animal Industry Circular 97).
Butchering, Keeping, Curing (U. S. Farmers' Bulletin 183).

CHAPTER XVIII

- Swine (U. S. Farmers' Bulletin 205, 183) (Iowa 4) (Nebraska 94, 99, 107).
Foot and Mouth Disease (U. S. Animal Industry Circular 38, 141).

CHAPTER XIX

- Sheep (U. S. Farmers' Bulletin 49) (Iowa 63)

CHAPTER XX

- An excellent High School course in animal production can be secured by sending to the office of Experiment Stations, Washington, D. C., for Circular 100.
Domestic Science for Iowa Girls.
Cooking Course 5 (Circulars 1 and 2 Iowa).
Sewing Course 6 (Circular 1 Iowa).

Washing Course 7 (Circular 1 Iowa).

Dust Course 7 (Circular 2 Iowa).

Fire Course 7 (Circular 3 Iowa).

Laundry Course 7 (Circular 4 Iowa).

Send for new Iowa Bulletin on "Household Work."

Domestic Science for Nebraska Girls.

Send to State Department of Public Instruction,
Lincoln, Nebraska, for:

Sewing (Series II, Bulletin 10).

Cooking (Series II, Bulletin 11).

Sewing and Cooking (Series II, Bulletin 17).

Irrigation—Farmers' Bulletins.

138. Irrigation in Field and Garden. P. 40, fig. 18.

158. How to Build Small Irrigation Ditches. P.
28, fig. 9.

263. Practical Information for Beginners in Irriga-
tion. P. 40, fig. 25.

371. Drainage of Irrigated Lands. P. 52, fig. 19.

373. Irrigation of Alfalfa. P. 48, fig. 32.

Dry Farming (Nebraska 118) (Exercise 43, U. S. 408).

Good Roads (U. S. Farmers' Bulletin 311, 321, 338).

The following is the list of all bulletins mentioned in
the above outline:

UNITED STATES BULLETINS.

Teachers should send to the Department of Agriculture,
Washington, D. C., for the following free bulletins. Send
at the beginning of the term so that the material will be
at hand when needed:

- Farmers' Bulletins Nos. 28, 32, 35, 41, 42, 44, 49, 51, 52, 54, 55, 59, 61, 63, 64, 77, 99, 101, 106, 113, 121, 127, 128, 134, 135, 138, 141, 158, 166, 170, 179, 181, 183, 187, 188, 192, 194, 196, 198, 200, 201, 204, 205, 213, 219, 220, 231, 243, 248, 250, 254, 263, 282, 283, 289, 306, 311, 315, 316, 318, 321, 337, 338, 339, 371, 373, 380, 395, 397, 408, 409, 413.
- Bureau of Animal Industry Circulars Nos. 38, 56, 78, 96, 113, 141.
- Bureau of Entomology Circulars Nos. 22, 26, 29, 32, 36, 39, 60, 62, 70, 74, 77, 89, 108, 171.
- Experiment Station Bulletin 34
- Year Book Reprints Nos. 197, 443, 486.

IOWA BULLETINS.

- Teachers can receive all of the following bulletins free by writing the Iowa College of Agriculture, Ames, Iowa:
- Farmers' Bulletins Nos. 1, 2, 3, 4, 11, 12, 13, 15, 16, 17, 18, 19, 21, 22, 63, 83, 84, 89, 104, 105, 114, 117.
- Extension Courses: Course I, Circulars 2, 3, 4, 6, 7, 8; Course II, Circulars 1, 3, 4; Course III, Circular 3; Course IV, Circular 5; Course V, Circulars 1, 2; Course VI, Circular 1; Course VII, Circulars 1, 2, 3, 4.

NEBRASKA BULLETINS.

- May be secured free of cost by addressing The University Farm, Lincoln, Nebraska.
- Bulletins: 19, 25, 41 (Article V), 48, 51, 70, 85, 89, 90, 93, 94, 96, 99, 100, 101, 104, 105, 107, 112, 113, 114, 116, 117, 118.
- State Department of Public Instruction.
- Series II, Bulletins 10, 11, 17. Series IV, Bulletin 1.

THE PLANTS OF THE FARM

CHAPTER I

WHAT IS A PLANT AND WHAT IS IT DOING?

The farmer is the man upon whom we must mainly depend to feed the world. We cannot take food from the earth. We may fish a little of it out of the sea; we may find a few things that we like growing wild; but the grain, the fruit, the vegetables, the pork and beef—in fact, about everything we care to eat—must come from the farm. The farmer then must know how to raise the plumpest kernels of wheat, the tenderest meat, the finest fruit and vegetables, and how to raise the most of them, if he would do his part in furnishing the vast supply of food which the world needs; and he will do this all the better if he understands something of that wonderful process by which the minerals of the soil, and the gases of the air, and the water in the falling raindrop are brought together and built up into food for man and beast.

For the farmer cannot mix together the minerals and the water and the air and make out of them anything good to eat. True, there are a few things that we eat which come from the mineral world; but these, like salt for example, are after all not really foods; they may season our food, but they cannot feed us. All our food,

everything that can really nourish us, comes from plant life. Even the beef and mutton and pork, yes, even the fish of the river, have to feed on plants in order to furnish us food.

Plants Alone can Manufacture Food.—The farmer then must first of all make friends with the plant; for the plant must be his chief helper in feeding the world. He must, also, as we shall see, make friends with the sunshine and the soil, and even with the birds and the insects, for they, too, can help him somewhat; but the plant must be his right-hand man; for the plant can do what no one else in the world can do, not even man himself; it can take the minerals and the water of the soil, and the gases of the atmosphere, and build them up into starch and sugar and other things that go to make our food. The chemists have tried to put together these materials and construct food products out of them, but they have not yet succeeded; perhaps they will some day, but at present the only known way in which any of the foods of man or beast can be constructed, is to put a seed into the ground and let the growing plant, with the aid of the sunshine, build and store up for us in its own tissues the food which alone can nourish our bodies.

What the Plant is Trying to Do.—Let us see, then, how the plant does this wonderful thing which it alone can do. Let us trace its life history from the time it is a tiny seed until it is a full-grown plant, bearing somewhere about it, in the kernel perhaps, or in its root, a supply of food for man or beast. What is a plant anyway, and what is it trying to do? For a plant is a living thing just as truly as a man, and it has a purpose of its own

to accomplish just as much as the farmer has; and its purpose is not so very different, either, from that of an intelligent and prudent man. It has two main objects in life: first, to make a living for itself; and second, to provide something for its offspring so that they may get a fair start in life when the parent plant is dead and gone. For the plant is a living thing; it must eat and drink and breathe; it almost seems as if it could think and plan for itself.

How the Young Plant Gets its Start in Life.—And so we will begin with the seed, and see what the parent plant has done for it and what it can do for itself. The seed is generally a tiny young plant with a supply of food laid up for it to feed upon until it is old enough to get a living for itself. Take a kernel of corn and pull away the skin which covers the hollow on one side of the kernel. Under it lies the young plant, or germ, consisting of a leaf or two, not thin and green as they will be when they have grown up into the sunlight, but thick and plump and yellow. The rest of the kernel is mostly starch and gluten, which make very good food for the young plant. When the seed is put into the

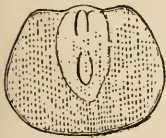


FIG. 1. The germ in a kernel of corn.



FIG. 2. The corn germinating.

ground the germ feeds on this rich store of food which the parent plant has provided; its little leaves rapidly grow upward to the air and sunshine, while its roots as

rapidly push downward into the soil in search of food and drink, and by the time the store of food is all used up the little plant is able to get its own living.

Examine the bean. Here the seed—that is, the germ—can be split into halves. These are the first two leaves of the young bean-plant joined together at the base by a very short stem. Between them you will find another tiny leaf or two which will also push their way up into the air when the bean is planted. Now, the first pair of leaves, that is, the halves of the bean, are so thick and white because they are full of food stored in them by the



FIG. 3. The bean split to show plantlet.

parent plant for the purpose of feeding the growing plant. When the bean is planted, these two plump leaves will come up out of the ground and will then gradually yield up their extra store of food for the larger growth of the other little leaves and of the root until, as before, the plant is strong enough to get its own living out of the soil and the air. In the corn, then, the seed consists of a germ with food stored around it in easy reach, while in the bean the whole seed is the germ with the food stored in it; that is, in the first pair of leaves.



FIG. 4. The bean germinating.

Now the Young Plant Must Make its Own Living.—After a little the young plant will have used up its store of nourishment and must shift for itself. Like the young man starting out in life, it must take up seriously the problem of making a living, and it must manage to get its food out of the soil and the air. This the plant cannot do alone any more than man can. It must have the help of the sun. While it was living on the rich food which the parent furnished it, the young plant did not need the help of the sun. It could grow in a dark cellar, as the sprout of the potato often does. But building up food out of mineral matter and water and the gases of the atmosphere is not so easy a matter, just as the young man sometimes finds that it is not so easy to make a living after the money which his father gave him to start with is all spent.

How the Sunshine Helps.—The only force that can put together the minerals and the water of the soil and the gases of the air so as to form starch or sugar or any similar food product is the sunshine, and the only workshop in which this can be done is the green part of a plant. So we see how the farmer must make friends of both the plant and the sunlight if he would succeed in his task of raising something to eat. We do not know yet just how the sunshine manages to combine the materials which it has to use so as to form starch or sugar or other foods, but we do know that starch is composed of three elements which are plentifully found in the earth and air. These elements are carbon, oxygen, and hydrogen. Carbon is a black, solid substance; a lump of hard coal is mostly carbon; there is, also, plenty

of carbon in the atmosphere, existing in a gaseous form, combined with other elements. Oxygen and hydrogen are also gases, and water is nothing but these two gases combined and condensed into a liquid. But no one can take a piece of coal and mix it with water and make starch out of it. Nor can he get the carbon out of the air and combine it with water any easier. And the plant is as helpless as we are about it except there come to its aid the power of the sunshine. And the sunlight can accomplish no more than the rest of us unless it finds the necessary materials in the right place; it can do nothing at all with them when the water vapor and the carbon gases are floating about in the atmosphere; it can do nothing with them if it finds them in the ground; it is only when the plant has brought them together in its own green leaves that the sunshine can act upon them. And so the leaf is a loose, porous tissue into which the gases find their way; and the stem of the plant is a sort of pump to bring up the water from the soil into the leaves. Now, when the sun shines upon a leaf with the water and the gases in it, the sun can do its work; it can build up these materials into food for plant and man.

Why are the leaves put so high up that the plant has to pump water up to them? Evidently because they must be up in the sunshine or else the sun could not do its work. Why are they so thin and flat? Because there must be plenty of chance for the gases to get into them and for the sunshine to fall upon them. Why are there so many of them? If one could take all the leaves of a great tree and spread them out on the ground,

they would probably cover several acres, but on the living tree they are all bunched together so that the tree does not take up very much room while yet the atmosphere and the daylight can get to the leaves; the same is true of a field of wheat or corn. Evidently this is a wise contrivance to enable the plant and the sunshine to construct a great deal of food in a small space. If the plant generally had thick leaves and only a few of them, as some plants do, or if the leaves were spread out in one great sheet, our farms would hardly be big enough to raise enough to eat. And why do most plants and trees lose their leaves in autumn and get new ones in the spring? Because during the winter it is too cold for the plant to build up any food, and so it has no use for leaves. In the tropics most plants are evergreen; that is, they keep their leaves all the year around because it is warm enough for them to be at work throughout the whole year.

How the Plant Stores up its Food.—But if the plant food is built up in the leaves only, how does it get to the stem or other parts of the plant, where it is needed for growth, or to the seed or root, where it is wanted for storage? It must first be turned into sugar and other substances which will dissolve in the sap and thus be able to pass into other parts of the plant; and so this quantity of plant food which the sun is making in the leaves of the growing corn is first converted into sugar, and other soluble substances, then dissolved into sweet sap and carried off where it is wanted. The stem of the growing corn, as every farmer's boy knows, is full of sweet sap. In fact, most plants have a sweet tooth,

and their growing tissues are mainly fed on this supply of sugar.

But not all of this sugar is used immediately in the growth of the plant; some of it will be stored up for later use in the root or in the seed or somewhere else in its tissues, and it is just here that the plant can be of so much use to the farmer; this food which it has stored up for its own use is not only good for the plant to feed upon, but for the food of man and beast as well. In short, the plant, and the plant alone, can build up from the lower world of mineral matter the food which can supply its own needs; and then the animals and man can use the same plant food to sustain their own higher life.

Now, let us see how cleverly the plant manages this matter of storing up food. Although it is sugar in the sap mainly that plants feed upon, it would hardly do to store up food in the form of sugar. It would be too easily dissolved and wasted. The plant has no dry bin or cellar in which to store its products. There is where the farmer may help the plant. Yet the plant in a wild state cannot help itself; it cannot build a dry granary in which to store its food. So having first manufactured a lot of sugar which can be dissolved and carried from the leaves to the proper parts of the plants, it now turns the sugar back into starch or some other insoluble form in order that it may not be dissolved and wasted. For starch and sugar, although they seem so different, are chemically very much alike. They are composed of the same elements, carbon, oxygen, and hydrogen, and the plant is chemist enough to change the sugar into starch or the starch into sugar according to its needs.

So a grain of wheat is mostly a mass of starch, as dry and hard and compact as the plant knows how to make it. And so is a grain of oats, only the latter is still further protected by a tough, dry hull wrapped around it. Truly the parent plant has made the best provision it could for this little package of starch. Now, if the farmer comes along and stores it in a dry granary, so much the better. But the wheat plant would not like to depend upon that, for in the wild state the grain would have had to lie out on the ground in the winter in order to sprout in the spring; and it can do this if necessary without much danger of harm. But plainly it would not have been a good plan to leave the food stored in the condition of sugar instead of starch, for it would easily be wasted away and lost.

What the Flowers are For.—The plant has germinated and grown and reached maturity; it has made a living for itself, and has even laid up something for the future. It must now attend to the other duty of its life; it will soon grow old and die, so it must bear seeds in order that its race may not perish from the earth; and this is, perhaps, the most wonderful part of the plant's life and growth. For the purpose of producing seeds, the plant must go through the flowering process. Perhaps we think of flowers as something made chiefly to be beautiful rather than useful; but in plant life as in human life it is more important to be useful than to be beautiful, and so the flower is not primarily made to look handsome, but because its beauty, as we shall see, can be made very useful in the development of the seeds of the plant.

What then do we mean by a flower, and what has it to do in the production of seeds? The essential parts of a flower are two: the pistil, or the little pod in which the young seeds are developed; and the stamens, or little sacs which contain the pollen, or yellow dust, which must fall upon the immature seeds and fertilize them in order that they may be able to grow.

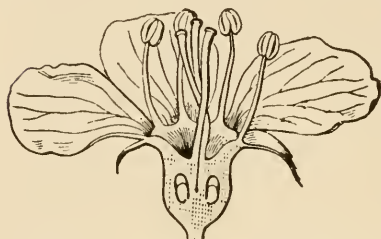


FIG. 5. Section of wild apple-blossom.

Thus in the apple-blossom the pistil is the young apple, the stamens are the cluster of little slender stalks within the flower, each with a sac at the end which when ripe will shed a shower of golden dust if you crush it.

How the Bees Help.—Besides these essential parts of the flower there are the beautiful pink and white petals which we so much admire; and well we may, for what is there more beautiful or fragrant than an orchard of apples or cherries or plums in bloom? And, perhaps, we have thought that they were made so attractive chiefly to make us glad with their beauty, and have forgotten that the flowers are first of all for the plant and only secondarily for us. And now we shall see what the beauty and fragrance are for; the pollen might fall upon the young seeds in the same flower and fertilize them, but it is better for the plant if they are carried to some other flower instead. However, the tree is rooted in the ground and cannot visit some neighbor

tree to exchange pollen with it. So here again we have another example of that beautiful system of co-operation of which we have already seen so much, as we have learned how farmer and plant and soil and sun



Fig. 6. Bees distributing pollen.

must work together to accomplish what neither of them could do alone. What new help can the farmer call to his aid to carry the pollen from tree to tree? It must be some one provided with wings and some one willing to work. Who then better than the bee? And so the bee, coming out of one flower with her head pow-

dered with the yellow pollen and flying away to push it into another, may think that she is only getting honey for her own use, but she is really doing a very important and necessary service for the plant, and for the farmer and the world as well, by distributing pollen from plant to plant. And now we see what the showy pink and white blossoms are for, standing out so conspicuously against their back-

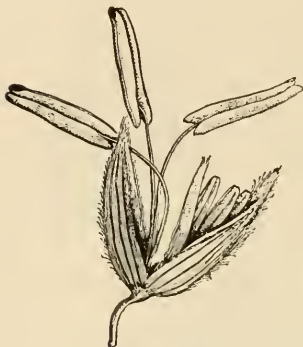


FIG. 7. Staminate flower of the corn.

ground of green leaves. They are to catch the eye of the bee and guide her to her work. And we see why flowers are generally fragrant, for the bee knows very well what that odor means long before she can see the flowers. And we see why a little honey is stored in each blossom. If it were not for the honey, the bees would soon quit their job; and be-

sides, it is only fair play between the plant and the insect, that as the plant gets its pollen carried for nothing it should at least board the helper while she works.

How the Wind Distributes the Pollen.—But some plants do not depend upon the insects for this service, and when they do not, there is no use for showy flowers, or fragrance, or honey. For example the corn is not ordinarily thought of as having flowers; yet it does possess the essential parts of a flower. The tassel furnishes the stamens and in the proper season they shed a per-

fect shower of pollen. And each young kernel of corn is a pistil which is to ripen into a single seed; each kernel has a long slender tube, the silk, reaching out to get the grains of pollen, one silk from each kernel of the ear. Now we see why the stamens are put at the very top of the plant instead of close to the ovary, as they are in the apple - blossom; since the corn-blossoms have neither the showy petals

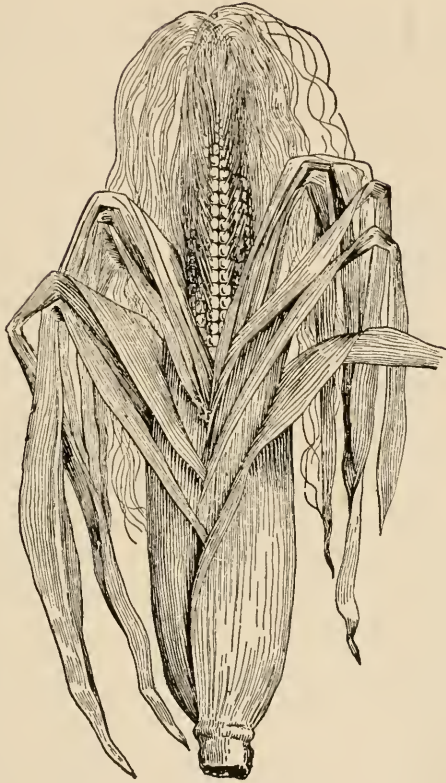


FIG. 8. Pistillate flower of the corn.

and penetrating fragrance to attract the bee, nor the honey to reward her services, the corn plant must depend upon some other helper which does not care for honey, and this time it is the wind. When the pollen

sacs are ripe, and just at the same time the silks have pushed out their ends from the tip of the young ear, the pollen dust may be found for a few days flying thick about the field. The tassels are high up where they can catch the breeze; or, if the wind does not blow, the pollen can at least fall upon the ears of the same plant. So the pollen reaches the young silks and usually enough of it to fertilize almost every kernel in the ear. This is always a critical time in the life of the corn plant; sometimes a few days of hot, dry winds just at this season will wither up the moist tips of the silks before they can catch the pollen, and in that case the kernels of corn will not mature; and although the stalk and leaves of the corn may be green and the plant may look quite thrifty, there will be no good ears of corn, and both the corn plant and the farmer will feel that their labor has come to naught.

Giving the Young Plant a Fair Chance.—When the young seeds have been fertilized by the pollen, and the little germ has been produced, there are just two duties which remain for the parent plant to do for its offspring; then its life work will be done, and well done. It must lay up the store of nourishment which the young plant will need while it is getting roots and leaves of its own, and it must, if possible, provide some means by which its numerous offspring may scatter themselves about a little before they settle down and root themselves to the ground where they must ever after remain to fight the battle of life. If the seeds féil near together they might be so crowded that none of them could get a good chance at the sunshine. They will have plenty of strange

and unfriendly plants to contend with any way, without having to struggle with their own brothers for a chance to live and grow.

How the Seeds are Scattered.—Let us notice a few of the many devices by which this scattering of seeds is accomplished. Every thoughtful farmer boy or girl can call to mind a variety of such devices. How many plants can you think of, or find growing, in which, as in the cottonwood or the milkweed, every little seed is provided with a tuft of hairs so that it may be carried by the wind? How many winged seeds do you know where wings serve the same purpose as a tuft of hairs?



FIG. 9. Seed of the milkweed.



FIG. 10. Winged seeds of ash, elm, and maple.

In the catalpa, perhaps, you will hardly know whether to call it a wing or a tuft of hairs; but any way, it serves the same purpose. How many seeds do you know that are provided with hooks or barbs or rough surfaces so that they may cling to the clothes of man or to the fleece of animals, and so be carried free of charge on their journey from the parent plant to their new homes? Such cases as these are familiar to every one who has watched attentively the growth of plants. Perhaps some other modes of travel, although equally familiar, may not have been thought

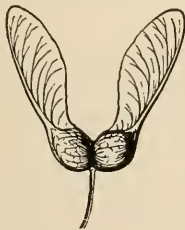




FIG. 11. Seed
of bur marigold

of as designed for this purpose; there are the tumbleweeds, in which the plant grows stout and bushy, its stiff branches making the whole plant a loose, round ball, which, when the seeds are ripe, is torn loose from the ground by the wind and goes rolling across the prairie scattering its seeds by the way.



FIG. 12. Seed
of cocklebur.

And thus in a great variety of ways nature has provided for the distribution of seeds so that they may reach favorable locations in which to strike root and grow and again produce their kind. Some plants even provide their seeds with the means of burying themselves in the ground. Some of the grasses, for example, have a seed with a long awn, or bristle, attached. Perhaps you did not know what these were for, except that they make good darts to throw at your playmates. But these long, stiff bristles twist up when dry and straighten out when wet; so when they fall in the tangled grass every successive drying and moistening pushes the sharp pointed seed into the ground until it has planted itself.

Surely these are wonderful contrivances in which the plant first looks out for its own life and then provides for its offspring. What more could any little plant ask than that it be sent out into the world on the wings of the wind, dropped where it will have room to grow, sometimes even pushed down into the warm earth, provided at the outset with food enough to last until it

can make its own living, the food well selected and well preserved and commonly packed in a nearly waterproof case. Even the tastes of the young plant are not forgotten. We have seen that although plants like best of all the sweet sugar of the sap for their food, it was rather necessary that the parent plant should convert it from sugar into starch for safe storage. But we are not quite at the end of this wonderful, true story; the little plant is to have its sugar after all; in fact, it could not possibly eat the starch. When the grain is softened by the warm moist soil in the spring, the first thing that will happen will be that the starch is again turned back into sugar; again it will be dissolved into sap, and in this condition will be carried up to feed the tissues of the growing plant. It certainly does almost seem as if the plant was not only a living thing, but that it could even think and plan. Any way, if it cannot, the wise Creator must have done a great deal of thinking for it.

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1. What are the main objects in a plant's life?
 2. How does the parent plant give the young plant a "start in life"?
 3. What things are necessary in order that a plant be able to prepare food?
 4. How does plant food get from one part of the plant to another? Why is it stored as starch rather than as sugar?
 5. Bring in seeds that illustrate the different devices for seed distribution. Why is it necessary that seeds be scattered?

See page 195 for exercises and page 198 for free references, which your school should not fail to secure. These exercises are to be taken up in connection with pages 1 to 50 of the text, as the class is prepared for them.

CHAPTER II

HOW THE FARMER CAN USE THE PLANT

Now that we have learned what the plant is trying to accomplish in the world for itself and its offspring, we can better understand how the farmer may use the plant to further his own ends—the feeding of himself, his domestic animals, and the world.

In the first place, he will choose carefully among the many plants which he might use, those which will best serve his purpose; then he will try to improve these plants so that they will be still more useful; and finally, he will assist the plant in every way he can, by giving it a suitable soil in which to grow, by enriching the soil itself with such fertilizers as the plant will like best and thrive most upon; he will take the side of the plant in its struggle with insect enemies and with other plants which would, if they could, crowd it out of the field or choke its healthy growth; he will keep the soil in good condition about it so that its roots may get as much moisture as they need; he will even turn physician if necessary, and by spraying the plant with various mixtures, will help it to combat some of the diseases to which it may be subject. In short, he will help the plant to make the most of itself in every way he can. All this calls for a great deal of thought and care on the part of the farmer, and for a good knowledge of the plant and its needs.

What Crops to Grow.—Plants are as different from each other as people are; probably more so; in fact, they may almost be said to have dispositions of their own. Some plants seem bent mainly upon making a living for themselves; others seem to be more concerned in giving their offspring a start in life. The former grow plenty of stem and leaves of their own, but they produce very small seeds. In such cases, however, they often produce a prodigious number of them. They seem to go on the plan of living well themselves and producing enough seeds so that even if the most of them do die, yet probably somehow there will be enough of them that will manage to live that the family name will not be cut off from the earth. Naturally such plants would not be the kind the farmer would choose; their little seeds would be too poorly provided with food to serve his purpose. Other plants produce but modest stalks of their own, just enough to support the seeds and to supply them with abundant nourishment and give them a good start in life; such plants often produce but few seeds, so that every one of them may be well provided for. One of the noblest is the Indian corn; commonly a stalk will not undertake to bear more than one or two ears, just what it can well mature, but what great magnificent seeds the kernels are, in which each little seed, as we have seen, is embedded in a rich mass of food; a royal crop indeed is the corn. So is the wheat and the rye, and so would the oats and barley be were it not that they are so anxious for the safety of their seeds that they take the extra precaution of wrapping them in a hard, indigestible shell. The horses and cattle do

not mind this, but it is rather too much trouble to get these hulls off for us to make much use of them for human food.

Equally rich in provision for their offspring are most of the vegetables from the garden. First among these is the potato, with its huge tubers of starch for the young plants to feed upon when the tubers are planted in the spring. Naturally such plants as these have been chosen by the farmer as his allies and helpers in the business of food-production.

Varieties can be Improved.—In the second place, it has been possible to greatly improve the farm crops in just the way that they are already so good. Let us remember that the part of the plant in which the farmer is chiefly interested is not generally the stem or the leaf. All he cares about these parts is that they be vigorous enough to enable the plant to grow a large rich kernel or fruit, or some other part in which food products are stored. Having found some plant which tended in the first place to grow large kernels or luscious fruit, men have been trying ever since these plants were discovered in their wild state to make them grow still fatter kernels, or larger, sweeter fruits. This can be done, partly by fertilizing the soil and by proper cultivation, but more yet by selecting for seed the most promising varieties, so that we may get better and better kinds of grains and vegetables and fruits.

How the Farmer can Help the Plant.—Now, when the farmer has found a noble species of plant to grow in his fields, and has gotten a choice variety of it, it is his business to give the plant every assistance in his power

in making the most of itself. He must plow the ground deep so that its roots may find a loose soil in which they can easily push their way down where moisture is plenty; he must plant the seeds at the right time and at the right depth; he must know how thickly to seed the ground so that the plants may fully occupy the soil and use all the moisture that it can furnish, and yet not so thickly that they will crowd each other for room; he must kill the weeds that start, especially at the very outset of the season, when the crop is young and feeble. If his plants have gotten a good start the weeds will not matter so much. It would be only a waste of time to kill the weeds in the cornfield after the corn has reached a good height. It will then be able to take care of itself and a few weeds struggling for a living in the shade of the cornstalks will not amount to much, and will eventually be plowed under to enrich the soil for another year.

Breaking the Crust to Keep in the Moisture.—But the farmer must cultivate the soil for another reason than merely to kill weeds, and that is to keep the moisture in the ground as much as possible for the use of the crop. When it rains on a cultivated field, a little crust forms as the ground dries off and this porous crust acts much as a wick does in a lamp; it sucks the moisture up from the ground and lets the sun and the wind dry it out and carry it off and waste it; if now this surface crust is broken up by the harrow or cultivator, even if there is not a weed to be seen, it is a great help to the growing plant; for the moisture in the soil, finding a thin layer of loose, dry dirt on top, cannot escape up through it to the air above, and so it remains in the

soil down where the roots of the plant can find and use it. This surface cultivation after each rain for the purpose of breaking up the crust and leaving it like a loose mulch that keeps the moisture down is especially important in a region like Nebraska, where the sun and the wind have such a drying effect.

What is a Weed?—Of course one of the best ways in which the farmer can assist the plant is by keeping down the weeds which might get the better of it. The weed, like any other plant, has its own ends to gain. It, too, is trying to make a living and to provide for its offspring. Commonly the strong point with a weed is the getting of its own living, rather than the making of any very generous provision for its offspring. In fact, by a weed we generally mean, not a vicious sort of a plant, that stings us or poisons us, not always an ugly plant, for some of the weeds have very beautiful flowers; a weed is any particularly vigorous plant which is abundantly able to look out for itself, but generally lays up such little provision for its offspring that it would not be of much use for the farmer to encourage it for any food products which he could get out of it. So he prefers to take sides with the corn and the wheat and the potato, rather than with the purslane or the pigweed, or even with the wild morning-glory with its beautiful blossoms.

Habits of Different Weeds.—And yet the weed, because it is so well able to take care of itself, is not a plant for the farmer to make light of. Commonly it is a foeman worthy of his steel. Let us take a few familiar examples and see how it is that weeds are such vigorous contestants in the struggle for existence with the farmer

and his crops; and we shall discover, too, a great variety of devices which different weeds have for getting the better of their rivals in the field.

Some of them, like the quick-grass and the wild morning-glory, or bindweed, are almost impossible to kill out by any ordinary process of weeding; not because they are so numerous, for they produce but few seeds, so that we do not have a whole carpet of young plants covering every furrow and ridge after a rain, as we do of some kinds of weeds; but because when one of these morning-glory seeds gets a start, it rapidly spreads in all directions, covering the ground with its tangled mass of clinging vines; and it is able to do this mainly because it has a peculiar kind of underground branches which hide away out of your sight: slender white branches which burrow in the ground where you cannot well get at them; branches without green leaves and which, therefore, could

not make a living for themselves and would quickly perish were they not fed by the living plant above. These underground branches spread in all directions, striking root here and there and sending up numerous other branches to add to the tangle of vines above ground. It does not do much good to clip off the plant with a hoe nor even to pull it up, for you cannot pull up

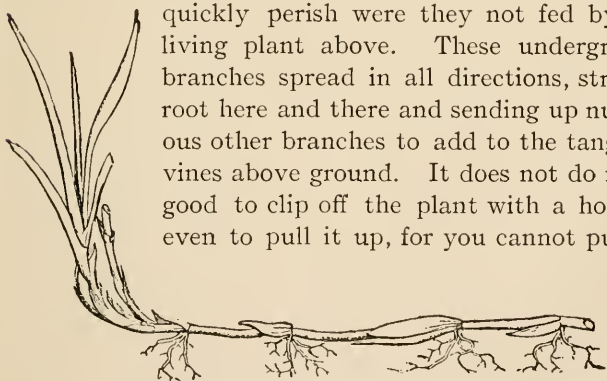


FIG. 13. Underground stem of quick-grass.

with it its numerous underground branches; these remain unharmed and will quickly send up new vines to replace the old. It is of no use even to tear to pieces the underground plant with a cultivator, for unless you can actually get it out, root and branch, you have only broken up a single plant into a number of separate plants, each capable of living and sending up new leafy vines.

Another vigorous grower, and one of the most troublesome of weeds, is the purslane plant, so that to be "as mean as pusley" has become a byword. Did you ever stop to consider the points in its make-up which give the purslane its staying qualities? You will find that it lives and thrives in a very different way from that in which the bindweed does. The purslane is a hot-weather plant, and does not get in its work until the season is well advanced, and it does not need to. It has a thick juicy stem covered with a tough skin, so that while other plants wilt and wither under a scorching sun, the purslane does not even feel thirsty. Again, it has a habit of bushy, spreading growth which well shades the ground and keeps the moisture in it; it is always damp under a big purslane plant, no matter how dry the field may be elsewhere. If you hoe it off at the surface of the ground and do not take the precaution to turn it bottom side up, it is very likely that its pulpy stem will live long enough without drying up to strike root again, especially if there should be a shower of rain to moisten the ground, so that it goes on growing very much as if nothing had happened. Really about the only way to be sure you have killed it is to

feed it to the pigs; and even then if your hoe has happened to cut it off a little above the ground, you are pretty sure to leave a bud or two on the stump, which, with a good root to nourish them, will quickly reproduce a new crop which rises to greet you serenely at the next hoeing time. Finally, it is a plant which produces a prodigious number of seeds. Finding a thrifty purslane plant almost as large as a bushel basket, the author once made a rough estimate of the number of little seeds it bore. Taking as nearly as he could tell one-tenth of the whole plant, he counted the number of seed pods on it, then broke open a number of them and counted their seeds, so as to get some idea of the average number in each pod. It was found thus from calculation that the whole plant must have borne something like 100,000 seeds. Try it for yourself some time and see what results you get.



FIG. 14. Many-seeded pod of purslane.

If this number of seeds were planted a foot apart, so as to cover the ground with a new crop of purslane, that one plant would have seeded more than an acre. Do you wonder that the more modest plants of the garden need the aid of man in their struggle for existence with such an aggressive rival?

Plant Diseases.—Plants, as well as animals and man, are subject to certain diseases, which the farmer ought to understand since, in many cases, it is possible for him to doctor his crop of plants and vegetables with certain spraying mixtures or in other ways to help them to get well. Most of such plant diseases are due to the growth of a minute fungus in some part of the plant itself;

sometimes in the leaves, sometimes in the stem, or it may be even in the fruit or the grain. This fungus is itself a little microscopic plant, whose tiny seeds or spores are easily blown about in the wind. If they fall upon a suitable plant and upon the right part of the plant, they will germinate and grow, pushing their minute branches into the plant itself and feeding upon it; perhaps even killing it, or at least producing diseased places in it.

Thus the smut of corn and other grains, which swells and distorts the kernels and turns them into a mass of black powder, the mildew, which forms whitish patches on the leaves of many plants, and the rust, which produces reddish spots on leaves and stems, are all species of fungi, and they sometimes do considerable damage. Spraying with various poisonous liquids will kill many of these fungi and often it will be worth while for the farmer or gardener to do this. Scab on potatoes and apples, blight which shrivels up the twigs of fruit-trees, and even rot, which affects potatoes and fruits,—these and many other diseases are caused by different species of fungi, and many of them can be prevented or destroyed by understanding their various habits and peculiarities and knowing what remedy to apply.

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1. How can we improve the varieties of plants?
 2. Why do we cultivate the soil? Does cultivation do any good when there are no weeds? How?
 3. Make a list of the ten worst weeds of the neighborhood. What is the character that makes each one a bad weed; that is, able to live in spite of man? Tell how each one can be most easily kept down.

CHAPTER III

DIFFERENT CLASSES OF FARM PLANTS

We have now learned what a plant is and what it is trying to do for itself and also how the farmer can use it and co-operate with it so as to serve his own ends as well as those of the plant itself. We have found that different plants possess very different traits and peculiarities, and have very different and peculiar ways of making a living. Let us now see how the different habits of plants may be made to furnish the farmer not only food, which is the matter of first importance, but also fuel and shelter and shade and ornament and many other things to make his life more comfortable and happy. Almost every class of plants has some peculiarity of growth on which it relies mainly to make its way in the world. The farmer must know these peculiarities and take advantage of them and use them to his own betterment.

The Cereal Grains.—For example, we have already seen that the various grains, such as wheat, oats, and corn, owe their importance as farm crops to their habit of storing a large supply of excellent food in the seed itself; this is their strong point; the young plant, because it has been so well provided for by its parents, is able to sprout quickly and to make rapid growth at the outset, so that it is apt to get a good start in the race for life as compared with seeds which have been only

meagerly supplied by their parents with nourishment. The crop of wheat or oats so quickly covers and shades the ground that the weeds get but little chance, hence we do not need even to cultivate the ground after the seed is planted. It is this large size of the seed, together with the excellence of the food stored in the cereal grains, that makes them on the whole the most important of the farmer's crops.

Vegetables.—Most vegetables are useful to the farmer because of a very different habit of the parent plant, namely, that of storing up food in their own tissues and mainly for their own use rather than for their offspring. Thus the radish plant for a considerable time seems not to be growing much; it does not form many new leaves nor push up a stalk nor send out branches. One might be tempted to think that it had no serious purpose in life either in the way of doing anything for itself or of developing seeds and providing for its offspring; but we must be content to let every plant manage its own business in its own way for that way is always best. And the way the radish manages is this: it spends its young and more vigorous days during the spring and early summer in accumulating all that it can and storing it in the root so that when it gets ready later in the season to attend to the matter of developing flowers and seeds, it may have a good supply of food to draw upon for this rather exhausting process; and so when the proper time comes it pushes up its stem and puts out its branches and its flowers, and finally its seeds, at an astonishing rate of speed. Most root crops, as the turnip, parsnip, and carrot, do the same thing, except that they usually

take two years instead of one to do it in. They spend one year in storing up food and the other in developing flowers and seeds. Other vegetables use a different part of the plant for a storehouse. The lettuce stores its supply in a thick tuft of leaves; the cabbage in the still more compact bunch of leaves which we call the head;

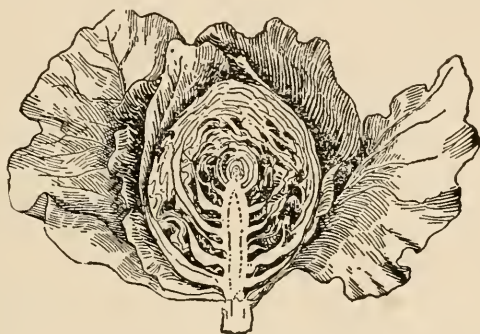


FIG. 15. Section of cabbage.

the onion in a similar bunch of leaves, developed under ground, forming the bulb.

In all such cases the farmer can take advantage of this habit which the plant has of laying up for its own use; if he does not care to gather a crop of seeds from his parsnips or carrots or cabbages, he can let the plant do the first half of its work and then pull it up and so stock his cellar with choice vegetables for the table.

The potato, perhaps our most important vegetable, is useful for a similar reason, only in this case it does not store food in the tuber for its own old age, but for its offspring. The potato, being in its wild state a native

of warmer regions where the ground does not freeze much, has adopted a rather peculiar way of propagating itself from year to year. Although it produces flowers and seeds the same as most plants do (the seeds are

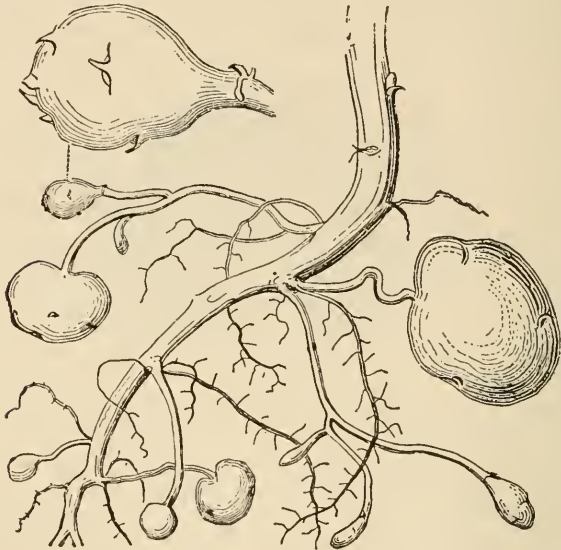


FIG. 16. Potato plant forming its tubers.

found in little balls which grow at the top of the plant), it does not depend much upon these seeds for reproducing itself; it develops peculiar underground branches, whose tips thicken and form the tubers, and it is the buds, or eyes as they are called, in these tubers from which the new crop will grow. So, wisely, the parent

plant stores plenty of food in these tubers for the young potatoes to live upon until they can push up above ground and develop leaves and branches of their own. So when the parent plant dies down in the autumn, these underground branches, or tubers, live to reproduce the plant another year. In our part of the world, of course, the ground freezes too severely during the winter for the safety of these tubers, so, as the farmer has brought the potato from its warmer native regions to our less hospitable climate, of course he must not neglect to take up these tubers before the ground freezes, store them safely in a cellar over winter, and then put them back in the ground again in the spring if he wants to grow a new crop of potatoes. Or if he does not need them for seed, he may fill his bins with them for sale or for eating.

Forage Plants.—Not only must the farmer provide for his own eating, but for that of his domestic animals as well; and he must provide suitable food for them, too. The cat and the dog and the chickens may get along very well on the same kind of food as the farmer does; the pig will not be in the least particular about his food; almost anything is good enough to suit him; but the horse and the cow and the sheep would not thank you for the finest of meat or the freshest of eggs, and even a loaf of home-made bread or cake would not suit them half so well as a bale of hay. Their systems require coarse vegetable food; and because it is coarse and not very nutritious they must have great quantities of it. So the farmer must not forget, along with the finer grains and vegetables for his own use, to grow

or gather large quantities of forage for his stock. The plants which furnish our chief supply of forage are of two classes: the clover plants—such as alfalfa, and the red and white clover; and the grasses. For the clover, although often spoken of as a grass, is evidently a very different sort of plant; it is more nearly related to the bean or the pea than to the grasses; this will be evident if you pick to pieces a flower of the clover and one of the bean and compare them.

The peculiarity of the grasses which makes them valuable as forage plants is, that they have come to depend, in their struggle with weeds and other enemies, mainly on growing as a thick sward at the base, in which other plants can hardly get a start; and then in order that they may not crowd each other to death, they have learned to grow tall and slender in their reach after sunshine. So their stems and leaves are stout and coarse and abundant, just the thing that suits the alimentary canal of the horse and cow. If they have developed a top full of seeds in which a little richer food is stored, so much the better, provided it is plentifully mixed with the coarser stems and leaves.

Fruits.—In some cases the parent plant has made double provision of nutritious matter for the young plant, and this device has given us some of our most luscious foods, the various fruits. In the apple or pear, for instance, not only is the little plantlet packed away in a seed which contains nourishment to start the germ into growth, but these seeds are embedded in a still larger mass of food, the apple itself, which by its decay furnishes a rich bed from which the growing plant may

get additional nourishment long after the supply in the seed is used up. So the farmer may well rescue the apple from this use and make it another of the many foods with which to feed the world.

How the Birds Help.—Many of the fruits, as the raspberry and the currant, are brightly colored, and must be very attractive to birds, too much so, perhaps, to suit us; but we may as well make the best of it, the plant itself does not object to the birds; the seeds found in these bright colored fruits are hard and stony and are not destroyed when eaten; they fall unharmed to the earth in the droppings of the birds and so are scattered far and wide from the parent plant. Can we doubt that the bright color of the fruit and the stony nature of the seeds which is associated with it were intended for this very purpose; that they might be discovered and eaten by the birds, and thus their seeds scattered abroad where they have a better chance of life than if they had fallen under the parent tree? So let us not find too much fault with the birds, but be thankful rather that their tastes are not so different from ours, and that the juicy berries and fruits which the parent tree has hung out for the birds are equally pleasing to us, and make another of the choice products of the farm.

Trees.—There are some other things which the farmer needs besides food and drink; he must have fuel and shelter; he must build barns and fences and bridges. Now, there is one class of plants whose way of getting on in the world adapts them very well indeed to furnishing the farmer just the material which he needs for

these purposes. The tree is a plant which depends for its success in life mainly on its own bigness. Its scheme is to push up so high into the world of sunshine that the

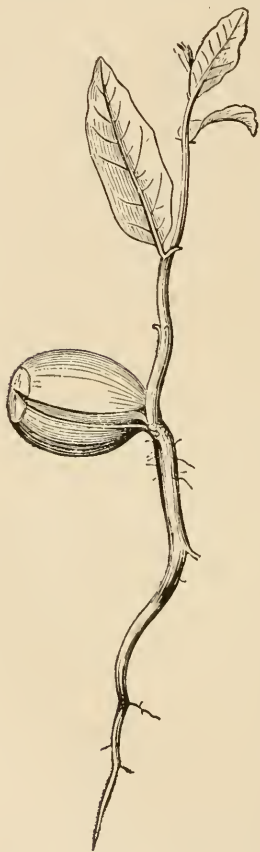


FIG. 17. Rapid growth of oak plant from acorn.

weeds and other plants cannot trouble it. To this end it must generally have the means of getting a quick start in the race; accordingly, many trees produce nuts or acorns, which are seeds with a particularly large and rich supply of food. So when the seed germinates, the shoot pushes up very rapidly and soon overtops its rivals and gets the lion's share of the sunshine. Now, since the tree has planned to grow so large and tall, it will have a new adversary to battle with; namely, the wind. The smaller plants which strive to grow in the shade of the woods need not trouble themselves to form stiff stems, and they generally do not. But the tree must have a particularly stout stem, well hardened with woody fiber, and it must bury its great roots deep in the soil in order to anchor the tree to the earth, so that it may stand the strain of wind and weather.



FIG. 18. Measuring the "Grizzly Giant," Wawona, Cal.

What a contrast there is in this respect between a tree and the purslane plant, and yet how well each succeeds in its own way. The tree insists on outgrowing its humbler neighbors and leaving them in the shade. Some of them do not mind this, but learn to thrive best in the cool and dusky forest; the tree itself is generally thriftier where it is partly shaded by its neighbors; it grows slowly and for many years until it is sturdy and strong. But the purslane plant, because it cannot get enough sunshine where the trees grow, adopts the other alternative of making a break for the open ground where there is so much sunshine that even a sturdy tree would hardly try to live and grow there. The purslane plant by developing a weak, pulpy stem, soft and juicy, lives and thrives best of all in the scorching sun, because that is the life to which it is best adapted. And so the purslane would make very poor fuel or timber, but the maple and the ash and the oak are just what the farmer wants where strength and durability are required.

Ornamental Plants.—While the plants which have thus far been mentioned contribute most to man's life and health and comfort, we should not forget that this is not all of life, but that the farmer will be a happier and probably a better man if he also sees and admires and enjoys some of the beautiful things with which the world abounds. And we have already learned that many plants, for good reasons of their own, have found it worth while to be beautiful and fragrant and to welcome and shelter the birds with their concerts of song; so even this peculiarity of plant life the farmer may take advantage of to make his home more enjoyable and attractive.

And we shall see, too, that he may not only gather about him the beautiful plants with which the world abounds, but he may even increase their beauty by

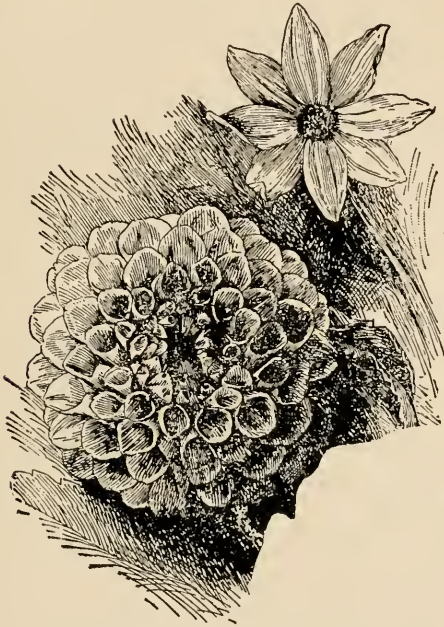


FIG. 19. Wild and cultivated dahlia.

developing richer and more showy flowers, just as he has improved the useful plants by developing richer grains and sweeter berries. Many of the more beautiful flowers of the garden have become such by reason of the gardener's intelligent selection and cultivation. The wild rose, for example, has but few petals

and many ovaries and seeds; for the rose plant was naturally more concerned with growing good seeds than with merely looking well. All that was needed in the way of show was just color enough to catch the eye of the bee, and win a visit from her, and so manage the matter of getting its pollen distributed. But the gardener does not care for the rose seeds; he can propagate new plants from slips set in the ground. So he has used such modes of selection and cultivation that, in the finer varieties of the garden rose, nearly all of the stamens have been developed into showy petals, forming a mass of beautiful color. Never mind if the plants have lost their power of producing seeds; seeds are very important sometimes, but here we do not care for them; instead, we have gotten something that is a joy forever; for what is more beautiful in form and color and fragrance than a full-blown rose? The farmer may use the habit of compact growth which the grasses possess to furnish himself not only a meadow, but a lawn. He may use the sturdy habit of trees to furnish shade as well as timber. He may even combine beauty and usefulness in the fragrance and bloom and fruitage of the orchard. He may thus make his home not a mere treadmill in which to live and work and earn, but a place of beauty and comfort and enjoyment as well. And the success of the farmer will depend not merely upon his own hard work, although there must be plenty of that, but also upon knowing how to make the most of his partnership with nature, with the soil and the sunshine, with the plants and the domestic animals; yes, even with the insects and the birds of the farm.

CHAPTER IV

THE IMPORTANT FARM CROPS

Maize (Indian Corn, Corn).—Maize is a south Mexican plant, which was first cultivated by the inhabitants of America nearly if not quite two thousand years ago. In the twelfth century its use had spread to the Rio Grandé on the north, and to Chile on the south. Later it was used by the North American Indians as far north as the Great Lakes and the southern coast of Maine, while in South America its use had spread into Venezuela, Peru, and Bolivia.

It was thus an old cultivated plant when Columbus discovered the New World, and among the strange sights which he saw were the fields of maize. When the Pilgrims came to New England, in 1620, they found fields of maize, and the following spring they planted it for their own use, being taught how to care for it by friendly Indians.

The name "maize" was introduced into Europe by Columbus, who adopted it from the Indians who grew it on the islands he visited. As all kinds of edible grains (as wheat, oats, rye, barley, etc.) are called "corn" in England, it was quite natural that the early English settlers should speak of maize as "Indian corn," and from this has come the American usage of speaking of it simply as "corn." Strictly speaking it is maize, but since it is the largest, and perhaps the most important,

“corn plant” for this country, it has usurped the name “corn” for its exclusive use.

We do not know the wild state of maize, although it is thought by some botanists that the tall Mexican grass known as teosinte may be wild maize. Teosinte has a tassel which closely resembles that of maize, but its ears are very slender, and each bears only a few grains, in two rows. Possibly the ear of maize came from the union of several of these slender ears. At any rate, it is interesting to remember that on the ears of maize the rows are always even-numbered, as if formed by the union of several two-rowed, slender ears.

During the long time that maize has been under cultivation it has become so changed that six species have been produced, namely: (1) Pod-corn, (2) Pop-corn, (3) Flint-corn, (4) Dent-corn, (5) Soft-corn, (6) Sweet-corn. These again have developed numerous varieties, especially in those species which have been much cultivated by white people in this country.

In Pod-corn each kernel is surrounded by a little husk, and the whole ear also is covered with husks. This species is grown with us as a curiosity only.

In Pop-corn the plants are small, as are the ears also, and the kernels are very hard, and when heated they suddenly burst open, turning inside out. Twenty-five varieties are known.

Flint-corn is much like the last, the plants and ears being rather small, and the kernels very hard. However, the kernels are all round-topped, and they do not burst open on heating. The ears are commonly

eight-rowed, and are long and slender. There are sixty-nine varieties, many of which are grown in the far northern states.

In Dent-corn the plant and ears are larger than in any other species, while the kernels are not as hard as in flint-corn, and are dented at the top. The hard, horny structure which fills the whole of the flint kernel is found only along the edges in the dent, the remainder being softer and more granular. The ears are commonly from twelve to twenty-four rowed, and are rough on account of the dents on the kernels. Three hundred and twenty-three varieties are grown in different portions of this country.

In soft-corn the plant is usually small or of medium height, and the ears small, and eight to fourteen rowed. The kernels have no hard, horny portion, the whole substance being soft and granular, and as a consequence they may be crushed easily into meal, for which purpose this species was grown by the southwestern Indians. Twenty-seven varieties are known, some of which are grown for grinding into white meal.

Sweet-corn is peculiar in having soft, sweet kernels, which become tough, horny and shriveled when dry. The plants are small, and the small ears are usually from eight to fourteen rowed, although in some large varieties they are from sixteen to twenty or even twenty-four rowed. Sixty-three varieties are known.

When a kernel of maize germinates it first sends out a root from the lower end, and then the little roll of leaves pushes out some distance above. About this time or a little later other roots come out at different places on

the side of the kernel. For some time the principal work of the roots is to get water for the young plant, the kernel containing food enough to last for ten to fifteen days. So the roots grow out rapidly in every direction and collect water from the soil.

Before the food in the kernel is all used the leaves must be in condition to make food from the gases in the air and the water and solutions taken in by the roots. The plants have no difficulty in getting all the gases they need, but sometimes they do not have enough water.

The manufacture of food takes place only in the green leaves; so the larger and more numerous they are, the more food they make. Anything which injures the leaves reduces the amount of food which the plant makes for its use.

When full-grown the maize plant bears a tassel of staminate flowers above, and an ear of pistillate flowers on a short side branch. The purpose of the former is to produce pollen, while the purpose of the latter is to form the kernels.

In each tassel-flower there are three stamens, each containing about 2,500 pollen-cells. In an average-sized tassel of the larger varieties there are about 7,200 stamens, making about 18,000,000 of pollen-cells for every plant in the field.

In each young ear of the larger varieties there may be as many as 1,000 kernels, each with its long, thread-like style. So there are about 1,000 threads in the "silk" of the ear. Each one is somewhat hairy near the tip, and this portion is of the greatest importance, as it

is on it that the pollen-cells must fall and grow in order that the young kernels may become fertile. Unless at least one pollen-cell germinates on each silk thread the young kernel at its base will not develop into a full-grown kernel.

The fertilized kernel soon begins to enlarge, and a tiny plant grows on its upper side. While this is taking place starch is being packed away in the kernel at the side of the little plant. By the time the latter is as large as it usually grows in the seed nearly all of the available room is filled with starch. The seed is now complete, but it is still soft and watery, and the drying out of this moisture constitutes the last stage of the ripening process.

Maize is subject to several diseases, the most serious of which is the smut of the ears. This is caused by a minute fungus which lives in the tissues of the stem and leaves and at length punctures the ears. Here it thrives upon the rich food in the young kernels, and finally produces its own black spores, which are the tiny seeds of this fungus, and constitute the black, powdery mass in the affected ears. These spores are the means of its propagation, and when these are allowed to fall to the ground they infect it, so that next year it is almost certain that there will be more smut in case the field contains maize.

Smut may be reduced very much by carefully collecting and burning all smutted ears. A rotation of crops is good as this smut does not affect any of the other crops. It does little or no good to soak the seed corn in a solution of copper sulphate before planting.

Wheat.—It is not certainly known where or when wheat originated, as it came into cultivation so long ago that no records of its first introduction remain. Some preserved wheat grains found in Egypt are regarded as more than 5,000 years old. A low, bearded grass, called wild wheat, growing in southern Europe and Asia, has been suggested as possibly the wild state of wheat, but this has not yet been proved. At any rate, we may say that wheat originated in the Old World, probably in that part of it adjoining the Mediterranean Sea, or in the region to the eastward.

Eight specimens of wheat are of interest to us, namely: (1) Bread wheats, (2) Club wheat, (3) Poulard wheats, (4) Durum wheats, (5) Polish wheats, (6) Spelt, (7) Emmer, and (8) Einkorn. These again have given rise to many varieties, each adapted to some condition of soil, climate, or the particular needs of the community.

The Bread wheats include nearly all of those kinds commonly grown in the United States. The number of varieties now known is about one thousand. These are classed as, (1) winter wheats, when sown in the autumn, and (2) spring wheats, when sown in the spring, and these again into (*a*) hard, and (*b*) soft wheats, according to the hardness of the kernels. In some varieties the heads are bearded (bearded wheats) while others are not bearded (smooth wheats). Again, the varieties are spoken of as early, or late wheats.

The soft winter wheats, which vary in color of grain from amber to white, require considerable moisture, and a mild, even temperature. They are grown from Maine to the mountains of Virginia, in western and

northern Europe, Japan, and portions of China, India, Australia, and Argentina. The hard winter wheats, which are red-grained and usually bearded, are grown where the summers are hot and dry, as in Oklahoma, Kansas, northern Missouri, southern Nebraska and Iowa, in Hungary and Roumania, southern Russia, Asiatic Turkey, Persia, and northern India. Hard spring wheats resemble the preceding and grow under nearly the same climatic conditions, with, however, shorter summers and more severe winters, as in northern Nebraska and Iowa, North and South Dakota, Minnesota, northern Wisconsin, central and western Canada, eastern Russia, and southern Siberia. The white wheats are adapted to the Rocky Mountain and Pacific states, the Caucasus, Turkestan, Chile, and portions of Australia. In Illinois, Indiana, Michigan, and Ohio semi-hard wheats are grown, while in the southern states from Arkansas to Kentucky, Tennessee, North Carolina, and Virginia, early varieties of soft or semi-hard wheats are preferred.

A wheat kernel germinates by sending out a little root from its more pointed end, and this is followed by the stem and leaves which push out from its rounded side between the root and the middle of the kernel. Other roots grow out later from near the leaves, so that the plant soon has a cluster of many roots upon which to depend for food.

In growing, the wheat plant remains single unless it is well fed, when it branches (stools) just at the ground, forming a cluster of stems. For a long time the stems are short, but when they have formed all of their leaves

each stem-joint rapidly elongates, so that in a few days the whole plant is much taller. The young head is all this time on a short stalk deep in the folds of the upper leaves. Its stalk now elongates and pushes it up into the air.

The head consists of many scales (chaff) inclosing and hiding fifty to one hundred little flowers, each of which has three stamens and one pistil (young kernel) with two feathery stigmas. These flowers, therefore, are perfect, and not of two kinds, as in maize.

The lower flowers are the first to mature, and then open for a few minutes, the stamens and stigmas being thrust out. Much of the pollen falls out at this time and is carried away by the wind, but enough usually remains in each flower to fertilize the young kernel. The pollen which blows away may fall on other wheat flowers and fertilize them. It takes several days for all of the flowers in each head to open and become fertilized, those at the top being the last.

The kernel when young is almost globular, but as it grows longer and broader its sides are folded backward so as to leave a deep crease on its back. When full-grown it is filled with closely packed starch, but it is still soft and watery, and this surplus water must dry out before it is fully ripe.

Wheat is subject to many diseases, the most common of which are smut and rust, which are caused by minute fungi which live in the plants. Loose smut attacks and destroys the heads, and turns them into naked, black stems. Close smut also attacks the heads, but it destroys only the interior of the kernels, which it turns into

black, fetid masses of spores. Soaking the seed-wheat in a solution of copper sulphate just before sowing is recommended for preventing these diseases.

Rust is often found attacking the leaves and stems. Early in the season it is red or yellow, and is then called red rust, while later it is black, and is then known as black rust. Red rust spreads very rapidly from plant to plant in the field, but the black rust lives over the winter on the straw, and from this the new wheat crop is infected. Some varieties of wheat are not often attacked by rust, and the sowing of such kinds is the best preventive of this disease.

Oats.—The oat plant appears to have originally grown wild in southeastern Europe, where it was first brought into cultivation about two thousand years ago. It is not now known in the wild state, although there are many closely related kinds which grow wild in many places in the northern hemisphere.

By long cultivation we have produced many varieties of oats, but these are not as numerous nor are they as well marked as in wheat. More than one hundred and fifty varieties are grown in the United States. These are of two general forms: spreading oats, and side oats; and these again may be chaffy, or naked (hulless).

The germination of the oat grain is very much like that of wheat, and the growth of the young plant also is quite like that of wheat. When the head appears the flowers soon open and the pollen is blown by the wind from flower to flower.

The fertilized young kernel grows quite like that of wheat, only here the chaff adheres to it, so that at ma-

turity in the common oats the kernel is tightly inclosed within the chaff. In hulless oats the chaff does not adhere in this way, so that the kernel is free.

The diseases of the oat plant are similar to those of the wheat. Thus there is a smut which attacks the heads and turns them into black masses, the kernels being entirely destroyed. This disease is caused by a minute fungus much like that which causes loose smut in wheat, but it is not exactly the same. The same preventives may be used as in wheat.

The rust attacks the oat plant also, and here again, while it looks much like that on wheat it is not exactly the same. Wheat rust will not infect oats. Some kinds of oats are not as much affected as others, and these are the kinds which should be sown.

Barley.—The barleys originated in the region east of the Mediterranean Sea, many centuries ago, certainly as long as 2,500 years ago, and perhaps much longer. The simpler kinds have been found in a wild state in the region mentioned, but not the larger kinds.

There are three principal kinds of barley, and these have probably originated by long cultivation. These are known as two-rowed barley, four-rowed barley, and six-rowed barley, and these again have produced many varieties. In most of the varieties the chaff tightly surrounds the kernel, but there are some naked or hulless kinds, just as there are in oats.

The germination and growth of barley are so much like those of wheat and oats that they need not be separately described.

The heads are more like the heads of wheat than oats.

In two-rowed barley there are two rows of kernels up and down the head, in four-rowed barley there are four such rows of kernels, while in six-rowed barley there are six rows. Usually there are long, rough beards on the heads, but there are some varieties which have no beards.

The young seeds are fertilized as they are in wheat and oats, and the young plant forms and grows in the seed quite as the other grains already described.

The principal diseases are smut and rust, which again are much like those in the wheat and oats. The suggestions already made as to preventives may be repeated for the diseases of barley.

Rye.—Rye is another old plant in cultivation, yet it does not extend back as far as many other cultivated plants. It appears to have originated in southern and southeastern Europe nearly two thousand years ago. It is said to have been found recently in a wild state, in southern Europe, where it escapes from cultivation very easily, which may indicate its original home.

Rye has not produced many varieties in the course of its cultivation. It commonly is cultivated in Europe for its nutritious kernels, which are used for human food, but in this country it is not much grown, excepting for food for domestic animals, and for its long, straight straw.

In its germination, growth, and fertilization it does not differ much from wheat, to which it is quite nearly related. The kernels have the same structure as those of wheat, but they are longer and somewhat more slender.

Rye is singularly free from diseases. The one which is most common is the ergot, which is produced by a minute fungus which attacks the young kernel about the time of blossoming. The ergot-fungus at first grows on and in the kernel, and then forms a large blackish grain about as thick as a kernel of rye, and several times as long. When full grown the ergot grain is an inch long, and nearly an eighth of an inch in thickness. It is hard and brittle, and of a white color inside. It is poisonous to stock and sometimes causes much loss.

1. Give as many different cultivated plants as you can, and tell what peculiarity or habit of the plant makes it of value to us. Can you think of any of our food that does not come directly or indirectly from plants?

2. Which of the six species of corn are grown in your county?

3. Is the wheat grown in your county a hard or a soft wheat? Visit a flour-mill and find out all you can about the manufacture of flour. What is macaroni wheat?

4. What is a plant disease? Give some that affect each crop.

5. Which of our farm plants were brought from the eastern hemisphere? Which were found in America?

CHAPTER V

THE INSECTS OF THE FARM

Insects in General.—We find a great many kinds of living creatures about the farm, on the prairies, and in the woods. All of these are of interest to us on account of their ways of living—some being of use and others of harm. To know something about them is of importance to the farmer, as well as to all other persons who cultivate the ground for the purpose of growing different kinds of plants. Even housekeepers must know a little about some kinds of these small animals.

Many of these creatures have jointed bodies and jointed legs and feelers. Some of them are made so as to live in water, while others can exist only on land. Most people call all of these jointed animals “bugs” or “insects.” But those of us who know better have different names for many of them. Only those that have six legs when full grown are the ones we call insects. Those that have eight legs belong to the spiders and their relatives, the mites and scorpions. Those that have twelve or more legs and that live in damp places or in water are called sow-bugs, or more correctly, crustaceans. They are the relatives of the cray-fishes and lobsters. The many-legged, worm-like creatures should be called *centipedes*, or “many legs.” One of each of these forms is shown in this picture so as to help those who do not know how to remember them in any other way.

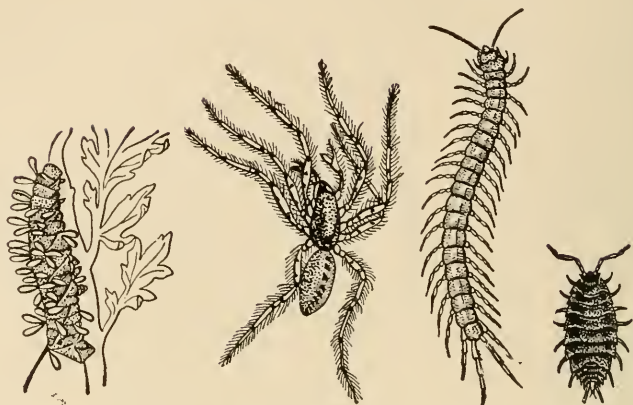


FIG. 20. Insect (caterpillar), spider, myriapod, and sow-bug.

Of course all of us know a few things about insects, as well as about their distant relatives which are mentioned above; but, in order to help others who do not know so much about them, we will have to tell some additional things concerning them here.

An insect, besides having six legs, has its body made up of three separate parts. These are the head; the thorax, or middle part; and the hind portion, or abdomen. Some kinds have wings, but others do not. Some jump, a few crawl, and others fly. Some bite off and chew what they eat, others only suck the juices or sap of plants, or blood of animals. Instead of growing larger and larger in a steady way, they shed their skins a number of times. Each time this is done they come out of their hard old skins covered with soft new ones that soon stretch to two or more times the size of the

old ones. Most insects, but not all, are also quite different looking when young from what they are after becoming full grown. The "grub worm" is not at all like the June beetle, which lays the egg from which it hatches. The caterpillar is very different from the butterfly or moth of which it is the young. The "wiggler" in the rainwater barrel does not look at all like its parent, the

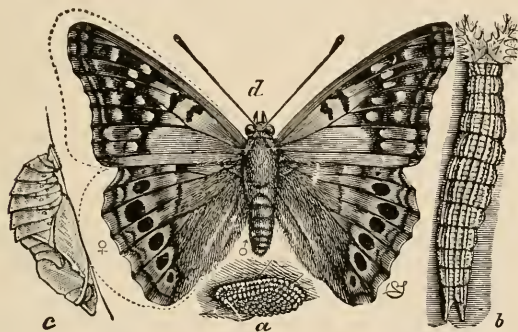


FIG. 21. Hackberry butterfly in its different stages.

mosquito; nor does the maggot resemble the green or bluebottle fly that lays its eggs on decaying meat.

A number of other things about insects are very different from what we find them in animals like dogs, mice, birds, and snakes. An insect does not breathe by using lungs or its nose, but has little holes placed along the two sides of its body through which the air passes in and out. Its blood is transparent like water, and is pushed through the body by the beating of a large blood vein, or artery, which lies along or near its back, instead of by a heart. The brain is scattered in knots or bunches

along the principal nerve situated near the lower side in the middle of the body, instead of being all in its head.

Besides these differences we find that insects' skeletons are on the outside, instead of inside their bodies, as we find them in ourselves, birds, and other animals which we know. Then, besides, insects have ears and eyes only when they really need them. Their ears are never on their heads, but may be found on their legs, or even on their abdomens. Only those that sing or make noises have ears; and one kind makes all its noise with its ears. Some insects have two kinds of eyes. These are, first, the large compound eyes, as they are called, which are composed of a great many small ones, joined together so closely as to make them look like simple eyes with the surface regularly roughened. When examined closely with the microscope these seem to be made of little plates which are arranged to look like a piece of capped honeycomb. Second, the small simple eyes which are placed between the larger or compound eyes, either on top of the head, or else in the upper part of the face. One of these little eyes is placed in the middle, and the other two are between it and the large eyes, but generally above or back of it. They are to see with in a different way from that of the compound eyes; but just how we cannot say here. Insects very likely smell with their feelers; and in some kinds, perhaps, also with their legs or feet.

Insects, like many other kinds of creatures, are cold-blooded, and can stand freezing without being killed. A great many kinds live over winter hidden away among

old grass, under stones, fallen leaves, logs, loose bark, and in the ground. In the spring they come out of these hiding-places, and move about just as if they never had been frozen stiff. Their eggs and young can also freeze solid and not be hurt. This way of passing the winter is called *hibernating*.

Some kinds of insects live much longer than others; and some raise several generations of young in a single summer. Many are more hardy than others and can withstand greater changes of climate; while different forms are able to live only under certain limited conditions. A few kinds are furnished with arrangements for defending themselves against their enemies, as are the skunk and the weasel. Others can and do feed on a number of different plants; while still others attack only a single kind of food-plant. Each form has its particular enemies, which, like the hosts themselves, are likewise subject to the influences of climate and to the attacks of diseases and enemies.

Knowing all these things about insects, we can begin to understand why some kinds are more numerous and do more harm than others.

Insects generally die soon after laying their eggs. A great many die even before their eggs hatch, hence do not live to see their young. A few, however, like the queen of the honey-bee, live much longer, and even take some care of their young. Some insects eat all the time while growing, never going to sleep, and stopping to rest only long enough to shed their skins. Such kinds as live on flesh have been known to eat two hundred times their own weight of food in a single day; and certain

kinds of caterpillars may increase in size ten thousand times inside of thirty days.

Where Found.—Insects are found in all countries, at all times of the year, and under nearly every condition. They live in our homes, gardens, and fields, in the woods, and on the prairies; they occur upon and within the bodies of our domestic and wild animals, as well as in the air, water, and earth. No region is without one or more forms of these creatures. They enter into and affect our daily lives more or less everywhere and under nearly every condition. We are more or less dependent upon them; or at least use many of them or their products in our food, clothing, and the arts, almost every day of our lives. In fact, among insects we find both friend and foe, be our calling in life what it may. They come across our path as enemies to all kinds of useful plants, as parasites that attack and infest useful animals. We may meet them on the other hand as friends that help to fertilize and gather honey from flowers, make wax, spin silk, clean away dead animals and rotting plants. We may also meet them as parasites upon and within the bodies of the enemies mentioned above.

The Proportionate Number of Insects.—About nine-tenths of all animal forms are insects. The other one-tenth includes the forms described above as being their near relatives, as well as the fishes, birds, angle and other worms, reptiles, and other four-footed animals like mice, cats, sheep, horses, and monkeys. But we can notice only a few of them here.

CHAPTER VI

USEFUL INSECTS

If we remember what has just been said about insects in general, we already know that they are not all harmful or destructive, but that there are, perhaps, just as many useful ones as there are of the other kind. Of course we who live in the country know all about this. It is mostly for the benefit of the folks who live in towns and cities that we must tell many of these things about insects.

Some of the most useful insects are the bees, wasps, ichneumon flies, flesh flies, dragon flies, tiger-beetles, burying-beetles, lady-birds, and silk-worms. All of these, and many others, live in such a manner as to help us in different ways.

Bees and What They Do.—The bees, of which there are a great many kinds, spend much of their time in visiting flowers, where they gather honey for themselves, and pollen for their young. While doing this, they carry the pollen, or yellow dust, from one flower to another, and without knowing it do just the very thing that must be done before there can be fruit or seeds.

The *honey-bee*, which has been tamed and taught to live in hives, stores honey for fall, winter, and early spring use, and for the wax-makers to eat while they are furnishing wax to the comb-makers. The other workers about the hive also live on honey. In a bee-hive there

are workers, a queen, which is the mother, and drones. The drones are the males, and do not help about the hive nor gather honey, or pollen. When the swarming season is over they are killed by the workers. Some time you will learn a great deal more about honey-bees because every farmer and fruit grower should have one or more hives of these useful insects on the place.

Bumble-Bees.—Every boy and many of the girls who live in the country can tell you where to find them. Like the honey-bee, they gather both honey and pollen, which are carried to their nests and stored for future use. If we rob a nest we learn that some of the cells, or little sacks, which we find there are filled with honey, and others with a yellowish green paste. This last is the "bee-bread," as it is called. It is made by mixing pollen and honey together, and is the kind of food the little bees must eat.

How They Live and Raise their Young.—If we take the trouble to examine all the different sacks or cells in the nest, we find in them eggs, small, middle-sized, and full-grown grubs, as well as the pupæ or "resting stage." In the cells where there are eggs, none of the pollen paste or bee-bread will be missing, but in those where there are grubs, more or less will have been eaten. A cellful of pollen as provided by the parent is just enough food for a young bee to eat in order to become full grown. So when all has been eaten the grub simply changes to the pupa, and a little later is full-grown; i. e., it becomes a bumble-bee and is ready to carry pollen and honey, or to work in the nest, along with the others. Bumble-bees, like the honey-bees,

have queens, workers, and drones or males; but there may be a dozen or more queens in a single nest instead of only the one. The queens alone live over winter, hence all bumble-bees in spring appear to be much larger than those we see in summer, when there are workers and males also. Both the queens and workers gather honey and pollen. The males visit flowers to feed, but do not carry honey or pollen to the nest.

There are a large number of other kinds of wild bees which live in the ground or in the stems of plants. Most of these have only two forms, or sexes, the male and female. Neither do they store honey; nor do they live in nests where there are very many together. Some of them are quite small and either shiny green or blue. Others are gayly marked with yellow and white dots and bands. Each kind seems to choose some particular flower or flowers which it visits in preference to all others to feed upon the honey and pollen.

Cuckoo Bees.—Some bees are not made with pollen baskets on their hind legs or on the under side of their abdomens like those which do store this substance. Still they must raise their young in some way, so they do it by laying their eggs in the nests of those bees which can carry and store food. These bees which lay their eggs in that manner are called "cuckoo bees," because of their imitating the European cuckoo, a kind of bird that steals its eggs into other birds' nests. Our cowbird does the same thing in this country.

Wasps.—There are a great many kinds of wasps, just as there are of bees; and like the latter, they live in different ways. Some live in colonies, that is, they

gather together like people in a town and make large nests. Some of these nest-making wasps we call "hornets," some "yellow-jackets," and others "mud-daubers." The hornets and yellow-jackets make paper nests. All of these wasps catch insects and other small creatures which they feed to their young. Some kinds



FIG. 22. Caterpillar killed by *Ichneumon* parasites.

even chew the food before giving it to the young grubs, which live in the cells like young bees. The hornets and yellow-jackets often catch large numbers of biting flies, like those that worry our cattle and horses as well as ourselves. They also at times gnaw holes in ripe fruit and in this way do some damage.

The Mud-Dauber Wasp generally fills the cells of its nest with spiders and then lays an egg upon them and seals up each cell as it is finished. The egg soon hatches and the little grub begins feeding on the spiders which were furnished for its use. When the spiders are all eaten it is full grown, and changes to the pupa, and later to the wasp state.

There are still other kinds of wasps that dig holes in the ground. These are called "digger wasps." Some of these provide caterpillars, others grasshoppers, and still others cicadas, etc., as food for their young. The digger wasps are solitary instead of social, i. e., they do not live together in large numbers, but only singly or in pairs. Some of the digger wasps have very long and slender bodies, hence the term "wasp-like" body.

Ichneumon Flies.—Related to the wasps are a number of wasp-like creatures which live as grubs within the bodies of caterpillars and other insects. These belong to several families known as ichneumon flies. Instead of catching the insects which are to serve as food for their young, these flies simply sting them and drop in one or more eggs which hatch into grubs that begin feeding and growing within the body of the host. When full grown these grubs either spin up within the host's body, or come out and seek a suitable place to undergo their change, so that later they themselves can sting insects for the purpose of laying their eggs. There are hundreds and hundreds of

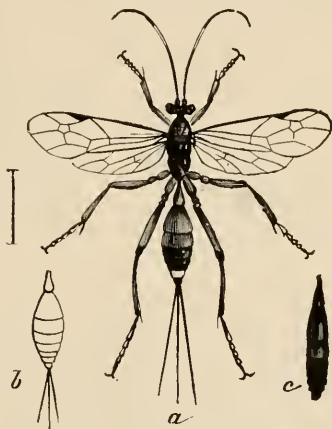


FIG. 23. Ichneumon fly.

kinds of these ichneumon flies; and they vary among themselves a great deal in form, as well as in size and color. Each kind is more or less confined in its attack to a single, or to but two or three hosts.

Taking all kinds of insects into consideration that suffer from their attacks, it is easily seen that there must be an army of these ichneumon flies with varying habits in order to meet the demands placed upon them. Some work singly, others in numbers; some attack the

larvæ, others the pupa, and still others the mature host. Even the eggs of insects are sought out and made to serve as breeding places for many kinds of these ichneumon flies. In this latter case the attacking insect must be very small, since it not only finds enough to eat, but also the room to grow and move about, shed its skin, as well as spin its cocoon, and change to a full-grown insect—all inside the egg of its host. One case is known of an insect of this kind being so small that sixteen individuals of it were reared from a single butterfly egg.

Some of these ichneumon flies are known to attack other ichneumons. Such little insects as different kinds of plant lice also suffer greatly from them. Even the ichneumons that attack other ichneumons are in turn attacked by other kinds, and these again by still others.

Flesh Flies, or Tachina Flies.—By keeping our eyes open we may see a great many surprising things that are happening in nature about us. We will be enabled to learn the answers to many puzzling questions for ourselves. “What good are flies?” is one of the questions that often come up in the minds of persons who do not use their eyes. If such persons would only look, they would see a great many things about the lives of different kinds of flies that are useful. When an animal dies, or a piece of meat decays, large numbers of flies gather about it. In a short time they lay their eggs upon it, or “blow” it as we sometimes say, and soon maggots appear in large numbers and eat it up. Others of these flies have a habit of laying their eggs upon the bodies of caterpillars, grasshoppers, and plant lice.

These eggs soon produce maggots which bore into the bodies of their hosts; and, like the grubs of the ichneumon flies described on another page, cause their death. Many of our grasshoppers are destroyed each year by these grubs of flies, as are also numerous cut-worms and other caterpillars. The insects, like the ichneumon and flesh flies, which live in the bodies of and kill their hosts, are called *parasites*.

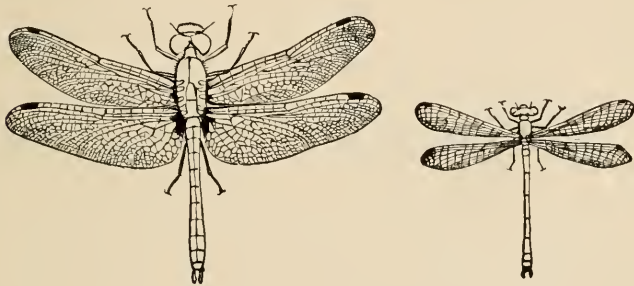


FIG. 24. Dragon flies.

Dragon Flies.—Sometimes we learn to call things by wrong names. This is simply because the persons who named them in the first place did not know much about their ways of living. So when certain insects were called “snake feeders” or “darning-needles,” there was this kind of a mistake made, and we should do all we can to correct it. We know that these insects do not feed snakes, just as well as we know that they will not sew up our ears. But they do spend much of their time flying about and eating all kinds of mosquitoes, gnats, and small flies. So destructive and fierce are they among these to us troublesome insects that they are

the veritable dragons of the air. Hence "dragon flies" is a very good name for them. Or, if we prefer to call them "mosquito hawks," we can do so, for they spend most of their time chasing and catching mosquitoes, of which they are very fond. A few years ago a prize was offered to the person who would write the best essay on ways of getting rid of mosquitoes, and it was given to the person who wrote about the habits of the dragon flies—how they live as young in the water, where they feed on "wrigglers" and other small animal forms, and later on mosquitoes, etc.

Robber Flies.—Sometimes when we are walking along a road or path in spring, fall, or summer, we suddenly become aware of the presence of some fierce insect; at least so we imagine when we hear the loud buzzing of its wings as it darts out in front or to one side of us. By watching closely we soon see him. It is a large, long-bodied, strong-legged fly, with its face well covered with stiff whiskers. A closer inspection shows him to be a regular robber or pirate in appearance.

Not only does he look fierce, but he is just as terrible as he looks. Perhaps at the very moment you are watching him he will pounce upon a grasshopper or some other insect which he kills and robs of its blood. The names "robber" or "pirate" are both good ones for these fierce, bewhiskered flies, of which there are a great many forms. They kill a great many



FIG. 25. Robber fly and pupa.

kinds of other insects, but seem to like the grasshoppers best. Some of these robber flies are as large as, and even look very much like, bumble-bees.

Lace-Wing Flies, or Aphis Lions.—The delicate, gauze-winged insects with golden eyes which will be called to mind by the picture on this page are very useful insects, because they spend their lives among plant lice, upon which they feed. Both the full-grown and young

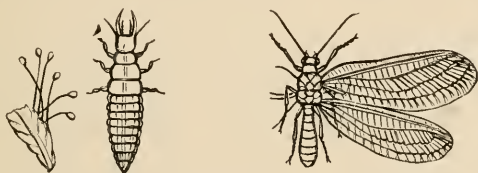


FIG. 26. Lace-wing; eggs, larva, and fly.

insects occupy their time doing this good work. In fact, so fierce are these little inoffensive-looking insects that nature has found it necessary to defend them against their own relatives. When their eggs are laid they are placed on the end of hair-like stems, so that, when they hatch, the young larvæ cannot get at and eat one another. Each one as it hatches drops off its perch and must wander off by itself in search of plant lice to satisfy its keen appetite. Once among the lice its food is plentiful and there is less danger of their eating one another. These "aphis lions," or lace-wings, are relatives of the ant-lions, which dig in the sand and make little funnel-shaped pitfalls to draw down ants and other wandering insects on which they feed.

Tiger Beetles and Ground Beetles.—Not only do we find that insects are attacked by other kinds which dart upon them while flying in the air or feeding on plants, or which lie in wait for the unsuspecting victim, but we see them assailed on all sides by still others which steal cautiously forth in search of them, just as a cat does for mice or a fox for rabbits. Among these latter the tiger beetles and their relatives, the ground beetles, are most important. There are hundreds of kinds of these carnivorous beetles.

The tiger beetles are rather bright colored, long-legged, active insects that live on the ground. They may be seen running swiftly along roads or paths in pursuit of game, or basking in the sunshine lying in wait for some approaching victim. Their grubs, or young, also feed on other insects, which are caught by stealth. They live in perpendicular holes at the tops of which they lie in wait till some ant or other insect steps right into their open mouths.

The ground beetles nearly all hunt in a similar fashion but these instead of doing their hunting during daytime prowl mostly after nightfall. Some kinds remain on or near the ground, but others run up the trunks and among the branches of trees, where they feed on caterpillars and other leaf-feeding insects of various kinds. Some of these tree-climbing kinds are beautifully colored, and are called caterpillar-hunters. Most ground beetles are provided with arrangements for producing offensive odors. A few can even discharge this substance from the tip of the abdomen, with such force as to produce a noise like shooting. When this is done in daylight

"smoke" is seen. The last described are called bombardier beetles.

Lady Birds.—Besides the tiger and ground beetles just mentioned, there are other kinds of beetles which spend their time doing good by destroying harmful insects or their eggs. Quite prominent among these latter are the small red-and-black spotted lady birds, or lady "bugs," as they are most often called. These eat the eggs of such harmful species as the Colorado potato beetle, flea beetles, the chinch-bug, and others. They also eat large numbers of plant lice of different kinds, and in doing this become our friends.



FIG. 27. Lady bird.

Scavenger Insects.—As already suggested, insects can be useful in a number of ways. On the preceding pages some of the forms have been described which are useful as destroyers of harmful kinds. It is also known that some kinds of insects either feed on weeds or on dead and decaying animals and plants, which, if allowed to remain unmolested, would be the cause of disease. The last of these we call scavengers. They may be either flies or beetles. Some of the flies belonging to this class are closely related to those already mentioned as destroyers of caterpillars and grasshoppers, but others are not. The beetles are called either "burying beetles" or "dung beetles," but these two names do not include all of the forms that serve as scavengers. If a mouse, snake, or other small animal dies and is left lying on the ground during warm weather

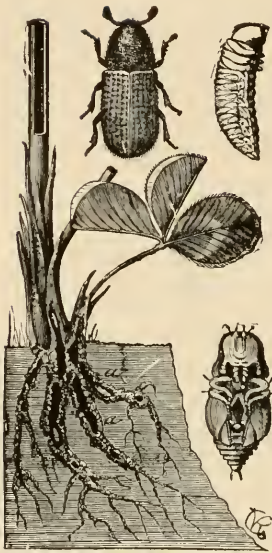


FIG. 28. Clover root beetle.

the odor soon attracts large and small beetles of several kinds, which at once begin digging underneath it so as to let the animal settle into the earth. This digging by the insects continues until the dead animal is buried or covered with dirt. Before leaving it the beetles lay their eggs on or near the body, so that their young when hatched will be provided with food.

Not only dead and decaying animals and plants are thus used by some insects for food for themselves and their young, but even the dung or droppings of most

larger animals is likewise made use of by them for a similar purpose. The "tumble-bug" selects a portion of such material, lays an egg in it, and then rolls it over and over along the ground, till it has become covered with a hard layer of earth. The pellet is then buried and left, the parent beetle knowing that the young grub will be well supplied with food to last till it is fully grown and ready to change to the beetle state. Others of these beetles simply bury some material without at first rolling it about; and still others do not even bury it, but are satisfied with simply laying their eggs upon or within it. Some of these scavenger beetles are beautifully colored,

and are also adorned with horns and other queer ornaments.

Other insects, like the silk-worm, cochineal, and lac or shellac making kinds, occur in some countries. A number of different kinds of insects are also eaten by the wild and partly civilized peoples who live in various countries. Some of these edible insects are such as grasshoppers or locusts, meal-worms, water boatmen, and various borers taken from decaying logs. Insects may also be considered valuable when used for fish-bait or when fed to fowls. In fact, whenever a direct or even an indirect use of them is made whereby man may be profited in any way, they may be said to be of some benefit to him.

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1. Why should the farmer know something about insects?
 2. What should he know? Why?
 3. How does an insect breathe? Where are its ears? Where is its skeleton? How is its blood different from yours?
 4. In what ways do insects pass the winter?
 5. Why do insects shed their skins?
 6. Upon what insects is man more or less dependent?
 7. What kinds of bees are found in a hive? Give the life history of each.
 8. What is "bee-bread"? Find the pollen basket on a bumble-bee.
 9. How do bumble-bees differ from honey-bees?
 10. What are "cuckoo" bees?
 11. Open the mud nest of a dauber wasp and examine the young and their food.
 12. "What good are flies?"
 13. By means of a garden rake drag the trash from a shallow pond and bring the "nymphs" of the dragon-fly to class.
 14. Why do aphid lions lay their eggs at the end of hair-like stems?
 15. In what way do scavengers aid man?
 16. Make a list of useful insects, and state in what way each benefits the farmer.

CHAPTER VII

HARMFUL INSECTS

Locusts, or Short-Horned Grasshoppers.— Perhaps the most important insects that do damage here in the West year after year are the ones we call the “short-horned” grasshoppers. A better name for them is locusts; but if we insist on calling them by the name “grasshoppers,” we should add to it “short-horned,” so that the bug-man will also know what kind of jumping insects we are talking about.

Not all of the short-horned grasshoppers are to be dreaded. Still, every one of these insects feeds on plants, and nearly all such food-plants are more or less useful to us in one way or another. In this state there are nearly or quite one hundred and eighty different

kinds. Some of these are quite small, others are quite large; some have long wings which they use in flying from one place to another, but others are almost or entirely without these helps for getting about. They are of nearly all colors and live in almost every part of the country.

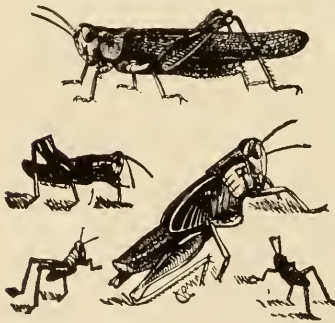


FIG. 29. Rocky Mountain locust.

Nearly all the different kinds of grasshoppers of this family lay their eggs in the same way, so that a single account will do for all. Female locusts are so made that they can dig holes in the ground with the tip of their abdomen. When the hole is of the right depth it is lined with a froth-like substance, and the eggs are laid as shown in the picture. Different kinds lay different numbers of eggs. Some deposit only about two dozen, while others lay more than one hundred in a single pod. After the eggs have been laid, the rest of the hole is filled with the same frothy matter mentioned above. This dries and leaves an easy way for the young hoppers to reach the surface when they hatch. These insects lay their eggs in varied places. Some like dry, sandy, or gravelly ground; others soft, loose earth in low places; and still others choose the soil about the tangled roots of plants, or hard-trampled paths and roadsides for the purpose. They lay their eggs at different times, but mostly during late summer or in the early fall of the year. A few kinds also lay them in the spring. This difference in egg-laying makes them hatch at different seasons. The spring-laid eggs generally hatch in late summer or fall. So when we see grasshoppers on warm days in winter and early spring we need not feel alarmed. These are some of the kinds that always live over winter as young or full-grown hoppers instead of in the egg state. There are only a few of these kinds, and they hardly ever do much harm. It may seem that they are intended for winter and early spring birds, as well as for those of us who like to study about insects.

In growing, these insects shed their skin four or five

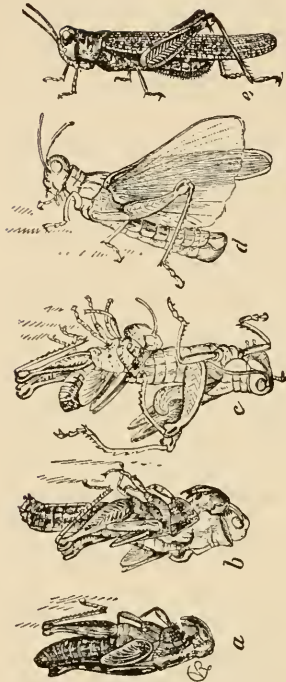


FIG. 30. Rocky Mountain locust moulting.

times. The different sizes are shown in the picture. The time required for a grasshopper to grow up is from six weeks to nearly or quite two months. Each one of these insects eats fully as much food in a day as its own weight, and often a great deal more. So when there are a great many in one place they do much damage.

Grasshoppers, like all other kinds of insects, are more or less affected by the weather and by different kinds of enemies. This is why we see them more plentiful some years than others. But we cannot tell you here about all of the natural enemies, or even about how cold and heat, or wet and dry, is apt to affect their hatching and

growth and make them plentiful or scarce.

It will be remembered that a number of different kinds of useful insects were said to destroy grasshoppers and their relatives. In addition to what these useful insects do towards reducing their numbers, many die from sickness; still others are killed off year by year by animals of the prairie, woods, and farm. The study of how one

kind of life depends upon another is very interesting as well as useful to the farmer, and he should take it up if he would make the most of his life and opportunities.

Grasshopper Diseases, like the sicknesses of other animals, often cause the death of thousands of these insects; but we have not yet been able to spread these diseases artificially so as to make them of much use in killing the 'hoppers. We must destroy their eggs in fall, during winter, or early spring, by disking or harrowing the ground. We must catch the young and full-grown insects with 'hopper dozers and other machines, or else we must by some other means prevent them from destroying our cultivated plants and grasses that grow wild upon the prairies.

Crickets, Katydid, and Other Relatives of Locusts.—These insects, like the short-horned grasshoppers described above, are also plant-eaters. But they hardly ever become so numerous as to destroy whole fields of grain or the grasses of the prairies and meadows. In fact, they seem to be more or less necessary to complete our idea of a country picture. Their thrilling music seems to be ever present during the warm days



FIG. 31. Angular-winged katydid.

and delightful evenings of late summer and early fall. This insect music is one of the most characteristic features of country life, and we would miss it greatly were all these insects to die and no longer chirrup their songs of love. They are the chief musicians of the insect world and they appeal to most of us who have been endowed with sentimental natures, much as do birds.

As mentioned on a former page, in these insects we find fully developed ears, which are located on the front legs just below the knee, or elbow. Their feelers, or "horns," are nearly or quite as long as their bodies, hence they may be called "long-horned" to separate them from the "short-horned" grasshoppers referred to above. Then, too, the females are furnished with a sword-like egg-layer. These

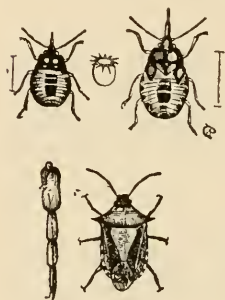


FIG. 32. Spined soldier-bug. Upper figures, egg and immature. Lower figures, beak and mature.

long-horned 'hoppers may be separated into two families—the crickets, and the katydids and katydid-like insects. These musical insects also have their natural enemies among the useful kinds already described.

Bugs and their Relatives.—When we tried to tell you about insects in general as differing from all other animal forms, you will remember it was said that certain kinds had their mouths made in the form of a jointed beak or tube. These insects suck blood and sap. Some of them

are called bugs, some cicadas, others leaf and tree hoppers, and still others lice and plant lice.

Most of the members of this great army of insects with sucking mouths belong to the harmful insects, because we find them living either as enemies to man or to the domestic animals which he has tamed; or else they are harmful to the plants which we use. Such common kinds like lice and bed-bugs we all know about. We also know about the squash-bug and chinch-bug, both of which are very troublesome. The squash-bug sucks the juices from squash, pumpkin, cucumber, and melon vines; and the chinch-bug injures wheat, barley, rye, oats, millet, and corn. All of these, and a lot of others, have a peculiar strong odor. So we often call them "stink bugs." They are the *true bugs* and we should be careful about calling other insects by so bad a name. Even these jointed-beaked insects are not all called "bugs," as stated above.

In summer we often hear insects singing in the trees, which seem to make noise enough to be as large as a cat or a dog, but which are really no larger than the outer joint of one of our fingers. These are cicadas, or as they are sometimes wrongly called, "locusts." One kind takes seventeen years to become full grown, and then appears in large numbers or swarms. For sixteen years it lives under the ground sucking the sap from roots and growing slowly, but the seventeenth year it comes to the top of the ground, gets wings, lays its eggs, and dies. These eggs, which are placed in the twigs of trees by the female insect, hatch and the young cicadas drop to the ground and dig down to live there like their par-

ents did for sixteen years. These cicadas make all their noise with their ears. Queer insects, indeed!

Tree-hoppers and Leaf-hoppers.—They are so-called, because they live on grass, leaves, and trees, and because of their jumping habits. Like their relatives, the cicadas and bugs, they live on sap. Some of

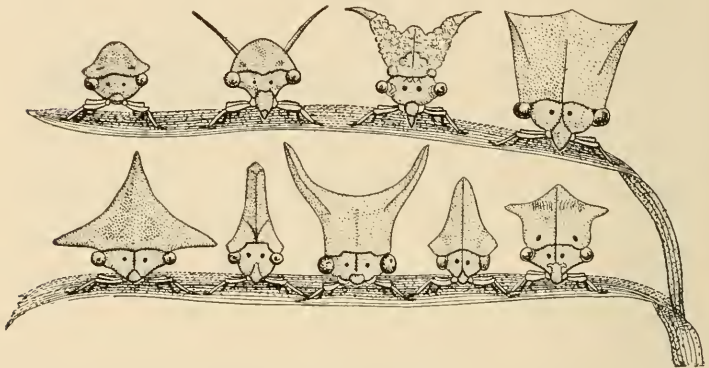


FIG. 33. Brownie bugs.

them are very queer-looking creatures indeed. If we believed that there were such creatures as fairies and brownies we would surely say that they were these insects, so bedecked are they with queer haunches on their backs and shoulders; and with their bulging eyes, which suggest the productions of Palmer Cox. Some of them really have been called "brownie bugs," because of their likeness to the brownies.

There are hundreds of these jumping insects, and each kind seems to be an enemy of some particular plant.

Throughout the summer, nearly every blade of grass on the prairies, every weed in the field, or herb in the forest, to say nothing of cultivated plants, has one or more of these insects perched upon it busily engaged in sucking the sap. No wonder that plants suffer and are so often killed, when such a host of insects is continually at work upon them. But these, like other harmful insects, all have their own enemies and diseases to keep them in check. Sometimes, however, we must fight them ourselves in order to prevent their doing too much damage to our crops. The 'hopper dozer can then be used, or we can spray the plants with kerosene emulsion, which is made as described in the chapter on remedies.

Plant Lice.—Plants, like animals, are often bothered by lice. Sometimes they are even killed by them, if there is no remedy at hand. The lice of plants are either shell-like and stick very close to the twigs or leaves; or they are active and move about from place to place like many other insects. The first kind are called "bark lice" or "scale insects"; and the last "aphids" or simply "plant lice."

Scale insects, when full grown, do not look at all like other insects; but when they are first hatched they resemble a "sow-bug" and are quite active and run about on the plants which they infest. After a little while they settle down upon the bark or surface of a leaf, insert their beaks, and begin sucking sap. They then commence to form a shell or covering of wax over their bodies and remain stationary the remainder of their lives. Different kinds make scales or shells of different shapes. The male insects, when full grown,

change form, and leave the scales as winged creatures, but the females do not. The latter simply remain where they are, lay eggs under the shells, and die. At the right time these eggs hatch and the young run about over the plant until they settle down just as their par-

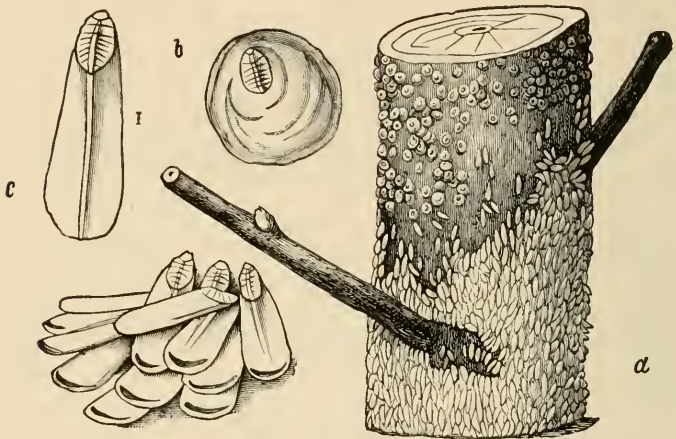


FIG. 34. Peach Scale. *a.* Natural size; *b.* Female; *c.* Male, enlarged.

ents did before them. A very few kinds produce living young instead of laying eggs. The much-talked-of San Jose scale is of this latter kind. The wax from some kinds of these insects is used for making varnish. Mealy bugs and the cochineal insect are relatives of the scale insects.

The aphids, green flies, or true plant-lice, form a very interesting family of insects. So if a little more time is spent in telling about them than was given to other forms you will, no doubt, pardon the writer. Besides

being very interesting on account of the way in which they live and raise their young, very many kinds are among our most harmful insects. They are also among the most rapid multipliers in the insect world. A few kinds feed on several plants, but most of them attack only one species upon which they continue to live till they die.

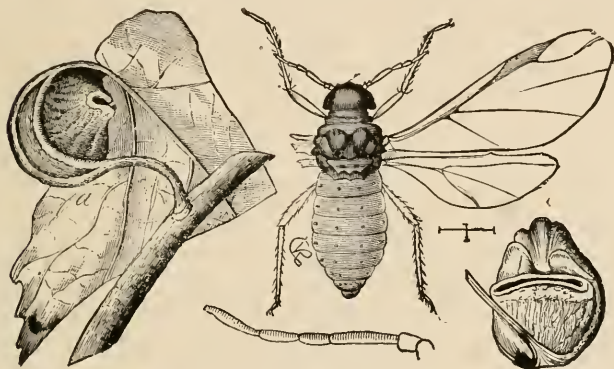


FIG. 35. Cottonwood gall louse.

While feeding they discharge a sweet substance from two tubes which grow on their backs near the sides of their abdomen. This fluid is called "honey dew," and often attracts a great many other insects, like bees, wasps, and ants which come to lap it up. Ants in particular are fond of this honey dew and often take care of the plant lice as we would of cows just to obtain this honey dew when they want it. In fact, plant lice of this sort are very often called ant's cows. Perhaps, if there is room for it in this little book, more will be told about ants and their cows.

How They Multiply.—Plant lice increase by laying eggs, as well as by what is called “budding.” A true female louse lays eggs in the fall on the plant where its young must feed. This egg hatches into another kind of mother louse the next spring. When full grown, instead of laying eggs, she produces little lice—about twenty-five a day for two weeks or more. In about a week these little lice are grown up, when they, too, give birth to other little lice, and these in turn become mothers, and so on all through the spring, summer, and fall, till cold weather indicates that it is time for eggs to be laid for taking the lice through the winter. In this way we can have countless millions of lice produced in one season from a single egg.

Some of these lice live on the surface of the plants injured, either upon the upper or lower side of the leaves, or upon the stem itself. Others cause the leaves to curl or twist about, so as to form a protection for them. Still others cause the plant to form peculiar hollow growths, within which they feed, quite well protected from storms and certain enemies. Other kinds even feed on the roots of plants beneath the surface of the ground. Some change from one plant to another, or from above ground to below and back again as the seasons change.

These insects are the most rapid multipliers among insects. They also have many enemies, as you will remember from having read the chapter on useful insects. Sometimes even all of these enemies, when combined, are unable to keep their numbers small enough to prevent their doing harm. At such times

we must spray the plants with soap-suds, kerosene emulsion, whale-oil soap, and other remedies which are used for various soft-bodied insects.

Biting Lice.—Besides the lice that suck the blood there are a lot of different kinds of these insects which feed on hair, feathers, and scales of the skins of the animals upon which they live. They are called “biting lice,” to tell them from the “sucking lice.” Most of these biting lice live on birds, but a few kinds, also, live on animals with fur or hair.

Most wild birds know how to kill these lice, so they never become numerous enough to do much harm. Even our tame birds, like chickens, know that by dusting themselves in ashes and other dry, powdery substances they can rid themselves of their lice. Sometimes sitting hens and little chickens become covered with lice and must then be greased in order to kill these vermin. The grease chokes or stops up the breathing holes at the side of their bodies.

Beetles.—The insects which we call beetles are very numerous and differ a great deal among themselves in size, shape, habits, and the places where they may be found. Of course, as you already know, many of them are useful; but others are harmful because they destroy trees and other plants on or inside of the leaves, stems, and roots upon which they feed. Some kinds come into our houses and other buildings, where they attack and injure carpets, clothing, and even articles of food. In our granaries they attack stored grain, besides destroying flour and meal in mills.

Beetles differ from other insects in having their front

wings hard and bony so they can be used to protect their soft bodies and delicate hind wings, which are made to fly with. Their young are worm-like, and are called by such names as grubs, wire-worms, grub-worms, round-headed borers, flat-headed borers, and glow-

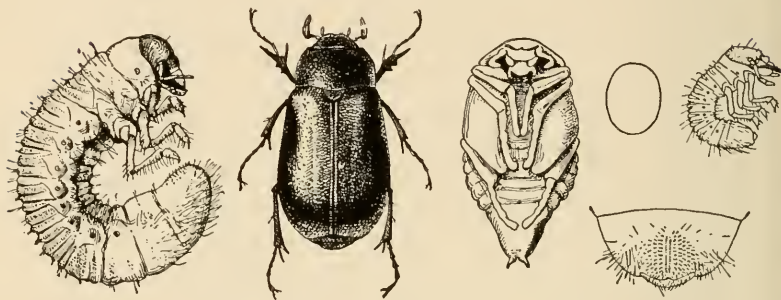


FIG. 36. June-beetle — stages.

worms, according as they are the larvæ of certain kinds or families of beetles.

Perhaps the commonest beetles that do harm on the farm are those we call "June-bugs" or May-beetles.

These are so well known that the picture alone will show what kind is meant. Of course town-folks and girls will have to be told that the grub-worms are their young, and that they live in the ground two or three years before they are full grown. These grubs dig their way about in the earth, where they eat the roots of grasses, clover, alfalfa, and a number of other plants. When ready to change to the pupa stage they make a nice little oval-shaped room in which this takes place; and

later, in which the beetle waits till it has become hardened enough to dig its way through the earth to the top of the ground. In spring, about corn-planting time, these beetles come out during warm evenings and fly around making their buzzing noise. Sometimes hundreds, or even thousands, of them gather on our fruit and shade trees; and when they do so, much harm is done because they eat the blossoms, leaves, and fruit. In a few weeks their eggs are laid and the old beetles die or are eaten by various kinds of toads, lizards, mice, and other small animals. One of the digger wasps, spoken of on another page, also kills many of these insects; but it generally attacks the grubs, instead of the beetles. Some of the relatives of the June-beetles, which are found in warm countries, are regular giants—being five or six inches long. Others of their relatives are the dung-beetles, like the tumble-bugs mentioned at another place in this book, and flower-beetles, of both of which there are many kinds.

Wire-Worm Beetles.—We sometimes find smooth, hard, yellowish-brown, slender worms among the roots of grasses and clover. These are called “wire-worms,” and are the young of click-beetles or snapping beetles. Like the grub-worm, these wire-worms often do much damage to growing plants by gnawing off their roots. On account of their living in the ground it is not so very easy to destroy them. About the only thing that can be done is to encourage their natural enemies, such as have already been mentioned or will be later. One of these wire-worms here in Nebraska is furnished with an arrangement for making lights like a fire-fly.

It is called a glow-worm. In the West Indies, and Central and South America, some of the larger "click" beetles are also fitted with very strong and bright lanterns for attracting their mates. People sometimes use these beetles for scarf-pins when going to a party at night. They can also be used instead of candles to read by.

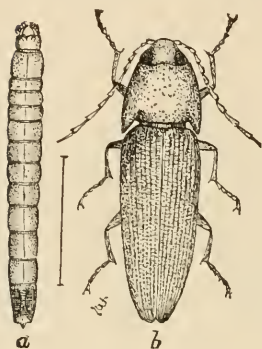


FIG. 37. Wire-worm and "click" beetle.

Leaf-Beetles.—Anybody who has learned to know the Colorado potato beetle can tell what leaf-beetles are like. These form a very large family of medium or small sized, bright-colored beetles, which feed on the

leaves of different plants. Even their grubs can usually be found on the same plant with the parents. To this family belong such rascals as the cucumber-beetles, the corn-root worm, the willow and the cottonwood beetles, the sweet-potato-beetles, flea-beetles, and others. Feeding as they do on many of our wild plants, it happens that every once in a while we learn of a new kind changing to one of the cultivated plants. When this is done we have one more insect enemy to fight.

Some of these leaf-beetles are protected from their enemies by being furnished with arrangements for making strong odors, or by having their bodies covered with distasteful substances. Others have the habit of living in little cases which the grubs make for themselves, and

still others drop to the ground when disturbed, where they lie as if dead. Many of these leaf-beetles live over winter hidden away under old rubbish, cow-chips, stones, and pieces of wood, where we may find them on any pleasant day if we only take the pains to look. Early in the spring they leave these winter quarters, and



FIG. 38. Leaf-beetles and larva.

fly to the plants on which their young are to feed. There are two or three broods or sets of young of many forms during the spring, summer, and fall. Many of the leaf-beetles are eaten by their enemies while they are still in the egg state. The lady-birds, spoken of on another page, do much of this good work.

Boring Beetles.—Every boy goes into the woods sometime during the year; or if he does not, he certainly must chop wood. In either case he soon learns that the trunk, branches, and limbs of trees are bored into by insects. Sometimes he even finds them in their burrows. Of course he has learned for himself that the worms of different shapes and sizes are the young of beetles—short-horned or long-horned. But the girls who stay at home and can't chop wood must be told about them here.

These wood-boring insects do a great deal of harm by

making holes so as to cut off the flow of sap. Sometimes they even weaken trees to such an extent as to allow the wind to break them off. The beetles that lay the eggs from which these borers hatch, mostly belong to two families, which are called the "long-horned" and

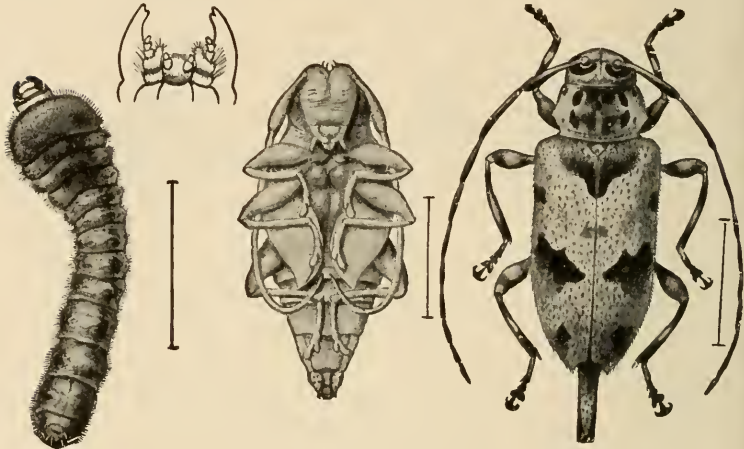


FIG. 39. Hackberry borer.

the "short-horned" boring beetles. Their young are called "round-headed" and "flat-headed" borers, the round-headed being the young of the long-horned beetles, and the flat-headed those of the short-horned. Even if these insects are hidden away on the inside of trees they are not quite safe from enemies. So nicely has everything been planned in this world that no kind of animal can escape from all others. A number of ichneumon flies and other insects make it their special

business to hunt out and destroy them. Then, too, as the boys will tell you, certain kinds of our birds are also made especially for the same kind of work. By looking over what is said about birds in this little book, you will

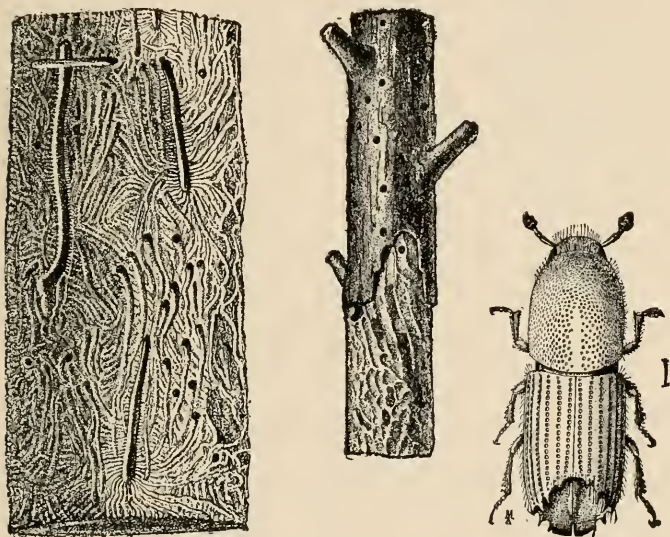


FIG. 40. Bark-boring beetle and injury.

learn which ones these are, and how they are fitted for the work they have to do.

Sometimes a slender wire or the point of a pen-knife in the hand of a man or boy, will save a tree when we know that a borer is at work in its trunk. By the time one of the borer's natural enemies gets around to the injured tree it might be too late.

Bark-Beetles.—In addition to the two kinds of boring beetles just mentioned, there are still others; but those known as “bark-beetles” are the most important. These, as the name indicates, are to be found either in the bark or between it and the wood. By the united work of many of these beetles a tree is soon girdled and killed. Most of these bark-beetles are rather small, but their numbers make up for their small size. They generally attack and hurt sickly trees, or those that have been already harmed by leaf-eaters or other borers.

Aside from their natural enemies we can do much towards keeping these bark-beetles in check by cutting off the infested limbs and burning them along with the beetles and their grubs. The bark-beetles that injure fruit-trees should be looked after first because they do the most harm and are not so often destroyed by birds which live in the woods and farther away from our homes.

Snout Beetles.—We often see beetles of different shapes, sizes, and colors, which have the front part of their heads drawn out so as to form snouts, or beaks. These are called “bill bugs,” or “snout beetles.” Nearly all of them are harmful in one way or another, because they attack and eat plants or their seeds and fruits. The grubs of these insects generally live inside of some part of the plants attacked. A good example of this kind of beetle is known as the plum-gouger, because it gouges holes and lays its eggs in that fruit. Other kinds are enemies of such fruits as the pear, apple, peach, and grape, while nearly all the varieties of nuts have each

one or more kinds of these insects which injure them. Some of the nut "weevils," for such is the name by which they are known, have snouts nearly or quite as long as their bodies. The reason for their having this very long snout is that they use their bills for making holes clear through the husk as well as the shell of the nut, so that their eggs can be placed where the grubs will live.

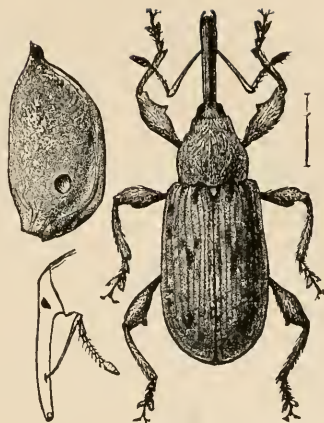


FIG. 41. Plum gouger.

Some of our weevils, or snout beetles, injure corn, sugar-cane, and even the smaller grains and grasses. Hundreds of smaller kinds live in the stems or else in the flower-heads and seed-pods of certain plants. One kind lives in the stems of the cockle-bur, and sometimes kills it. But we do not mind this, for we ourselves try to destroy the cockle-burs.

Stored Grain Insects.—Many of the smaller weevils are so fond of different kinds of seeds that they often go to our granaries where they attack and eat the stored grain. In fact, some kinds are only found in stored grain and other food substances made of grains and seeds like peas, beans, and rice. A few other small beetles besides the weevils are found in the same kinds of places and have similar habits. All of them have

natural enemies; but, living as they do in artificial homes with plenty to eat, they have more of a chance to escape these than do other insects which are less protected. This being the case, we must do more in the way of fighting them ourselves.

Butterflies and Moths.—It is very easy to tell butterflies and moths from all other kinds of insects, because they have their wings covered with little colored scales that easily rub off. But it is not quite so easy to tell them apart. Of course we know that butterflies fly about in the daytime, when the sun shines, and that most of the moths are night fliers. Then, too, butterflies have knobbed feelers, but those of the moth are either feathered or thread-like and pointed. Still it makes little difference to us, whether butterflies or moths, so long as they are harmful.

Since it is the young or caterpillars of these insects that do the harm, we should know more about them than about the full-grown insects, which only sip the sweet juices of flowers, and fly about laying their eggs and enjoying life. These caterpillars, even if they are worm-like, are different from one another in form and appearance. Some are smooth, some are rough and are more or less covered with wart-like knobs and hairs, others are long and slender, while still others are short and heavy. We call them by such common names as cut-worms, silk-worms, bag-worms, army-worms, apple-worms, measuring-worms, wood-borers, tent caterpillars, etc., according to the way in which they live and how they look.

Caterpillars differ from one another in their habits as

well as in their appearance. Some go in droves or armies, others feed singly or alone. Some spin webs under which to hide from their enemies, or by which to drop and hang when disturbed. Still others live as borers within the leaves, stems, fruits, and seeds of plants; and a few like to eat clothing, dried fruit, flour, and other articles which we keep in our homes.

These insects are quite rapid multipliers. By this we mean that they increase in numbers very fast. Most female moths and butterflies lay over a hundred eggs at one time, and some are known to deposit as many as five or six hundred, or even more. Some kinds have only a single brood each year; but others raise young two, three, or it may be four times a year. A good many kinds feed on only one or two species of plants, but others seem to be able to eat almost anything that grows. It is these last that are oftenest the most harmful kinds.

The eggs of the butterflies and moths are nearly always beautiful objects. Many of them have their shells nicely ridged with different kinds of figures which are arranged so as to make them look like small vases and other kinds of colored glass dishes. From these hatch the little caterpillars. These latter eat and grow very fast, and shed their skin four or five times before they are full grown and ready to change to the resting-stage. This stage in these insects is called the chrysalis. Sometimes the change from a caterpillar to chrysalis takes place inside of a cocoon made of silk, or of silk and hair. At other times it occurs in the ground in a little oval cell; and at still others within the burrows

of the caterpillars in the stems or leaves of plants. The caterpillars of butterflies most always change to the chrysalis without spinning cocoons, or even going into the ground or boring into plants.

Cut-Worms and Army-Worms.—Every year there is more or less damage done to young plants on the farm by caterpillars which we call cut-worms. This name is

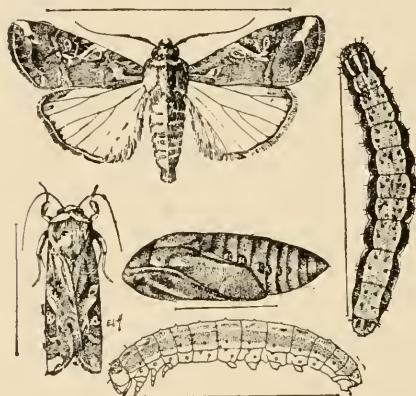


FIG. 42. Fall army-worm.

given to them because they most always cut off the plants near the ground. A few kinds even climb up the trunks of trees and other plants to do their mischief. The cut-worms work at night, but in the daytime they hide away in the ground, or under

sticks, clods, old boards, dried leaves, and other things which may be lying around loose. They are the young of certain gray or dull-colored moths, which also keep themselves hidden away during the daytime. There are a great many different kinds of these insects. Some of them often appear in large numbers, and at such times are called army-worms. When present in armies they do not always take the trouble to hide when the sun rises, but keep on feeding and moving about all

day. We know of the genuine, fall, the alfalfa, and the wheat-head army-worms here in our own state, and there are still others in different parts of the country.

The cut-worms and army-worms have dozens of kinds of enemies among the useful insects. These most always keep them so nearly killed off that they cannot do much harm to our crops. Sometimes, however, the weather is not just right for the friendly insects to be about in their usual numbers, and then these harmful kinds get ahead of them. When this is the case we ourselves must try to do something to assist in checking their numbers. We can use heavy rollers and other machines to crush the worms, or we may plough furrows and dig ditches for them to fall into where they may be killed, and later harrow the ground to destroy the chrysalids. Sometimes we may also put out poisoned baits to which they can be enticed and killed.

Tent Caterpillars.—These are the young of moths which live on trees. They have received their name because they spin webs that sometimes look like little tents tucked away in the forks of limbs. Like the cut-worms, these tent caterpillars are of several kinds and attack different trees. They also work in various ways, either in spring, summer, or fall. The eggs from which they hatch are laid by the parent moths in clusters upon the trees. Those of the kind that work early in spring are laid during the previous fall and summer; but those that appear later are deposited the same year. Some kinds of tent caterpillars spin cocoons in which they change into the chrysalis; but others dig into the ground before making the change. All kinds are more

or less thickly covered with hair, and for this reason birds do not care to eat them. The useful ichneumon flies, spoken of in another chapter, do not seem to mind this, for many of them lay their eggs on the bodies of the caterpillars so that their young can feed upon them. Other insects, also, like the flesh flies, attack and lay eggs on them; while such forms as some kinds of "stink bugs," caterpillar-hunters, and robber flies, destroy many more.

We can also do much ourselves towards preventing our fruit and shade trees from being harmed by these caterpillars, if we will only take the time to gather their eggs during the winter months, when the leaves are off and they can be seen. A torch attached to a long stick or pole may be used to burn the caterpillars that are too far from the ground to be reached by hand.

Cabbage Worms.—These are sometimes the young of butterflies, and at other times the young of moths. The common green ones are the caterpillars of the white butterflies that flit around our gardens. There are two or three broods of these worms every year, so that we seem to have them all summer. They are killed by some of the smaller ichneumon flies, one or two kinds of "stink bugs," and a few of the digger wasps and ground beetles. Toads also sometimes eat them. The English sparrows likewise feed many of them, as well as other insects, to their young during the summer months.

The Apple-Worm, or Codling Moth is responsible for most if not all of the wormy apples in this part of the country. So a few words about it may be useful here. In the spring of the year, just after the blossoms

fall, a small gray moth, with a dull, brownish, copper-colored patch near the outer edge of each front wing, lays its eggs in the flower end of the apples. These soon hatch, and the little worms eat their way into the fruit. In about a month or six weeks they are full grown and leave the apples, going quietly to the ground, cracks in the bark, and other places to spin their cocoons and change to the resting-stage. Ten days or two weeks later they have changed to moths, which, in turn, lay their eggs on the half-grown apples. This time many of the eggs are placed between two apples that touch, or between an apple and a limb, as well as in the blossom end. Some of the worms from the eggs of this second brood become full grown and leave the apple early enough to change to moths in time to produce a third brood of the worms before winter. Most of this second brood, however, live over winter in cracks, in the bark on trees, or else are taken in fruit to cellars and other places where they find safe retreats in which to pass the winter.

Spraying with Paris green and other poisons soon after the eggs are laid for the first worms is the best remedy. Not so much good can be done later in the summer by spraying. Picking up the windfalls and giving them to the hogs will likewise do some good. This worm also has its enemies among the useful insects mentioned in another chapter.

Flies, Mosquitoes, and Gnats.—Besides all of the insects about which we have already learned, we know of still others that are of harm in one or more ways. Some of these we call by such names as “horse” flies, the house fly, mosquitoes, gnats, etc. These, instead

of feeding on plants, suck the blood or live on the bodies of some of our tame animals. Quite a number of them also bite and tease us when we are out of doors on the prairie or in the fields. Doctors tell us that some of these insects help to spread diseases like malaria and yellow fever. When mosquitoes are numerous about

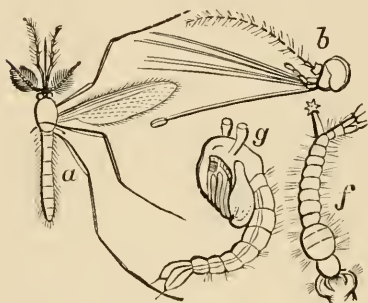


FIG. 43. Mosquito. *a*, Male; *b*, Head of female; *f*, *g*, Young.

the house we can get rid of some of them by putting a few drops of coal oil in the rain-water barrel so as to kill the wigglers, which later turn into mosquitoes.

Some insects do harm at certain times in their lives, while at others they are

useful. The "oil" beetles or "blister" beetles are examples of this kind. While young many of them live in the ground and feed on the eggs of the short-horned grasshoppers or locusts, but when full grown eat the leaves of plants. These beetles attack most kinds of cultivated plants, and quite a number of the wild ones. The young of certain flies, gnats, and mosquitoes are also useful since they eat dead and decaying animals and plants; but when they are full grown they live on the blood of man and beast. They are known also to carry the germs of diseases and drop them into our food or in sores on our bodies, and in this way do a great deal of harm.

Remedies.—When harmful insects are more than ordinarily numerous they damage crops. At such times it is often best for us to help their natural enemies in killing them off. When we attempt this we must do it in different ways for different kinds of insects. Some we can kill by harrowing the ground or by the use of heavy rollers for running over and crushing them. Others can



FIG. 44.

be killed by spraying their food-plants with poisons which they will eat and be destroyed. Still others may be reduced in numbers by spraying with substances that would kill by coming in contact with them. In small gardens we can pick them by hand, and later burn or crush them. Still others may be killed by poisonous fumes or gases. Fires in stubble fields, on the prairie, and about old weed patches may be resorted to for killing certain others, while torches fastened to sticks will reach caterpillars in trees, as already suggested on another page.

Some insects, as for example those with sucking mouth parts, must be killed by the use of kerosene

“emulsion,” or a mixture of coal oil and water, or by some other similar substance that will kill from the outside. But these mixtures must not be too strong or they will kill the plants also. They can be sprinkled on the bugs with spray pumps of different kinds.

For the names of these mixtures and learning how they can be made, you had better write to the “bug-man” at the State University, who will gladly tell you what you wish to know. In the mean while try to find out all you can about how the different kinds of insects live, and what their natural enemies are.

Spiders and Mites.—As a rule the life histories of most of our spiders are such as to make them useful. Both the web-makers and those that live in holes catch different kinds of insects upon which they feed. The web-makers especially destroy large numbers of flies, gnats, and mosquitoes; while many a moth and other harmful insect is entrapped by the beautiful circular webs that are nightly stretched for this purpose, in prominent places, among vegetation.

Ground spiders are generally dark colored, while those that live among and on plants are lighter colored and more or less ornamented with spots, stripes, and bands so as to assist in hiding them from the insects upon which they feed.

Spiders are destroyed by quite a large number of other kinds of animals. Wasps use them for food for their young, as mentioned on another page. A number of small ichneumon flies destroy their eggs. Birds also catch and eat large numbers of them.

Mites.—The mites, which are close relatives of spiders,

are both useful and harmful. The useful kinds, like the small red one which we find on the wings of the grasshopper, attack insects. The harmful ones, like the itch and mange mites and the "red spider," attack our domestic animals or work on the leaves of plants.

Dipping an animal that is suffering from mange in a solution of zenoleum or chloral naphtholeum, will kill the mites that produce it and cure the disease. Burning sulphur in a greenhouse where there are "red spiders" will destroy them.

Myriapods, or Manylegs, are of two kinds, when we consider what they eat. They may also be separated into two groups by the arrangement of their legs. The plant-eating kinds have two pairs of legs to each ring of the body, while the flesh-eating kinds have only one pair to each ring. The poisonous kinds are among these last mentioned; but few if any of the kinds found in Nebraska are dangerous.

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1. How do grasshoppers live through the winter? Where do they lay their eggs? In what ways may the eggs be killed?
 2. How do plant lice and chinch-bugs get their food? Can they be poisoned? How can we kill plant lice? What insects kill them?
 3. How can you tell a beetle from other insects?
 4. Where do the larvæ of mosquitos live? What diseases are spread by mosquitos? What did the Americans do to stop the yellow fever in Cuba?
 5. Name the ten insects which you think do the most damage in Nebraska. What may be done to keep each one down? What is done in your county to control insect pests?

See page 197 for exercises to be taken up in connection with pages 51 to 100 of the text, as the class is prepared for them.

CHAPTER VIII

BIRDS

Quite prominent among the various animals which we see almost every day of our lives are the birds. They are of great variety, and have different habits, one from the other. Next to the



FIG. 45. Black-capped chickadee or Titmouse.

insects, they are the most numerous of all the forms that live on land. Of course there is a reason for this, and by stopping to think we may be able to tell just what this reason is. If we don't know it now, we will before we finish reading the present chapter.

Birds differ from other animals by having their bodies covered with feathers instead of with hair, fur, or scales. Then, too, many of them have their front legs so changed that they can be used for flying through the air. Only the hind legs are fitted and used for perching, running, and walking.

Birds are found all over the surface of the earth, from the warmer to the colder parts, both on land and water. It seems, too, that man has been interested in them for

a very long time. More than three thousand years ago some kinds had already been tamed by the half-wild people who lived then. Some of the people who lived in America long before it was discovered by Columbus also had tame birds. Perhaps a few words about these kinds that have been tamed will be interesting to town-folks.

Birds that have been Tamed.—Chickens are first and foremost among these; for, of course, they are birds just as truly as the English sparrow or the robin. Although chickens are now of so many breeds, they all came from a single kind of wild bird, which is still found in the jungles or forests of southeastern Asia. This wild bird is called the jungle fowl or jungle bird, which is very much the same in its appearance as some of the tame game cocks of to-day.

But the many changes in living, which the tame birds have been made to pass through in these thousands of years, while living in places away from their forest homes, have produced the differences that occur between the langshangs, Plymouth rocks, cochins, Spanish, and other breeds and crosses. Each country seems to have produced one or more well-marked forms of chickens. The uses of chickens are many. But these need not be mentioned here.

Turkeys.—If the Old World claims the honor of furnishing man with the chickens, America can boast of an equally valuable prize in the turkey. What a noble bird! How could our ancestors, of only a few hundred years ago, in Europe, celebrate such days as Thanksgiving and Christmas without turkeys?

While turkeys have been tamed for a much shorter time than chickens, they are already pretty well spread over the civilized world. There are, also, a number of distinct breeds of this bird. They came from our wild turkey and the Mexican wild turkey. The latter bird is a little but not very different from ours. Not many years ago plenty of wild turkeys were still to be found in parts of Nebraska; but to-day few, if any, remain.

Guinea Hens originally came from east Africa, where they live wild in the jungles. Although an easy fowl to raise, they are too noisy for most people. Then, too, their flesh is rather dark colored and less inviting as an article of food than that of the ordinary fowl. Neither does the guinea fowl lay eggs save in the spring or early summer. There have also been produced several breeds of the guinea fowl which differ quite a great deal from the wild form.

The Peacock, or Pea-Fowl, like the chicken, was also first tamed in India or southeastern Asia, where quite a number of different kinds of pheasants and pheasant-like birds are still to be found living wild. Unlike the other birds mentioned above, the peacock is raised more for ornament than for food purposes. Its very large tail and other bright colored feathers make it a nice object to look at. Hence it is kept in gardens and parks among other beautiful things like the trees and flowers, to be looked at and admired.

Pigeons.—All of our tame doves, or pigeons, come from the wild bird known as the blue rock-dove, also of the Old World. Some of the many breeds of pigeons have been raised for special purposes. One of these is

the "homing" dove, as it is called, and is sometimes used for carrying letters from place to place. On account of the many times that they nest during the year pigeons are much used for food purposes. They are also in demand by would-be sportsmen for trap-shooting, which some of us do not indorse.

Ducks and Geese.—The different breeds of tame ducks are mostly off-shoots of the wild mallard found in the Old World and in North America. Some of the tamed varieties do not look much like their ancestors. Neither do many of the different kinds of chickens resemble the jungle fowl from which they came.

Tame geese are the descendants of two kinds of wild ones, both of which are found in the Old World. Many of our wild kinds could also be tamed, and would make just as valuable birds for the farm as do those we have now; but there is no need of our going to all the trouble of taming these when we already have those that are good enough. Besides, to tame animals and to get them to so change their lives as to be at home under all the different circumstances which would be necessary, takes a long time.

Canary birds, mocking-birds, parrots, and a few others have been caged for house birds, but these are of no especial use on the farm, therefore, we will say nothing about them here.

Wild Birds.—It is concerning the wild, or untamed, birds that we are the most interested, and about which a great deal can be said that will be of use to the farmer as well as to all other persons. Nebraska is a very good home for such wild birds. We know of more than

four hundred different kinds that have been found here. Of these about two hundred nest in the state every year; and perhaps as many as fifty others sometimes. In winter more than one hundred remain with us, while the others leave in fall for the warmer south country, only to return to us with the pleasant weather of spring.



FIG. 46. Goldfinch.

While there is much to be learned about the migrations, nesting, moulting, songs, and peculiar ways of living among the different birds that we may see in our groves and fields, along the streams, on the prairies, and about the hedge-rows and garden patches, the most important feature connected with their lives to

us is their food habits. For it is by what they eat that birds make themselves of so much use to us. Of course birds are of different sizes and forms, and have their beaks, feet, wings, and tails made so as best to conform to the uses for which they are intended. The wood-peckers have hard, chisel-like beaks for cutting wood; and at the same time, their tail feathers are stiff and pointed so as to be of use as props to hold the birds in place while they are busily engaged at nest-making or digging for borers. In a like manner their long tongues are barbed so as to spear and drag out the worms when reached. The

short, strong beaks of the sparrows and their relatives are exactly suited for cracking the many kinds of weed seeds eaten by these birds in winter, as well as for crushing such insects as are fed to their young in summer.

On account of this most important feature in connec-

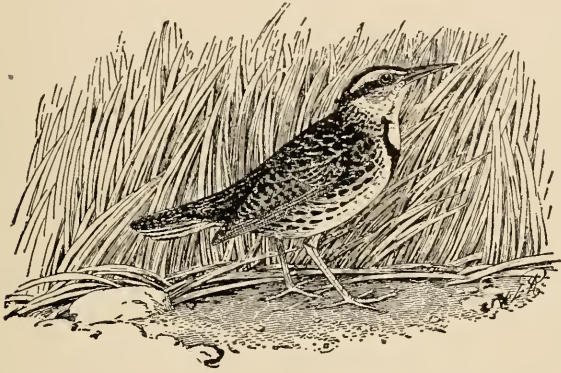


FIG. 47. Western meadowlark.

tion with our wild birds we will talk more about what they eat now, and leave the description of them, their haunts, migrations, nest-building, etc., for another time. Then, too, almost everybody already knows some of these things about most of our common birds.

Usefulness of Birds.—Birds can be useful to us in many ways. They can carry the seeds of different plants from place to place so as to help start new groves in which we may find shelter from the cold in winter and the heat in summer. They plant shrubs by the wayside that spring up and later bear good fruit. They

also carry the eggs of fishes and small crustaceans among their feathers into new waters, and feed upon the countless millions of weed seeds that are scattered over our fields. Some kinds live almost entirely on insects; while others hunt out and destroy such small animals as mice, ground squirrels, and gophers. Still other birds, like some of the useful insects spoken of in another chapter, act as scavengers by helping to remove decaying things that would make us sick if not cleared away.

In addition to these direct benefits which are the gifts of birds, we are further indebted to them for the cheer which their gay music, bright plumage, and pleasant manners bring to us. The birds form a carefully planned army of police, which is engaged in keeping things balanced in nature.

But we can go even further when summing up the benefits that human beings may derive from birds. A great many kinds are excellent food, while others furnish soft feathers for pillows and warm coverlets on our beds.

Birds as Enemies.—Everybody knows that birds sometimes also do harm. So we must try to learn just what this is and whether or not it is as great as some people would try to make us believe. Quite a number of different birds are continually doing things that we call wrong. If we only knew of these wrong things and nothing of the good they do, it might go pretty hard with the doers.

Some of the wrong things that birds do are cherry and berry stealing, grain eating, grape puncturing, apple pecking, corn pulling, the carrying of some kinds of bark

lice on their feet from one place to another, the spreading of hog cholera by crows and turkey buzzards, the robbing of the poultry yard, and lastly the disturbing of our slumbers in the morning by their singing.

Some of these so-called crimes are genuine and are to be regretted. Others are more imaginary than real. A few of them could be prevented in part or altogether, while others might be made less severe if we were inclined to take the trouble to do it. After all that can be said in favor of and against the usefulness of birds in general, there can be no doubt left, in the minds of thinking people at least, as to the value of these creatures. Only ignorant and thoughtless persons will continue to destroy our birds after learning facts like these about them.

Food Habits of Birds.—So varied is this task of “evening up” in nature spoken of above, that if attended to in the right way, the workers must be many and have widely different habits. That such is the fact, can easily be seen from the following short account of the food-habits of some of the different groups of our birds.

Grebes and loons feed chiefly on snails and other water animals such as are found about ponds, lakes, and rivers. They also destroy grasshoppers when found about their haunts.

The gulls, with their long



FIG. 48. Kingbird.

wings and great powers of flight, often reach far inland in their journeys. Whenever they do they catch large numbers of grasshoppers, crickets, June-beetles, and other common insects. Four or five kinds of these birds breed in large numbers in our state every summer.

The ducks and geese, like their tame relatives, are also fond of insects, which they catch about the margins of ponds and lakes near which they build their nests and raise their young. Even such birds as the bittern and shitepoke kill many insects in addition to the small fishes, frogs, snails, and other animals which in part make up their bill of fare.

The different kinds of snipes and their relatives are also great destroyers of insects. Moving, as many of them do, in large flocks which spread out over the meadows, pastures, hillsides, and fields, they perform a large amount of careful police service in arresting the rascals among insects. They even pry them out of cracks and holes in the ground where they have crawled and are hiding during the daytime.

The prairie chicken and sharp-tailed grouse, as well as the quail, or "bobwhite," all feed almost entirely on insects in summer. They also eat large numbers of these creatures during the remainder of the year whenever they can get them. The quail especially is to be considered one of the very best insect destroyers, since it will eat both the Colorado potato-beetle and the chinch-bug. Perhaps no other bird on the farm pays higher prices for the grain it eats than does the quail. Living in the hedge-rows, groves, and in ravines, where insects gather and lurk during the greater part of the

year, this bird seizes large numbers of these enemies daily. Not only during the summer months when they are moving about, but all winter, too, it scratches among the fallen leaves and other rubbish seeking for hibernating insects of various kinds. Being a timid bird it seldom leaves cover to feed openly in the fields, and therefore does little real harm in the way of destroying grain.

Even the barnyard fowls do much in the way of destroying many kinds of insects throughout the summer. Where fields can be gone over by chickens, turkeys, guinea hens, and ducks, little or no damage is done by the grasshoppers and cut-worms, unless, of course, these insects are too numerous to be eaten by them.

Ordinarily doves and pigeons are not considered harmful. Yet they eat but few insects. But, on the other hand, many weed seeds are eaten by them. Perhaps, all told, the good done by them during the year will more than balance the harm caused by their visits to the grain-fields and feed-lots.

During recent years, since we have been watching more carefully just what the various species of birds have been eating, it has been found that many of those which we have heretofore called rascals are now known to be friends. Hawks and owls, all of which were killed on sight by nearly every man or boy who could shoot, are now spared, except when caught in the very act of stealing chickens. This is because we know that they feed mostly on mice, squirrels, gophers, prairie dogs, and rabbits, as well as on many harmful kinds of insects.

Our yellow-billed and black-billed cuckoos feed chiefly

on hairy caterpillars and several other kinds of insects, which they find lurking among the leaves of trees. They even come about our houses and into the towns and cities for their favorite insects.

There are few persons who will not admit that the woodpeckers, as a family, are very useful birds. Feeding, as they do, on the young of wood-boring insects, they can do more relative good for the number of insects destroyed than if they fed on such kinds as attack the leaves. A single borer left undisturbed might kill a tree, while hundreds of leaf-eaters of the same size would scarcely be noticed in the appearance, to say nothing about the health, of the same tree. Some common kinds of woodpeckers in this country are the flicker, red-headed, downy, and hairy, all of which are often seen about the groves and orchards, where they carefully hunt for borers and other harmful insects.

Birds like the whippoorwill, night hawk, and chimney-swift eat nothing but such insects as those which they catch in the air while flying about. The first two are the night fliers, while the other is one of our birds that fly during daytime.

The family to which the kingbird or bee-bird belongs is also one that is made up of insect eaters. They catch such kinds as flies, butterflies, moths, beetles, and grasshoppers. The few bees eaten by the bee-bird should not count against the other members of the family, nor should we blame even the bee-killer himself too much for the occasional rascal of his kind that prefers to sit near a hive and catch drones and an occasional worker.

Crows and their relatives, the magpies and jays, are sometimes called rascals. Perhaps there is a good reason in a number of cases for giving these birds so bad a name; but we must not judge too hastily, for sometimes there are good deeds done even by the greatest of rascals. After finding out what all these deeds, good and bad, are, we may think that enough good has been done at least to give the rascal another chance. All of these birds eat more insects, bulk for bulk, than they do of any other substances.

The bluejay does much of the mischief for which we blame the robin, orioles, and thrushes, and then sneaks away like a thief. He also robs the nests of some of our smaller and weaker birds. To partly offset these mean acts he destroys large numbers of injurious insects.

The meadowlark, orioles, and blackbirds are the most important destroyers of such insect pests as attack field crops, that we have. They are with us during the whole year save only during a few months in winter; and gathering in large flocks, as several kinds do, they can wipe out an insect plague in a short time. Don't kill any of these very useful birds, for they more than pay for the food they get, aside from insects.

Our sparrows and

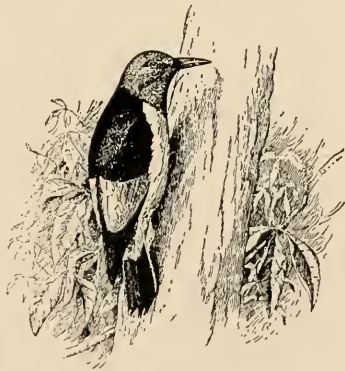


FIG. 49. Red-headed woodpecker.

their relatives form a very extensive family of highly useful, as well as beautiful, birds. They spend most of their time during the summer months in hunting for and destroying different kinds of insects. But this is not all the good they do. In fall, winter, and early spring, when mother earth has lost her beautiful green dress and is clothed instead in somber browns or wrapped in a mantle of snow and ice, the longspurs, snowbuntings, snowbirds, and some of the sparrows that have remained with us, are busily engaged in gathering for themselves a living. They hop and fly from place to place hunting for and picking up little seeds of grasses, weeds, shrubs, and trees with which to feed themselves till the warm weather returns and brings back the abundant supply of nourishing insects. Even during this busy cold season, they chirrup merrily as they work, so satisfied are they with the kind of life they are living.

The English, or European, house-sparrow, has the worst reputation of the entire family. But even it has some good traits, which tend to secure for it our friendship.

The swallows are insect destroyers; and seizing their prey as they fly, they naturally take such forms as flies, gnats, and mosquitoes—our worst personal enemies. We should, by all means, encourage these birds to build their nests about our barns and sheds so that they may pay rent by destroying the various flies that attack and worry our farm animals.

The shrikes, or butcher-birds, are genuine brigands or pirates, when it comes to killing other forms of life. They are true to their name, and butcher large num-

bers of insects, mice, lizards, small snakes, and even a few of the smaller birds. These they take to some thorn bush or barbed wire fence and impale their victims for future use or to dry up and blow away. The good they do will more than outweigh the harm.

The vireos, or greenlets as they are sometimes called, which frequent thickets and hedgerows, live almost entirely on an insect diet. Their food is composed chiefly of little caterpillars and grubs picked off the leaves of the small trees and shrubs which form the shelter in which they make their homes.

In the words of that pleasing writer, Dr. Elliott Coues:* “The warblers we have always with us, all in their own good time; they come out of the south, pass on, return, and are away again, their appearance and withdrawal scarcely less than a mystery; many stay with us all summer long, and some brave the winters in our midst. Some of these slight creatures, guided by unerring instinct, travel true to the meridian in the hours of darkness, slipping past like the thief in the night, stopping at daybreak in their lofty flights to rest and recruit for the next stage of the journey. Others pass more leisurely from tree to tree in a ceaseless tide of migration, gleaning as they go; the hardier males, in full song and plumage, lead the way for the weaker females and yearlings. With tireless industry do the warblers befriend the human race; their unconscious zeal plays due part in the nice adjustment of nature’s forces, helping to bring about the balance of vegetable and insect life, without which agriculture would be in

*Key to North American Birds, p. 288.

vain. They visit the orchard when the apple and pear, the peach, plum, and cherry are in bloom, seeming to revel carelessly amid the sweet-scented and delicately-tinted blossoms, but never faltering in their good work. They peer into the crevices of the bark, scrutinize each leaf, and explore the heart of the buds, to detect, drag forth and destroy these tiny creatures, singly insignificant, collectively a scourge, which prey upon the hopes of the fruit-grower, and which, if undisturbed, would bring his care to naught.

“Some warblers flit incessantly in the terminal foliage of the tallest trees; others hug close to the scarred trunks and gnarled boughs of the forest kings; some peep from the thicket, coppice, and the impenetrable mantle of shrubbery that decks tiny water-courses, playing at hide and seek with all comers; others, more humble still, descend to the ground, where they glide with pretty, mincing steps and affected turnings of the head this way and that, their delicate flesh-tinted feet just stirring the layer of withered leaves with which a past season has carpeted the ground. We may seek warblers everywhere in the season; we may find them a continued surprise; all mood and circumstance is theirs.”

Much could be written concerning birds like the thrushes, wrens, mockingbird, and catbird. But they are too well known in one way or another to make it necessary to spend either time or space here for the purpose of introducing them anew. Suffice it to say, they more than pay for what they eat by killing off some of our most harmful insects. Then, too, they are among the most beautiful singers of the feathered choir.

The nuthatches, titmice, and others of our winter and early spring birds are too well known as friends to make it necessary here for even hinting at their usefulness. The eggs of many hibernating insects are quite prominent among the things eaten by them through the season when the trees are bare.

The robin and bluebirds need no introduction to our boys and girls. We all know them only to wish that their numbers could be greatly increased. The former, as he hops over the blue-grass covered lawn in search of cut-worms, is engaged in his chief occupation. Seventeen quarts of caterpillars, it is claimed, is the average number of such insects destroyed by each robin annually; and of this quantity about one-half are cut-worms. We need not stop to ask whether or not the destruction of these will pay for the cherries and berries eaten.

Summing up the work of our birds as relates to the destruction of insects, we have it given briefly as follows:

“In the air swallows and swifts are coursing rapidly to and fro, ever in pursuit of the insects which constitute their sole food. When they retire, the nighthawks and whippoorwills will take up the chase, catching moths and other nocturnal insects which would escape day-flying birds. Flycatchers lie in wait, darting from ambush at passing prey, and with a suggestive click of the bill returning to their post. The warblers, light, active creatures, flutter about the terminal foliage, and with almost the skill of a humming-bird, pick insects from the leaf or blossom. The vireos patiently explore the under sides of leaves and odd nooks and corners to see that no skulker escapes. The woodpeckers, nut-

hatches, and creepers attend to the trunks and limbs, examining carefully each inch of bark for insects' eggs and larvæ, or excavating for the ants and borers they hear within. On the ground the hunt is continued by the thrushes, sparrows, and other birds that feed upon the innumerable forms of terrestrial insects. Few places in which insects exist are neglected; even some species which pass their earlier stages or entire lives in the water are preyed upon by aquatic birds."*

In nearly every case where the food habits of our birds have been carefully studied, we find that the good done far exceeds the possible harm that might be inflicted by our birds. Allowing twenty-five insects per day as an average diet for each individual bird, and estimating that we have about one and one-half birds to the acre, or in round numbers 75,000,000 birds in Nebraska, there would be required 1,875,000,000 insects for each day's rations.

Again estimating the number of insects required to fill a bushel at 120,000, it would take 15,625 bushels of insects to feed our birds for a single day, or 2,343,750 bushels for 150 days. These estimates are very low when we take into account the numbers of insects that various of our birds have been known to destroy in a single day. For example, the stomachs of four chickadees contained 1,028 eggs of cankerworms. Four others contained about 600 eggs and 105 mature females of the same insect. The stomach of a single quail contained 101 potato-beetles; and that of another upwards of 500 chinch-bugs. A yellow-billed cuckoo shot at six

* Chapman in "Bird Life."

o'clock in the morning contained forty-three tent caterpillars. A robin had eaten 175 larvæ of *Bibio*, which feed on the roots of grasses, etc.

Birds, like all other animals, feed upon that food which is most readily obtained, hence the insectivorous kinds destroy those insects which are most numerous—the injurious species.

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1. What is the origin of the barnyard fowls?
 2. Does it pay the farmer to keep fowls? Why?
 3. How many kinds of birds have we in the state?
 4. Can you give a reason for our having so many birds?
 5. Are the birds useful enough to make it wise to protect them?
Why?
 6. Compare the food habits of the different common birds.
 7. What do the swimming birds eat?
 8. Can you name thirty common birds?
 9. Account for the nervous actions of the warblers.

CHAPTER IX

OTHER WILD ANIMALS

Besides insects and their relatives and the birds, which are mentioned on the foregoing pages, there are still other kinds of wild animals to be met with in the country. Some of these are to be thought of only as friends, while others, on account of the way in which they live or the manner of treatment which they give our friends already spoken of, must be called enemies. Then, too, their relation to our crops, fruit-trees, garden plants and other growing things, must be taken into consideration before we can settle the question of friend or foe.

Mammals.—The animals with four legs that have their bodies covered with hair or fur are very different one from the other. They also vary a good bit in size, as well as in their food habits and the kind of places where they are to be found.

Some of them, like the prairie wolf or coyote and foxes, as well as the raccoon, steal our chickens and other poultry. The wolves sometimes also kill sheep and pigs, and by this means become quite a nuisance and deserve punishment. In some parts of the country, however, we are told that where these wolves have been killed off the jack-rabbits have increased to such an extent as to be quite harmful. These latter animals destroy our trees and bushes and eat large quantities

of grain and garden truck. So it is difficult to decide just what is the right thing to do, since the jack-rabbit is too large for our hawks to feed upon.

The skunks and weasels, as well as the mink, also kill our poultry whenever their accustomed food is scarce, or our hen-houses are extra handy for them to get into. Ordinarily, however, these strong-scented animals occupy their time in hunting out and killing and eating different kinds of mice, rats, and even rabbits, all of which do more or less harm by destroying grain and other products of the farm.

Besides these flesh-eating forms just mentioned, there are still others, like the moles and shrews, which also destroy harmful forms, like the grubs of insects.

Mice, rats, gophers, squirrels, chipmunks and their relatives, the rabbits, porcupine, beaver, and woodchuck are all more or less injurious to vegetation upon which they chiefly feed. But many of these animals also have other habits which make it very hard for us to decide just what would be the best thing to do in all cases.

The ground-squirrels and chipmunks are quite expert catchers of grasshoppers and other insects, and often destroy large numbers of these troublesome pests each year. Even many of our prairie and field mice have similar habits, while others must be thanked for destroying large quantities of the seeds of weeds and other troublesome plants.

Here again the birds come to our aid and assist in keeping things balanced, for the owls make mice and other small rodents their chief item of food. The

larger hawks and some of the flesh-eating mammals mentioned above keep down the pocket-gophers and prairie-dogs as well as the smaller rabbits.

All of this only teaches us the greater necessity for keeping a careful watch on the way the different animals about us live, if we wish to profit by their existence—if we would learn just what use they are in the world.

Reptiles and Batrachians.—Lastly, but by no means of the least importance, we must mention the turtles, snakes, lizards, toads, frogs, and salamanders, of which there are quite a number of different kinds.

The snakes feed on mice, ground-squirrels, small gophers, frogs, and toads, besides insects; while all of the other kinds of these animals are mostly destroyers of insects.

There is much in the lives of all of these creatures that would be new and of interest, as well as of value to us, if we only took the time to study and find out about them.

CHAPTER X

THE WEATHER OF THE FARM

Warm Weather and Cold Weather.—The comfort and happiness of man and beast depend very much upon how cold or how warm the weather is; and even the plants, which furnish both our food and theirs, cannot grow until the sun has warmed the soil which feeds their roots and the air which bathes their leaves.

How the Ground is Warmed.—The great furnace from which we get most of our heat is the sun. It sends to us little waves of heat, many thousands of these tiny waves every second; but they pass so easily and quickly through the air that they have little effect upon it on their way down; but they do warm the ground upon which they fall, for they cannot get through that so easily, and when the ground gets warm it soon warms up the air which lies upon it.

How the Ground Warms the Air.—This it does in two ways: in the first place the bottom of the atmosphere actually touches the ground and rests upon it and is warmed by it, just as a flat-iron is warmed when it is set on the stove; the heat creeps slowly up from the hot griddle of the stove into the bottom of the flat-iron, or from the warm earth into the lower air. This process is called *conduction*. Then again, the earth warms the air in another way; if you hold your hand near the ground when it has been well heated in the sunshine, you will

feel the warmth coming to your hand from the ground, even if you do not touch it. This is called *radiation*; that is, the heat is sent forth from the earth in little waves much like those which come down from the sun; but the heat waves radiated from the warm soil are mostly stopped before they get very high up into the air, and so the air is warmed by them. That is why it is cold high up in a balloon; the sun is shining there just as much as it is at the surface of the earth, but its waves pass by on their way down and do not warm the air much, and the waves coming back from the warmed earth do not get up so high, but mainly warm the lower air in which the plants and trees live and grow. And so the earth's atmosphere acts as a blanket to keep the earth warm by letting in the heat waves from the sun more readily than it lets out the heat coming back from the warmed earth. The glass which is put over a hot-bed acts in much the same way; it lets the sun's heat come in, but will not let the heat arising from the ground get out, and so the plants are kept warm. If the earth had no atmosphere it would not get very warm, even when the sun was shining upon it; and at night, what little warmth the soil had received from the sun during the day would be quickly lost, and the ground would become intensely cold. Everything would be quickly frozen solid as soon as the sun sank below the horizon.

Warm Days and Cool Nights.—We can now understand why the days are warmer than the nights. The earth is receiving considerable heat from the sun during the day and losing a little of it all the while by radiation out through the atmosphere into cold space beyond.

During the night the supply of heat from the sun is cut off, while the loss of heat from the earth still goes on; so the ground gets quite warm during the day and quite cold at night, and this makes the lower air also warm by day and cold by night.

The ground and air are not usually warmest in the middle of the day, but some hours later, because the sun is high in the sky for several hours, both before and after noon, and all the while it is adding to the earth's store of heat. As the sun gets lower in the western sky, although it still furnishes some heat to the earth, it does not give enough now to keep up even the little loss of heat that is all the while going on; and so for the remainder of the day the earth gradually cools off. This cooling goes on all night until just before sunrise, when some light and heat begin to come to us again over the eastern horizon from the sun. It is, therefore, usually warmest about two or three hours after noon and coolest just before sunrise.

Why the Sun Seems Hotter when High in the Sky.

—If you hold a tube of paper A, Fig. 50, so as to point towards the sun when it is high in the sky, and let a beam of sunlight pass through it and fall upon the ground, it will make a little round spot of light, B,

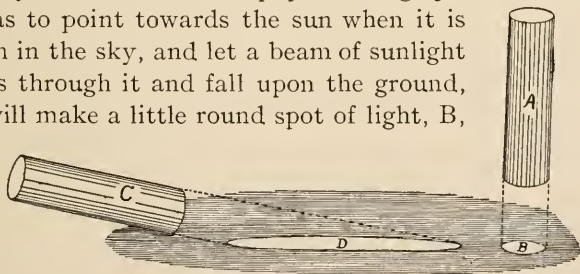


FIG. 50.

as large as the tube; this is the amount of ground which that beam of sunlight has to warm. If you point the same tube of paper at the sun early in the morning when the sun is low in the sky, and let the beam of sunshine pass through it, as at C, it will now fall so slanting on the ground that it will light up a long narrow streak, D; hence this beam of sunshine has more ground to warm than in the other case and it cannot warm it so fast; besides, it has had farther to come through the air than the other beam has, because it came slanting, and thus has lost more of its heat before reaching the earth. We sometimes say that the sun is hotter at noon than it is in the morning, but what we really mean is that it heats the ground faster.

Protection from Frost.—We have seen that the air itself is a blanket, through which the heat of the earth escapes but slowly; but if the air is filled with clouds it is a much better blanket, only in that case it both keeps the sun from heating the earth so hot by day and it also prevents the heat, which the earth has received during the day, from escaping so fast at night. For this reason, in cloudy weather the days are not usually very hot nor the nights very cold; but when the skies are cloudless we get warm days and cold nights.

That is why we must look out for a frost in the spring or autumn, if it appears that the skies will be clear during the night. In winter we do not think much about it because we have no tender plants out of doors to freeze; and in summer we are not afraid because we do not think it can get cold enough during the night to freeze, anyhow; but in the spring when the garden and orchard are

starting into growth, or in the autumn before the fruits and vegetables are all cared for, we look anxiously at the sky on cool evenings and wonder whether there will be a frost. If it promises to be cloudy we are not afraid, for we can trust the blanket of clouds to keep the earth from getting too cold; but if not, we may think best to cover the tender plants with sheets or newspapers, or we may build a smudge on the windward side of the orchard and let the smoke drift slowly over it all night. The newspapers or the smoke serve the same purpose as the clouds would have done; they keep the heat from escaping so fast from the ground and from the lower air.

There is another protection from frost which is almost as good as clouds or smoke, and that is a brisk wind. Down close to the ground is where there is the most danger of freezing, for it is the ground that first gets cold and that cools the lower air; just as it was the ground that first got warm in the sunshine and so warmed the lower air. When the ground begins to cool off rapidly in the night it is the lower air in contact with it that gets chilled the most, rather than the air in the higher tree-tops; and so it is the smaller trees and plants that are most in danger of freezing. Now, if the wind is blowing, it tends to mix the warmer air above with the cooler air close to the ground, with the result that neither of them gets cold enough to freeze the plants. It is for this same reason that there is often frost in the valleys when there is none on the hills; the higher ground is more exposed to whatever wind there is. The wind brings warmer air to the hills and not to the valleys; besides that, any cold air that forms close to the ground

on the hills, if it is not blown away by the wind, is apt to flow down the hillsides, somewhat as water would do, because it is heavier than warm air. From either or both of these causes the valley may be cold enough for a frost when the higher ground is not.

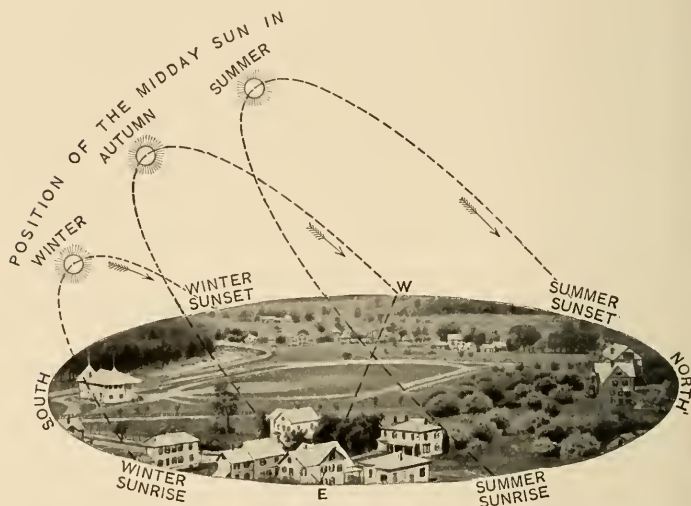


FIG. 51. The sun's path is highest and longest in summer.

The Heat of Summer and the Cold of Winter.— There are two reasons why it is hot in summer and cold in winter.

In summer the sun, as shown in Fig. 51, rises in the northeast, is high in the sky at noon, and sets in the northwest. In winter, on the other hand, it rises in the southeast and passes low across the southern sky to set in the southwest. Its heating effect is, therefore,

greater in summer than in winter, because its rays are more nearly vertical; the summer is hotter than the winter for the same reason that it is hotter at noon than it is early in the morning. But there is a further reason; a glance at the figure will show that in summer the sun has a long journey to make across the sky from sunrise to sunset; it rises early and sets late. In the winter, on the contrary, its daytime course is short and its night journey long. During a summer day more heat is received from the sun than can be given off during the night, and the weather gets hotter and hotter; while during the winter the short days and long nights have a contrary effect, and the earth and air get very cold.

Warm Spells and Cold Spells.—But the heat and cold of day and night and of summer and winter are not the only changes that we feel; we have warm spells and

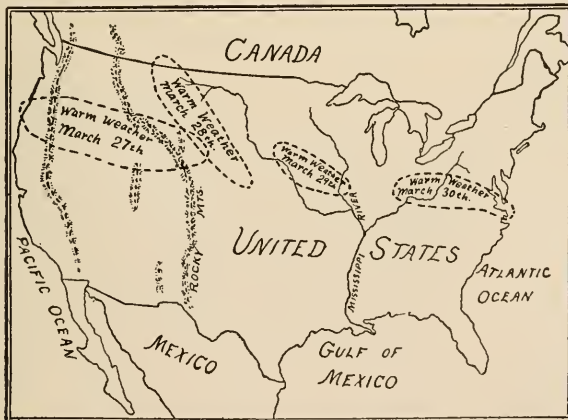


FIG. 52. A warm wave.

cold spells of a few days each, following one another, all the year around. We shall understand this better after learning, in Chapter XI, something about how the winds blow; but to begin with let us look at the weather map for March 27 to 30, 1895, Fig. 52, which will show how a wave of warm weather often passes across the country from west to east. On the 27th there was a belt of unusually warm weather stretching from the Pacific Ocean across to the Rocky Mountains; the next day this warm wave had moved to the eastward of the mountains; the next day to the Mississippi River; and by the fourth day it had reached the Atlantic coast. Such warm waves are continually traveling across the country, and the weather will be warmer than usual both day and night for several days while one of these waves is passing. In the same way cool waves, or very cold waves, sometimes pass across the country from west to east.

1. Why do the sunbeams warm the ground first, rather than the air?
2. The moon has little or no atmosphere: what kind of climate must it have?
3. Give two reasons why the sun heats faster at noon than before or after? Why, then, do the earth and air still continue to get warmer for a few hours after noon?
4. On what day of the year does the sun get highest in the sky? Why, then, is it hotter in July and August than in June?
5. On what day is the sun lowest? Why, then, is it colder a month or two later than this?
6. Give two ways in which nature often protects plants from frost. How may the farmer do it?

CHAPTER XI

THE WIND

In late years scientists have found out a great deal about the wind and where it comes from and where it is going. They have found that the wind generally blows in a great round eddy, sometimes half as big as the United States, around a center known as a "low." The map, Fig. 53, shows, for example, by the direction of the arrows, how the wind was blowing on the morning of March 29, 1895. You will see that at that time there was a region marked "low" near the middle of the United States and two regions marked "high," one in the east and one in the west, and you will see by

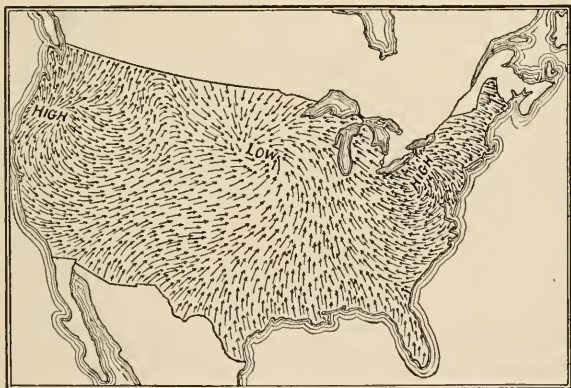


FIG. 53. How the wind blows.

the arrows that the wind was moving away from the highs and in toward the low from all sides. Now, since there is not room enough for so much air to crowd into a small space, it has to circle around it; and finally it rises up into the higher regions of the atmosphere and so gets out of the way. These great eddies are somewhat like the little whirlwinds which we often see, only they are very much larger and the wind blows toward them and around them in a gentle breeze, instead of a violent wind. In the center of the low it is generally calm because here the air is rising gently upward instead of blowing along the surface of the ground.

What Makes the Wind Blow.—The air in a low is not so dense as it is elsewhere; if we should look at a barometer, which is an instrument for measuring the density of the air, we should find that in a low the mercury stood low down in the tube of the barometer, indicating that the air is not very dense; that is why these regions are called “lows.” They are regions of low barometer or low pressure of the air, while in the highs the air is more densely packed and the barometer stands high. This greater density of the air is represented in the map by packing the arrows closer together.

We may understand why the air tries to blow away from these highs where it is crowded, and towards the lows where it is less dense, by thinking how a crowd of people will act if some portion of the crowd is less packed than elsewhere; they will surge that way until the greater crowding somewhere else is relieved. So the air moves away from the highs and toward the lows and that motion of the air is the wind. It would soon make the

low as densely packed with air as the high if it did not, as stated above, rise into the higher regions of the atmosphere, leaving the low still a region of low pressure. The winds continue to blow towards it for days at a time; commonly the region of low pressure moves slowly eastward across the country and the winds keep blowing towards it from all sides as it moves along. For instance, this low shown in Fig. 53, moved on eastward during the next few days towards the Atlantic Ocean, the winds all the time blowing towards it from all sides and circling around it just as they were doing when it was in the center of the United States, as shown in Fig. 53.

Why the Wind Changes.—We have seen that the direction of the wind depends on where the low is, towards and around which the winds are moving. At a place just east of the low, as you will see by the arrows on the map, the wind will generally be blowing from the south or southeast; if you are on the west side of the low, on the contrary, the wind will blow from the north or northwest; if you are just in the low, very likely there will be no wind at all. We can see now why the wind so often changes its direction. If, for example, there were a low just west of us some day we should probably have a south wind; then as the low moved eastward and covered the region where we were, the wind would die down to a calm; when the low had gone by and was east of us the wind would begin to blow from the north. Now, suppose that the low does not move over us, but that it passes by, somewhat to the north of us. You will see by the

map that the direction of the wind just on the south side of the low is apt to be from the west. In this case then the wind will not die down to a calm, but will gradually change its direction; it will blow from the south while the low is still to the west of us, will change into the west while the low is passing by, and will finally settle in the north or northwest when the low has gone on farther east.

The Cause of Brisk Winds.—The force with which the wind blows depends on whether the air in the low is very low in density or only moderately low. If the barometer stands very low it shows that the air is quite rare and in that case we may expect the winds which blow towards it to be quite brisk, or even violent. In summer the air is often not much more dense in the highs than it is in the lows, and then there are only gentle breezes; in March and April the lows are more apt to be especially low and to cause high winds; but such lows are liable to come along at any time and give us brisk winds while they are passing.

South Winds Bring Warm Weather.—We can now understand the behavior of the warm wave shown in Fig. 52. Let us compare this map with the map Fig. 53. The low shown in Fig. 53 was moving eastwardly across the United States; it took from March 28th to April 2d, five days in all, to go from the Pacific to the Atlantic. Fig. 53 shows how far it had gone by March 29th. It was in South Dakota and Nebraska, with warm southerly winds blowing up on the east side of it; it is just here on the east side of the low that the warm area

occurs, which is shown in Fig. 52, on March 29th, and we can easily understand how these southerly winds would cause warm weather, since they bring to us the air from the warmer southern regions; and we see, too, that if the low moved eastward, as lows do, it would naturally cause south winds to blow in states farther and farther east and the warm wave to move eastward, as the map Fig. 52 shows that it did.

The hot winds which sometimes blow across the western states from the south for days at a time are generally caused by a low which moves very slowly eastward, and so keeps the winds blowing in almost the same direction for a long time.

Cold Waves and Blizzards.—On the west side of a low, as Fig. 53 shows, northerly winds generally prevail and they naturally make the weather colder, because they come from the colder regions to the north of us. Thus while a warm wave generally occurs on the east side of a low and moves eastward with it, a cool wave, sometimes indeed a very cold wave, occurs on the west of the low and follows it across the country. If, as often happens, this cold north wind brings with it a fall of snow, it may amount to a severe storm, or "blizzard." When the north wind dies out and the cloudy skies clear up we are apt to have one or two very cold nights, because, as explained in Chapter X, clear skies, although they give warm days, tend to produce cold nights. The lowest temperatures that we get come usually on some clear night after a blizzard has passed which has brought down from the far North a mass of cold air, and left it

to get still colder under a cloudless sky at night. If a low, followed by one of these cold waves, moves far southward, instead of pursuing its more ordinary path eastward, it may do much damage by carrying the cold weather far into the Southern states, where the more tender vegetation is unaccustomed to such low temperatures.

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1. In what direction was the wind blowing in Nebraska on March 29, 1895? Why?
 2. In what direction was it blowing in Wisconsin?
 3. Why would the direction of the wind in Wisconsin probably change in a day or two? What change in temperature would probably result?
 4. Why are March winds apt to be high winds?
 5. What winds generally bring on a cold spell?
 6. Why does it commonly get still colder after the storm dies out?
 7. In what direction is the wind blowing this morning? In what direction from you do you think the barometer stands low? Where does it probably stand high?
 8. Is the wind very brisk to-day, or not? Do you think, then, that the barometer is very low somewhere near you?

CHAPTER XII

CLOUDY AND RAINY WEATHER

If we watch the steam spouting from a tea-kettle we shall notice that just where it comes from the spout it is quite invisible; a little farther out it becomes a cloud of visible steam. If the kettle were of glass we should see that the steam inside it does not look like steam at all, but is as transparent and invisible as the air itself. In fact, it is a gas like the air; it is the water of the kettle converted into a gas by the heat of the stove. Let us call it "vapor" while it is hot enough to be an invisible gas, and "steam" when it has cooled and become visible. Now, this steam is no longer a gas, but is composed of tiny drops of water, and the only reason that they do not fall to the floor at once is because they are so small that they fall but slowly. At first they are drifted upward by the currents of hot air rising from the stove; probably they do finally settle to the floor, or to the walls of the kitchen.

How the Clouds are Formed.—The atmosphere always contains invisible watery vapor like that in the tea-kettle; it has been evaporated from the ponds and streams and from the damp soil by the sun's heat, just as the vapor has been formed from the water in the tea-kettle by the heat of the fire; only not so fast, because the ponds do not get so hot. And just as the vapor in the kettle may cool into steam, so the vapor in the air may cool to form clouds.

Clouds, then, are not vapor, but are composed of tiny drops of water just like steam; they may be drifted upward by ascending currents of air, or they may slowly settle to the earth. If they do the latter we call it a fog, and we can see the tiny drops of water drifting about us, and settling to the earth; if the drops are larger they fall faster and we call it a mist or rain. Rain-drops are just like the drops of water of which clouds are composed, only they are larger and fall more quickly to the earth.

Snow, Hail, and Sleet.—If the air is very cold up where the moisture is condensing, it may form flakes of snow instead of drops of rain; that is, it may condense into tiny crystals of ice, which arrange themselves in loose, branching masses, just as the vapor of a living-room produces feathery forms when it condenses against a cold window-pane. If drops of rain are formed high in the air they may start for the earth as ordinary rain-drops, but, by falling through a cold layer of air on their way down, be frozen into little balls of ice called sleet. Sometimes these balls are larger and are called hailstones, which are often made up of harder and softer layers of ice, as if they had fallen from a great height and had passed through several different layers of cold air, which have added to the hailstone layers of hard and soft ice.

Dry Air and Moist, or Sultry, Air.—The air always contains some invisible watery vapor; if it contains very much of it on a summer day we say that the air feels "sultry." It feels uncomfortable to us, and the reason is this: when we perspire and the sweat evaporates it

produces a sensation of coolness; while if the air is sultry, the sweat cannot evaporate because the air is already full of vapor and cannot take up any more. Although it feels uncomfortable to us it is good for the plants, because it does not dry them out so fast. The time when the plants suffer is when the air is not only hot, but also dry; that is, when it contains but little watery vapor; then the water is rapidly drawn out of the leaves of the plants to supply the air with vapor and the leaves wither, and perhaps the plants are killed. The "hot winds," which are sometimes so trying to the crops in the Western states, are dangerous, not so much because they are hot winds as because they are dry winds.

What Makes It Rain?—We have seen that clouds are formed by the cooling of the invisible vapor of the air till it condenses into little floating drops of water; and that rain is only these same clouds when cooled so fast that the drops are too big to float, and so fall quickly to the earth. It always rains when moist air is sufficiently cooled. This cooling may be brought about in various ways.

First. On the east side of a low, the winds blowing from the south or southeast bring vapor-laden air from the Gulf of Mexico, or from the Atlantic Ocean; as this moist air moves northward into a cooler clime it is likely to condense into clouds, and perhaps to fall as rain. When a low is approaching us from the west, therefore, we often get cloudy or rainy weather.

Second. After a low has passed, the wind, as we have seen, commonly blows from the north; this chills the air and often produces rain or snow on the west side of a

low, especially in winter. If the wind has been blowing from the south, on the east side of the low, bringing moist air with it, then when the low has passed and the wind changes into the north, the cold air will blow along the surface of the earth, driving in under the warm, moist air, and bringing down its moisture as rain or snow. If it does not rain when a low is approaching from the west it often does rain or snow as soon as the low has passed and the wind changes into the north.

Third. We have seen that in the center of a low the air is generally rising, because it is not so dense and heavy there as it is elsewhere; as it rises it cools, and as it cools its vapor is condensed into clouds or rain.

We see then that in and around a low is the place to look for rainy weather. Lows are apt to bring clouds and rain; highs, on the other hand, usually bring clear skies and fair weather.

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1. Why do not clouds usually form close to the earth?
 2. What makes the earth feel sultry?
 3. Why do we feel the heat more in sultry weather? Why do the plants thrive in such weather? Why does it rain so easily?
 4. Give three ways in which the air may be cooled to form rain.

CHAPTER XIII

STORMS

When a low moves across the country it is apt, as we have seen, to bring stormy weather of various sorts—rain, snow, and wind. A low is, therefore, often called a storm-center. But there are several kinds of storms which a low may bring that are of a more damaging sort, such as thunder-storms, hail-storms, and tornadoes.

Thunder-Storms.—Thunder-storms usually occur on the southeast side of a low; here the air is warm and moist, and is blowing from the south or southeast on its way to the low. It is overlaid by a layer of cooler, heavier air, which lies upon it like a blanket and presses down upon it. The air underneath tries to escape upward; presently it makes a break, tears a big rent in the air-blanket above it, and pours up through it. The warm air rushing upward and the cool air coming downward to take its place are what cause the thunder-storm. Let us see how they will act; before the storm, the air has felt sultry—that is, moist and hot—and the wind has blown from the south or southeast; it has made a break through the upper air and started a thunder-storm somewhere to the west of us. Often we may see the beginning of the storm as a “thunder-head”—that is, a tall, towering mass of cloud, spreading out at the top like a sheaf of oats—or sometimes flowing out on one side only, looking

like the horn of a blacksmith's anvil. The storm drifts towards us, generally from the west, because the upper air in which the rent has been made usually moves eastward, even though the air at the earth's surface is blowing the other way. As the storm comes near us we see a confused mass of dark clouds rolling and tumbling towards us like a huge roll of dirty cotton, being rolled and tumbled over by the warm air rising and the cold air coming down, just as the roll of cotton would if you rolled it between your hands, one hand moving up and the other down. We say "there is wind in that cloud," or rather behind it; for we have learned that such a looking cloud has a blast of cool wind rushing out from under it, driving the dust before it, and taking the place of the warm, sultry air which has been blowing towards the storm cloud. About the same time big drops of rain begin to fall. These come from the moist air which has been carried aloft and cooled; often they are carried so high by the strong upward draft of air that they are frozen into hailstones. Thunder and lightning usually come with such a storm, because the violent rubbing and mixing together of warm and cold air produce electricity, which makes the flashes of light and tears the air asunder so that it falls together again with a loud noise. The sound waves also rebound from neighboring walls of cloud and so are re-echoed in a long-continued rumble. After the storm has passed on to the east, we may often see its west side lighted by the rays of the afternoon sun and spanned by a rainbow; for it is still raining from the cloud, and the sunlight shining on the distant raindrops is broken up into the rainbow colors.

Tornadoes.—A thunder-storm may be many miles in length, and may travel for hundreds of miles before it dies out; the opening in the layer of upper air is a long, narrow rent, perhaps several miles long and a few miles, or less than a mile, wide, and it advances broad-side across the country. But sometimes the warm, lower air bores its way up through a small round opening no larger than a farm, instead of through a long, narrow rent; up through this opening the warm air rushes like the draft of air up a chimney: in that case it becomes a tornado instead of an ordinary thunder-storm. As the air is drawn in at the base of this chimney-like opening, it begins to revolve like an ordinary dust whirlwind, only with terrific violence; as this whirling column of moist air ascends, it cools and becomes a column of cloud; it spreads out funnel-shaped at the top and may sometimes be seen moving slowly across the country. Its lower end, where it touches the earth, revolves so fast that it tears everything to pieces in its path. A tornado, or a “cyclone” as it is popularly called, differs from an ordinary thunder-storm, mainly in its small size and its violent rotation. Usually thunder and lightning, and rain or hail, accompany a tornado, but its destructive power is chiefly due to the enormous speed with which it revolves. Like thunder-storms, they occur in hot, sultry weather; they approach from some westerly direction, and are caused by a strong updraft of moist, warm air.

CHAPTER XIV

WEATHER PREDICTIONS

It is by knowing where the lows and highs are on any particular day, that the Weather Bureau is able to tell something about the probable weather of the next day or two. Weather observers are stationed throughout the United States and Canada, who take observations every morning and night at the same hour; they note how their thermometers and barometers stand, how the wind is blowing, and whether the sky is clear or cloudy. All these observations are at once telegraphed to Washington, where a map is drawn showing exactly what the weather was in all parts of the country, and especially where the highs and lows were situated at the time. Since we have learned about how fast and in what direction the lows and highs are in the habit of traveling, it is possible to tell about where they will be by the next day, and so to tell what kind of weather they will probably bring in different parts of the country. But this cannot be told with entire certainty, because a low may travel a little faster or a little slower than usual, or it may swerve somewhat from its ordinary direction, in which case the weather predictions will, of course, prove incorrect. A careful record is kept of the predictions made by the Weather Bureau, and whether they came true or not; it shows that about five predictions out of six prove to be correct. It is not

possible, however, to tell much about the weather for more than a day or two in advance, because in three or four days a low may get to quite a different part of the country from what was expected.

Weather Maps.—The maps printed by the Weather Bureau every day are distributed over the country, and posted in public places, and the pupil will do well to examine them from day to day, if he has the opportunity, and learn to understand them and to see for himself how the weather areas travel across the country, and what kind of weather they carry with them. He will not always find the lows and highs as well defined as they are in Fig. 53, in which case the wind will not be blowing as regularly toward them as it is in the figure, but he will find that, in general, the direction of the wind and the distribution of clouds and rain occur about as has been explained in these chapters on the weather.

Almanac Weather.—The various almanacs often undertake to tell in advance what the weather will be throughout the entire year, but these predictions are not much better than guesses. Of course anybody can tell something about the probable weather of any season. We know from experience about what part of the year is hot, or cold, or rainy, or windy; but it is plain that the almanac could not safely predict that rain, or warm weather, or high winds would come on a certain day, because it could not come to all parts of the country on the same day; at least it does not, as the weather maps show. A storm center or a wave of warm weather moves across the country and takes, as a rule, several days or a week to travel from the Pacific to the Atlantic.

When it is warm in one part of the country it is cold in another; or it rains in the East and is clear in the Mississippi Valley. If the almanac prediction is made rather indefinite and only means "about this time look for rain," very likely a storm will come near enough to that time to make the prediction seem to come true. But no one has yet found a way to tell beforehand when it will rain, or be hot or cold, in a particular state or city, except by knowing from telegraphic reports where the lows and highs are at the time.

The Moon and the Weather.—It is a common notion that the moon and the planets influence the weather; but scientific men have never been able to find any good evidence that they do. For instance, many people believe that the weather is likely to change about the time the moon changes; that is when the moon becomes new, or full, or at the quarter; and they say, "I have often noticed that it does." And that is probably true, because the moon changes so often, and the weather changes so often, that very, very frequently they would change together; but the only way to find out whether there was any connection between the two would be to keep careful records, for a number of years, of all the changes of the moon, and of all the changes of the weather, and then to see whether the changes of weather and the changes of the moon came on the same day more often than they came on different days. Scientific men have done this very carefully for many years, and they find that the weather changes just as often when the moon does not change as it does when the moon does change. They have not been able to find any

connection whatever between the weather and the planets; heat and cold, rain and sunshine, wind and calm, come without any reference to the heavenly bodies, so far as careful records show, but they come according to laws of nature that we are beginning to understand; laws of nature given by the bountiful Creator in order that "seed-time and harvest, summer and winter, may not fail."

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1. Why is it usually cool after a thunderstorm?
 2. Why does it often hail in such a storm?
 3. Would you fear a funnel-shaped cloud seen in the west?
In the east?
 4. How can the Weather Bureau tell how the wind is likely to blow to-morrow?
 5. Why are they sometimes disappointed? How often do their predictions fail?
 6. Why can they tell better what will happen to-morrow than day after to-morrow?
 7. Does the Weather Bureau predict the same kind of weather for to-morrow in all parts of the country? Does the almanac? Is the weather alike in all parts of the United States on the same day?
 8. Why can a low barometer bring a change of temperature while the moon cannot?

CHAPTER XV

THE SOIL

By the word *soil* we mean what is commonly called "dirt," or "earth." When it is very wet and sticky we speak of it as "mud," and when very dry it is carried about from place to place or blown about by the wind in the form of "dust."

How Soil is Made.—In some places where a deep hole or a railroad "cut" has been dug a very striking change in the nature of the walls of the cut, as it goes deeper into the ground, can be seen. At the top there will be a layer of very fine particles of earth, which is darker in color than the rest and which contains many little roots of grass and trees, and also little open places or holes where bugs and worms have made their nests or crawled about. Below this there will be found earth which is made up of the same very small particles, but which is lighter in color and packed together much more closely, and which may have in it large grains of sand or little pebbles. Under this will be seen a deep layer of sand, the particles of which get larger and larger as the cut goes deeper and deeper into the ground until the sand gets so coarse that it is called "gravel." If the cut goes down into this gravel, it will be seen that the little pebbles which are found in the upper part of it keep getting larger the deeper it goes, until finally great stones, and at last solid rock, are reached. These different kinds

of earth are not in layers which are sharply divided from each other, but the change is a gradual one, from finer to coarser particles of rock, all the way down.

This gives us an idea as to how the soil, which now lies on the top of the ground, was made. A very, very long time ago the top of the ground was all solid rock, like that which we now find down deep in it. But little by little the cold weather of the winters and the warm air and rains of the summers caused it to crack and large stones would break off. Then these stones in their turn were broken up into smaller ones, partly by the freezing in winter of the water that would get into the small cracks in them—just as a jug or bottle will break if it is filled with water and the water allowed to freeze—and partly by the decay and crumbling caused by the action of the air and moisture on the material of which the rocks were made, just as a piece of iron which is left out in the damp air soon gets rusty and begins to crumble off at the edges. So the stones kept getting broken up into smaller and smaller pieces, until at last they were no bigger than the fine sand or clay which we find near the top of the ground now. Since it is the weather and its changes which cause the rock to break up in this way, the action is called “weathering,” and the fine, earthy material which is made in this way is sometimes called “rock-waste.” This breaking up of the rocks is going on all the time wherever the big rocks are found on or near the top of the ground, but in most places the weathering has gone on for so many thousands of years that the large rocks are now buried deep under the rock-waste, which has been made from

those rocks which used to lie on the top of the ground. It is only where the wind has blown the fine rock-waste away, or where running water has washed it down to some lower place as fast as it was made, that the large stones or solid rock can still be seen.

Rock-Waste is the principal part of all soil, but it is not generally called soil until it has become mixed with a considerable amount of vegetable mold, or decayed or rotten plant roots, stems, and leaves. Often these decayed plants get mixed in with the sandy or gravelly rock-waste before it gets broken up fine enough to be called soil, because moss and other small plants like it begin to grow on the mother rock itself, and when they die in the winter they fall down into the cracks and decay there. This decaying vegetable matter often helps to hasten the breaking-up of the rock particles against which it lies, by causing them to decay and crumble more quickly, so that when these rotted plants get in among the pebbles they are much more easily weathered down to fine rock-waste. As this goes on year after year, more and more of the decayed plants, or vegetable mold, gets mixed with the rock-waste, until finally the fine particles of rock are all so small and so closely mixed with the decayed roots and other parts of plants that we can no longer see them separated from one another. This mixture of very fine rock-waste and vegetable mold is the soil which we see all about us. It is the decayed vegetable matter in it which gives it its dark color, and generally the more of this matter there is in a soil the darker it will be.

Kinds of Soil.—If all the rock from which soil has been

produced had been the same in the first place, we would find almost the same kind of soil all over the earth. But this was not the case. In some places the rock was sandstone and when the weathering had broken this up, and it had been changed into soil, there was formed a loose, sandy soil through which water can settle very easily, and which does not get muddy and sticky when it is wet. This kind of soil is frequently called a "light" soil. Then in other places the rock was limestone, and when this was changed into soil the particles formed were very fine and not in grains like sand, but more powdery, like flour. This kind of soil, which is known as clay, packs together when it gets wet, and is very sticky and muddy. Water cannot settle through it at all easily, because the tiny particles stick so close together and leave no open spaces between them, such as there are in sandy places. This kind of a soil is usually called a "heavy" one. Other kinds of rock produce still other kinds of soil, but these two are by far the most common ones. Some soils are very sandy and contain little or no clay, while others are very clayey and have very few sand grains in them, and there are all grades between these two. If the soil is too sandy it is not good for plants because the water from rains can settle away from it so easily and it then dries out and the plants die for want of water. On the other hand, if the soil is almost all clay, water cannot soak down into it, and when it rains the rain-water all runs away on the surface so that as soon as it stops raining there will be but little water in the soil for the plants to get.

Then, too, there are other varieties of soil caused by

the fact that in some places the soil lies just where it was formed from the rocks and is only changed by the things that grow on it, while in other places the wind blows away the lighter parts of the soil, or water washes away the finer parts. Then, again, the dust which is blown away from one place may be dropped in another and mix with the soil already there, or produce great beds of soil which was once formed from rock in another part of the country, or even in another country. A very large part of the eastern portion of the state of Nebraska, for example, is covered with soil of this kind, in some places more than a hundred feet deep, which many years ago was carried in here by the very strong winds that blew then. In a similar way, water may carry soils, or parts of soils, from one place to another. It is easy to notice how, after a heavy rain, when the water in a stream or river is running very swiftly, it is very muddy with the soil that it is carrying away, and how, after the rain stops and the water runs more slowly, it drops its load of mud, or soil, in some place where something stops the swift current of the stream, and gets clear again. Soils which still lie in the place where they were formed from the mother-rock are called "local" soils. Those which have been brought in from some other place by wind or water, or in any other way, are called "transported" soils. Transported soils are generally more easily cultivated and better for crops, because it is the finer, lighter parts of the soil, especially the vegetable mold, which is apt to be carried away by the wind or water, and this is the best part of the soil for crops to grow in.

Why Plants Grow in the Soil.—In order that plants may grow they must have food, just the same as animals must. But the kind of food that plants need is different from that which animals eat. A very large part of the food of plants is air and water. They can take in the air that they need through their leaves, but the water they get they have to take in through their roots. So there must be a place for the roots to get water. This is one of the uses of the soil. When it rains the water falls on the ground and settles into the soil. The soil particles get wet, and the little open spaces between them get filled with water, which stays there a long time, and the plant roots running through the soil find the water there which they need to drink. If the soil were still in the form of rock, the water could not soak into it, but would run off from the surface into a river somewhere; or if the soil were not so fine and did not have this power of holding water in its tiny open spaces the rain-water would settle down through it very rapidly and be lost below, so that in either case the plant roots could not find it. What really happens, though, is that when the rain falls on the surface of the ground the water creeps along from one soil grain to another, until the rain-water has all been soaked into the ground, just as when you dip one end of a piece of cloth into some water you can see the water go creeping along the cloth until it is wet to some distance away from where it touches the water. Then when a plant root grows into this moist ground and begins to drink up the water it finds there, as fast as the water in one place is taken away by the little root

some more comes creeping along from the wetter ground near by (just as when you light the lamp and the oil is burned from the upper end of the wick some more oil comes creeping along up the wick from thread to thread to take the place of that which has been burned), so that the plant root can keep drawing the water it needs without having to grow away from the place where it begins to drink in the water. So the soil feeds water to the plant root just as the wick in the lamp feeds oil to the flame.

But the plants need other food besides air and water. In order to grow strong stems and form fruit or grain, they have to have certain kinds of mineral matter, the same as animals have to have certain kinds of mineral matter in their food in order to build up their bones and other parts of their bodies. The kinds of mineral matter which plants need are found in most of the mother-rocks from which the soil was formed. But the only way the plants can get this mineral food is from the water which comes in through the plant's roots. Now, of course, the rocks, even though they contain the right minerals for the plant food, will not dissolve in the water, and so cannot be carried into the plant through its roots. It is only after these rocks have been broken up and changed by the weather, and more especially by the action of the decaying vegetable mold, that the part of them which plants want for food will dissolve in the water in the soil, and so go in with it into the plant's roots. Hence, rock-waste, even when it contains the right kinds of mineral matter, cannot give

it to plants for food. It is only after it has been changed to soil that it will furnish food for the crops.

How Soil is Made Rich.—By a “rich,” or “fertile,” soil we mean one that will furnish plenty of plant food to crops that are to grow upon it. For this, two things are necessary: first, that there shall be plenty of the right kind of mineral matter in the rock-waste of which the soil is made; and second, that there shall be plenty of the decayed vegetable mold to help change the rock-waste into the right condition so that it can dissolve in the soil water. The decayed vegetable matter also helps to furnish food to plants, since it contains itself some of the material which was once a part of a plant and which the new plants will need for food.

It is easy to see that whenever a crop grows on a piece of soil it takes away part of the plant food that was in the soil. And if the crop is cut off and carried away from the field, the soil will lose that much of its plant food. So it often happens that after a great many crops have been grown upon a certain field, so much of the plant food has been carried away that there is not enough left to properly feed more plants, and the soil has lost its richness, or fertility. Such a soil is called “poor,” “barren,” or “unfertile.” The only way in which a “barren” soil can be made to grow crops again is by adding to it some more plant food. Things that are added to soil to increase the amount of plant food in it, and so make it more fertile, are called “fertilizers.” There are two kinds of fertilizers: first, those which are plant foods themselves and are put directly into the

soil where the plant roots can get them; and second, those which will act on some more of the rock-waste in the soil and change it into a proper condition so that it can be used as food by plants. This second kind of fertilizers is mostly refuse plant substances like straw, corn-stalks, barn-yard manure, etc., which, when put into the soil, will decay and so add to the supply of vegetable mold in the soil. The first kinds mentioned are mostly mineral matter which have been prepared in the right form for the plant roots to take up, and which furnish a supply of food to plants as soon as they are put into the ground. They generally must be bought, and cost more than the second kind described; but these latter are much slower in their action, and it is often several years before any large increase in the richness of the soil on which they are placed can be seen.

Why Must Soil be Cultivated.—Some soils which contain plenty of mineral plant food are barren because they do not have water enough in them to supply the plants. This may be because not enough rain falls on them, or because the rain that falls is not held in the soil long enough. Of course, if too little water falls as rain this cannot be helped except by bringing in more water from a river, or well (that is, by irrigation). But if the soil receives enough rain-water and does not hold it, it can be made to do so by proper cultivation. Stirring the soil and breaking up the chunks of earth make it finer, and so better able to hold moisture. It is generally true that the finer the soil the better it will hold moisture, so cultivating any soil makes it

better fitted to supply water to plants. It also lets air into the soil, which helps to decay the vegetable matter and to change the mineral matter into plant food. And further than this, it kills the useless weeds which would otherwise use the moisture and plant food which ought to be saved for the useful crops.

1. Picture the earth before there was soil.
2. Which appeared first, soil or vegetation?
3. How many years has it taken to produce our soil, do you suppose? Is soil still being formed?
4. Account for the deep soil of the valley or lowland, and the shallow soil of the hillside. Ascertain the depth of the soil in your locality.
5. What part have the earth-worm, ant, and all burrowing animals taken in the history of soil-making?
6. Show how the death of plants and animals contributes to the fertility of the soil.
7. Which is better economy, to burn stubble, or to plow it under?
8. Why are some streams usually clear, and other streams more or less muddy?
9. What is meant by humus, loam, sub-soil, weathering?
10. What is the object of "rotating crops"? What is meant by soil "wearing out"?
11. If we burn plants or vegetation of any kind, some ashes will be left. These ashes are called the "mineral matter" of the plant, and they consist of potash, lime, sodium, and other minerals. Where did these minerals come from, and how did they find their way into the tissues of the plant?

CHAPTER XVI

DOMESTIC ANIMALS OF THE FARM

There are four kinds of domestic animals which are very useful to mankind: the horse as a beast of burden, the pig for its flesh, the cow for its flesh and milk, and the sheep for its flesh and wool.

Man by his higher intelligence has appropriated to his own use, whether rightfully or not, these lower animals. He should, therefore, strive to understand their ways so that they can be made still better and more useful to him. In this chapter we shall endeavor to learn something about these animals in the past, how they have been improved under man's control, how they differ in characteristics, and how they can best be cared for to make them most useful.

For information concerning the appearance of animals before the coming of man, we must go to the geologist. He examines those parts of the earth's crust which were formed at different periods and finds remains of animals which inhabited the earth during those periods. In the earliest formations of the soil he finds low forms of life, such as animals without backbones, like oysters. In later formations the animals become more complex, developing finally into the wonderful organism that we have in our domestic animals to-day.

The Horse.—The earliest trace of the horse shows him to have been about as large as a medium-sized dog.

In certain beds of rock in Wyoming and New Mexico, there has been discovered the skeleton of a horse about sixteen inches high with four complete toes on the front foot and three behind. On each toe was a horny material called hoof. With the four toes in front there was also found a small splint bone, or rudimentary toe, showing that the horse first had five toes. The teeth were sharp like those of a monkey, instead of broad and flat as in horses to-day. This horse lived about three million years ago. He inhabited swampy ground. The feet of a modern rhinoceros are very similar to the feet of this early horse. These two animals were then quite alike. When horses took to higher and harder ground most of the weight of the animal was thrown upon the middle toe, which in later generations became larger and larger and the outer toes smaller and smaller. If an organ is not used, the flow of blood in that part is lessened, and the organ becomes smaller. The first and fifth toes disappeared, then the second and fourth. The skeleton of our modern horse shows the presence of two splint bones between the knee and fetlock joint. These bones are the rudiments or last traces of what were once toes. All horses have splint bones, but these are not considered blemishes until they become enlarged on account of being bruised.

Our modern horse, then, has but one toe, and he walks on its very end. A large, horny encasement, called hoof, has been developed to protect the tender tissues. If the horse is driven on hard, stony roads the hoof gradually wears off and he becomes foot-sore. Iron shoes are tacked on to protect the hoof.

During past ages the feet and legs of the horse have lengthened considerably. His heel behind we call the hock joint; in front it is the knee joint. That part of the leg between the knee and fetlock corresponds to the palm of your hand, that between the hock and rear fetlock (or ankle) the sole of your foot. The fore fetlock corresponds to the joint where your finger joins the hand. As the legs lengthened it became necessary for the neck also to lengthen so that the horse could reach to the ground for food.

When man came upon the earth the horse was about the size of a small pony, with long, shaggy hair and large coarse head. Carvings have recently been found in a cave in France where early cave men lived, which represent such a horse with a string attached to the head, showing that it was in those very early times a beast of burden. Most horses, however, were wild during those early times and a few are still undomesticated.

There were five different types of wild horses, all found in Europe and Asia, and these are the ancestors of our domestic horses. That type of wild horse called Tangun, or the piebald horse, inhabited the high plateau of Thibet in Central Asia. They were about the size of our Shetland ponies of to-day. It is said their hair was about four inches long, white in color with large bay spots. These horses were protected by mountains and remained unmolested for years. They also remained unmixed with other wild horses. It is thought the Aryans first used these horses in their conquests about three thousand five hundred years ago. They were well

suiting for riding in war, because they were strong and active for so small an animal. The Tangun was not only fleet and enduring, but also intelligent. It is supposed that most of our modern circus horses are descendants of the Tanguns.

The Bay Horse.—Just east of the Caspian Sea there early existed a wild bay horse. The people there, the Tartars, called these horses Tarpan. One of the early Tartars has given this description of them.

“They form large herds which are subdivided into smaller troops, each troop or company headed by a stallion. Each of the great divisions is headed by a sultan stallion. Each company moves forward over the steppes in lines, the leader, who keeps continually on the watch for enemies, in front. If danger is scented, one goes forward to reconnoiter. If he discovers real danger he makes a sharp, shrill neigh, blows with his nostrils, and the whole herd gallops away, the mares and colts ahead, and the stallions behind. If a wolf or bear is met, the leader stallion rises on his haunches and strikes with his fore feet with great force. He usually kills the enemy. If he should be worsted, another stallion takes his place, and if successful is declared champion of the herd. If there is a large pack of wolves, the herd forms in a mass with the young colts in the center, the stallions attacking in a body.”

We do not know when the bay horses were domesticated, but as early as 2000 B. C., the Aryan people, mounted on these horses, overran and conquered Egypt. They were later introduced into Arabia, where, under the care of the Arabs, they became renowned. These

horses were rather small in size and bay in color with black manes and tails. They possessed strong, fine bones and hard muscles and tendons. They were fleet and very enduring.

The Dun Horse.—From a point just north of the Caspian Sea, extending east to the borders of China, there early existed what was called the dun horse. They were low and long in body, with slender but strong legs. The hair on the fetlock was heavy, as was also the mane and tail. They also had a peculiar black strip extending along the back from mane to tail and cross bars on the knee and hock joints. Such markings are occasionally found on horses to-day, which is proof that they have some of the blood of the original dun horses.

They were about fourteen hands (56 inches) high, and were noted for their intelligence. The Shetland pony and our western mustangs and Indian ponies are probably descendants of the dun. The latter were introduced into America by the early Spaniards.

The White Horse.—This horse probably inhabited both Europe and Asia. He was larger than the horses already described, more massive and compact in build. He was only about fourteen hands high, but was heavy. When domesticated this horse was not used to any extent in war. Being white in color he was sacred to the people, and an object of worship in their religion.

Black Horse of Flanders.—This horse, inhabiting north central Europe, was the largest of all wild horses. This was probably because of the abundant supply of food provided in that section. He was probably larger than any of our modern horses. All of our heavy draft

breeds have the blood of this black horse of Flanders, as he was called. He had a large head, bristles around the mouth, short, thick neck, heavy shoulders, broad, thick body, strong legs and feet, and heavy mane and tail.

These different races of wild horses blended together are the ancestors of our modern horses. Our horses to-day are of all colors because of a mingling of these different types.

Modern Horses.—Horses are divided into three general classes: draft, coach, and light or roadster horses.

The principal breeds of draft horses in America are the English Shire, Clydesdale, and Percheron.

Draft Type.—All draft breeds possess certain qualities in common. They are large in size, weighing from 1,500 to 2,100 pounds. They have rather short, broad



FIG. 54. The draft horse on the left is a Percheron stallion weighing 2,100 lbs. The coach horse in the middle is a German coach or Oldenburg stallion weighing 1,600 lbs. The roadster on the right is a Kentucky saddle-horse.

heads; short, thick necks; broad, deep chests and shoulders; broad, short, well-muscled backs, broad hips, short, strong legs, and good-sized feet.

A horse with a man on his back can pull a heavier load on a level pull than he can without such a burden, because the extra weight of the man makes him cling to the ground better. Horses often slip back when pulling hard because they have not sufficient weight to make their feet cling to the ground. So a certain amount of weight is needed in draft horses. Then horses with rather short legs can pull more on a hard road than horses with long legs, because, as with a pry under a rock, more power can be exerted if the weight is near the lower end of the pry. But if the ground is soft, like plowed ground, horses with short legs tire quicker, so the best length of the legs will depend upon the kind of work done.

The English Shire.—As the name implies, this breed of horses was developed in England. It is our largest breed. Like all draft breeds, it is supposed to contain much of the blood of the black horse, already described under wild horses. During the earlier history of England this horse was used in war. Cattle in those days were used for farm work. Before the invention of gunpowder men fought with sword and spear. They wore heavy armor plates to protect themselves. There was so much metal to carry that horses with great size and strength were needed. Later when fire-arms were introduced, lighter and more active horses were found to be superior. Then it was that these heavy English horses were put into use as draft horses.

In England the roads are quite level and smooth, so these heavy, compact, low-down horses are most satisfactory for the carting that has to be done in their cities.

The English shires are sometimes chestnut or sorrel in color. Bay and brown are also quite common. They often have a white stripe in the face and always have long hair, called feather, on the fetlock joints. These horses are somewhat slow of motion, but are faithful when put to a heavy pull. They have large, strong legs and feet, which is a desirable characteristic in draft horses.

The Clydesdale.—These horses come from Clyde, Scotland. In many respects they are quite similar to the Shires. Both have the feather on the feet and they are often quite alike in color. The breeders of Clydesdale horses are making them more active than Shires, but somewhat smaller in size. They are usually bay in color with a lighter shade of bay on the legs.

Percherons.—This breed of horses was developed in the province of Perche, France. Besides the wild black horse, this breed, no doubt, has the blood of the wild bay, which found its way into Arabia. We suppose the Percheron has Arabian blood, because horses were introduced from that country into France during warring conquests. Then, too, the Percheron has a disposition quite like the Arabian. The Arabs are very skillful horsemen. Their kind treatment of animals has developed in their horses gentle dispositions and wonderful intelligence. Many instances are recorded of how these Arabs' lives have been saved by their faithful horses. A horse has been known to stand all day in the hot

desert sun to protect from the hot rays his master who has been overcome and is lying beneath him. The Arabian horse is, also, very fleet and enduring. The Percherons have many of these characteristics, perhaps to a less degree.

In France the women and children have most of the care of the horses. They, too, are kind to their horses. There they are broken when one year old, but given very light work until they are old enough to market. Many are shipped to America each year. The heavy coach work in France developed in our modern Percherons strength combined with a certain amount of speed. They are now quite active for such a heavy breed. Their color in previous years was more commonly gray. Now nearly all are black or dark brown. They have somewhat smaller legs and feet than Shires and Clydesdales.

Coach Horses.—In this country the French coach, German coach, and Cleveland bay are, perhaps, most common. They are all medium in size, weighing from 1,200 to 1,600 pounds.

They are round and beautiful in form, with rather long, well-arched necks, and well-shaped heads. They are quite long in the legs, which makes them desirable for road work. They are also strong enough to pull heavy carriages and coaches. The coach horses are, perhaps, the most beautiful in form of all horses.

Roadster, or Light Horses.—This class includes the Kentucky saddle-horses, the English running horse called thoroughbred, the American trotter, and many other horses light in weight. This class of horses differs from

the draft type in having long, thin necks, narrow chests, narrow, sloping shoulders, rather long backs, and long legs. To be speedy a horse must have the legs fairly close together and long enough to take good strides. Then they must be covered with hard, strong muscles and tendons. They have a more highly developed nervous system to put the muscles in rapid action.

The English have developed the running horse, while the Americans have brought out the trotters. Wild horses either walked or galloped. Trotting, then, is an artificial gait. By selecting the fastest trotters for breeding purposes year after year, the time required for going a given distance has been greatly reduced. Our best trotters can now go one mile in a few seconds over two minutes. The American trotter is not a distinct breed of horses.

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1. Name four useful domestic animals and give the use of each.
 2. Trace the history of the development of the horse.
 3. Name the five types of wild horses.
 4. Describe each type as to origin, characteristics, and use.
 5. What are the three general classes of modern horses?
 6. Name the principal breeds of draft horses.
 7. What qualities do all draft breeds possess in common?
 8. State the origin, characteristics, and use of the English Shire; of the Clydesdale; of the Percherons.
 9. Name some common coach horses, and give the essentials of a good coach horse?
 10. What qualities do roadsters, or light horses, possess?
 11. How has trotting stock been developed?
 12. What classes of horses will become less useful as steam and electric cars are more extensively used?

CHAPTER XVII

CATTLE

The cow belongs to the same order as the horse, both having hoofs on the feet. The horse, however, belongs to the genus *Equus*, while the genus or group to which the cow belongs is called *Bos*. This genus also includes the humped cattle of India and the European and American buffalo, the latter being more properly called *Bison*.

Cattle have gone through much the same process of development during past ages as have horses. Like horses, they walk on the tips of their toes. In front this is what corresponds to that part of your finger from the end to the first joint, while behind it is the first segment of your toe. The cow now has but two toes upon which she walks. Her remote ancestors had four. Two of these have become rudimentary and are attached one on each side a few inches above the hoof. They are now called dewclaws, and are too small and too high up to be of any use.

The bony framework of the cow is quite like that of the horse. Unlike the horse, she has no front teeth on the upper jaw. When you feed the horse an apple he uses his strong upper lip to bring it between his teeth. Then he cuts it in two with his sharp front teeth. The cow runs out her tongue, draws in the apple, and crushes it. When she eats grass, she winds her strong tongue about it and pulls it off.

Some cows have horns and some do not. It is supposed that a few centuries ago all had horns. When in a wild state they needed horns to protect themselves from wild beasts. The cow cannot strike with her fore feet as does a fighting horse, neither can she kick with both hind feet at once. She cannot run as fast as some other animals. Her horns were, therefore, her best protection.

Wild cattle roamed about the plains of Europe, Asia, and Africa in earlier times. There are said to have been none on this continent when America was discovered by Columbus. They traveled about in herds under the leadership of the strongest bull. When a younger bull would become strong enough to fight and kill the former leader he would become the acknowledged king of the herd.

Nearly all cattle are now domesticated. There are still a few herds of wild cattle preserved in forest parks owned by English noblemen. These are white in color, with black noses and black tips on the horns and ears. They are smaller than our domestic cattle.

The cattle in our own herds have been domesticated and under the control of man for many generations back, yet they still retain many of their wild traits.

If a strange dog enters a field where cattle are grazing, all will unite in self-protection to chase him out. If a young calf is caught it will bleat long and loud and the herd will rush from some distance away to protect it. When a calf is born in some open tract the mother secretes it in the bushes or some place out of sight. Later she goes away to graze, satisfied that nothing will

discover it. The calf will not rise until the mother returns to feed it. If perchance some one passes near by, it will stretch out its neck close to the ground and remain motionless until after the seeming danger is past.

Since cattle have been under the control of man, there have come about marked changes in size, form, and function. The little fawn Jersey cow, weighing 700 pounds, is so different from her big Shorthorn cousin, weighing 1,600 pounds, we can hardly realize that modern breeds of cattle come from the same source. Our different breeds have been developed in different countries, where climate, food supply, and different methods of management have all contributed to produce the variations we now have.

Kinds of Cattle.—Our modern cattle may be divided into two classes: (1) those of mixed breeding and unknown ancestry; and (2) those of pure breeding and known ancestry. Our common cattle are usually a mixture of different breeds. It is not considered worth while to keep a record of the ancestry of this common kind.

By the term thoroughbred, full-blood, or pure bred, is meant those animals which have been bred without the admixture of outside blood. Such animals are usually registered; that is, their names are recorded in the association books together with the names of their ancestors on both sides for several generations back. Such animals command higher prices because their breeding is known. The better the ancestry the more valuable is the animal.



FIG. 55. The cow on the left has the typical dairy form. She has produced 1,843 lbs. of butter in five years. She is a Jersey cow weighing 750 lbs. The middle cow is a pure Shorthorn of the dual-purpose type. She gives twenty quarts per day while fresh, and fattens when not giving milk. Weight, 1,100 lbs. The cow on the right is also a pure Shorthorn of the beef type. She is always fat, but does not give a large quantity of milk. Weight, 1,600 lbs.

Cattle are again divided into three classes, according to their usefulness to man.

(1) The beef breeds, or those which fatten readily and produce a good quality of beef, but are not heavy milkers: as Herefords, Galloways, Aberdeen-Angus, and some Shorthorns and Polled Durhams.

(2) The dairy breeds, or those which are valuable for their milk, but not very good for their meat: as the Jersey, Guernsey, Ayrshire, and Holstein.

(3) The dual-purpose breeds, or those which are fairly good for both: as the Red Polled, Devon, Brown Swiss, and some Shorthorns and Polled Durhams.

Beef Cattle.—If we compare our modern breeds of beef cattle with the specimens which existed a century

ago, we find marked improvement. Systematic effort to improve beef cattle began about two centuries ago. Probably more has been accomplished within the past century than during all previous time.

Great Britain deserves nearly all the credit for this improvement. From ungainly cattle, which we would now call "scrubs," the people of England have given us the beautiful present-day Shorthorns and Herefords, and the Scotchman the smooth Aberdeen-Angus and curly-coated Galloway.

Abundant food supply, good climate, and wise selection in breeding have transformed these coarse, slow-feeding, late-maturing animals into smooth, blocky, easy-keeping, and early-maturing animals. It seems remarkable that so much could be accomplished in but a single century.

In all our beef breeds to-day we strive for certain qualities which together make the ideal animal. In these qualities we keep in mind the demands of the buyer and consumer, who want the largest possible proportion of the choicest meat with the least waste; and of the feeder, who finds it desirable to have animals which make the largest possible gains for food consumed.

The ideal beef animal, then, is one which has, first of all, sufficient size to make him profitable to the feeder. He should also have a vigorous constitution, as indicated by the large, open nostrils for breathing, a full, thick neck, wide and deep chest, i. e., wide on top just behind the shoulder blades, and wide between the fore legs. Then he should have good digestion and assimilation. If there is a good, active circulation of blood, food will

be thoroughly assimilated and good gains made. A soft, pliable skin, soft, glossy hair, and bright eye indicate a good circulation of blood and good health.

The older an animal becomes, the more food is required to produce a pound of gain. Beef animals must be fat when sold, to be profitable. Some animals cannot be made fat, no matter how heavily fed, until they are three years old. Others on the same feed can be made fat enough for the market when but two years old, or even younger. Such animals naturally mature earlier. In form they are short in the legs, broad, thick, and deep in body, and rather fine in bone. The short, broad head is another indication of early maturity. The steer with a long, narrow head, long, slim neck, long legs, coarse bones, is late maturing and slow to fatten.

To suit the buyers of fat cattle the beef animal should have a broad back and good width behind. Then when he fattens he will have a larger proportion of the choice meat. The high-priced roast beef comes from the front part of the back, from the shoulders to the last rib, and the very choice porterhouse and sirloin steak from the last rib to a point just behind the hip bones. The round steak, which is a little below the sirloin in price, comes from the thigh. The meat from the upper half of the animal is worth about three times as much per pound as the meat on the lower half, so you will see why wide backs and full hind quarters are wanted.

The Shorthorns.—This breed has also been called Durham, because it was started in Durham County, England, about two hundred years ago. They are now



FIG. 56. Shorthorn cows in pasture.

called Shorthorns, because their horns are short. There are more animals of this breed in America than of any other. They were first shipped here from England about one hundred years ago.

The Shorthorns are the largest of our beef breeds. The bulls sometimes weigh as much as 2,800 pounds and the cows as high as 2,000. The average would be 500 or 600 pounds less than these figures.

In color many are solid red, others are red with white markings, some are roan, i. e., red and white mixed together, and a few are white. The Shorthorn is the only beef breed which is not uniform in color. They also differ widely in their capacity to give milk. Some give twenty quarts of milk per day, and others not more than eight quarts. This is because some of the early Shorthorn men bred for milk as well as beef, while others bred for beef and paid little attention to the quantity of milk given.

The Shorthorns are quiet in disposition and make good gains when well fed. They are not able to stand so much cold, disagreeable weather as some breeds, because their skin is thinner and they have a lighter coat of hair.

It would be difficult to find any breed which excels the Shorthorns as a general-purpose breed for the farmer.

Polled Durhams.—The double-standard Polled Durham is a pure Shorthorn without horns. It happened that a Shorthorn calf was born and never developed horns. This was a freak of nature. That calf was the foundation of most modern Polled Durhams. They are called double standard because they can be registered both as Shorthorns and as Polled Durhams. Single-standard Polled Durhams contain some blood of the common red muley cow and are not pure Shorthorns.

The double-standard Polled Durhams are in much greater favor. What was said concerning Shorthorns applies to this breed also, except that this breed has no horns.

The Herefords.—This breed is named from the county of Hereford in central England, where it was started about two hundred years ago. Some of the cattle which were early used in forming this breed were solid red in color while others were white. This would give red and white animals. It is supposed a white-faced breed called the Flemish cattle were also used, and this tended to fix permanently the white face in all the cattle of the breed. Modern Herefords are red, with white on the face, along the top and bottom of the neck, on the under side of the body, and on the feet and legs. The red varies from light to dark.



FIG. 57. Hereford bull. Age, 2 years 4 months. Weight, 1,600 lbs.

In size they are a little smaller than the Shorthorns. They are not considered heavy milkers. Their inclination is to make a little food go a long way in the production of beef. Most Herefords are easy keepers and quiet in disposition.

They have thick skin and hair, and are therefore able to stand more cold and exposure than any other breed, except the Galloways. Their thick skin also protects them from the hot sun's rays. They are hardy and active in habits. These qualities combined make the Herefords unusually well adapted to range conditions in the West and Southwest.

Aberdeen-Angus.—This breed also derives its name from the counties where started. The original home of the Aberdeen-Angus was in the counties of Aberdeen and Forfar, northeast Scotland. Forfar County was



FIG. 58. Aberdeen-Angus cows.

formerly called Angus. The farmers in that locality are very skillful feeders, and they have succeeded in developing a very choice beef breed.

One hundred years ago a large number of these cattle had horns. Now they are all polled or hornless. The Scotchmen early found that the cattle without horns were more quiet when herded together and less troublesome while being driven to the pastures. They selected for breeding purposes, then, only those without horns. This practice continued, after several years has finally given us a breed free from horns.

The Angus cattle are uniformly solid black. Occasionally one will have a white mark on forehead or under side of body. They have no horns, and are therefore easy to handle in the feed lot. In size they average a little smaller than the Herefords, are usually

compact in build, and naturally mature early, probably earlier than any other breed.

They are easy to fatten, and when ready for market the steers make excellent carcasses of beef because the fat is usually well mixed with the lean. They are a little more shy than Shorthorns and Herefords, probably because they have in the past been handled less. As milkers they are fully equal to Herefords, but not so good as Shorthorns.

Galloways.—This is also a Scotch breed, coming from the southern part of that country. In many respects they are quite similar to the Angus. Both are hornless and solid black in color. The Galloways are some smaller and have long, wavy hair. They are also more flat on top of the head.

The Galloways having been reared in the mountainous district in southern Scotland, where the weather is cold and rainy, have developed a long, heavy coat of hair. This makes them well suited for our northern states. Like the Herefords they are also good grazers.

The Dairy Breeds.—A good dairy cow is one which will give a large quantity of rich milk for a long period of time. She must also be easy to milk and gentle to handle. If she has a tendency to convert part of her food into flesh, she is not an economical milk-producer.

Dairy cows, then, should be thin in flesh, even when well fed. It has been found that our best dairy cows are built something as follows: in form they are wedge-shaped, narrow in front, widening out behind, and very deep through the hind quarter. The

dairy cow consumes a great deal of hay and grass, and therefore must have a large digestive capacity.

Her head is long and narrow, her neck long and slender, her backbone, ribs, and hip bones prominent, her thighs thin, giving plenty of room for a large, evenly quartered udder. The milk vein running from the udder forward on the underside of body should be large.

Holstein.—This is our oldest breed of cattle. It is said that the people in Holland have had these black and white cattle for nearly two thousand years.

The little country of Holland is low, much of its territory having been reclaimed from the sea by the building of dikes or embankments which keep the tide back. This low, rich ground yields succulent grasses and other crops which dairy cows relish, and from which there is obtained a large flow of milk.

Then, too, the native Hollanders are very painstaking in their care of animals. In many instances the cows are stabled in a part of the house. But this is not so strange as it sounds, for they are very careful to keep the stalls clean and tidy at all times. What a comfort it would be to some of our American cows, which are made to stand all day in unclean and uncomfortable stalls, if they could have such places as are provided in Holland.

The people of Holland have bred their cattle for milk alone. They are to-day our heaviest milkers, but the milk is less rich than Jersey milk. A few Holstein cows have given as high as forty quarts per day when fresh. Thirty quarts per day is not unusual.

They are the largest of all dairy breeds. Some cows

weigh as high as 1,800 pounds, but probably 1,300 pounds would be an average. They are not very satisfactory for beef purposes, although most farmers prefer a Holstein steer to a Jersey.

Jersey, Guernsey, and Alderney.—Just across the English Channel, south of England and west of France, there are three small islands called Jersey, Guernsey, and Alderney. The first is largest, being about ten miles long and five wide. On these three little islands there have been developed the breeds of dairy cattle named from the islands.

The inhabitants of these islands, like the Hollanders, are very skillful in their management of cattle. An abundance of food is provided. Warm quarters are also furnished, because dairy cows need warm, well-ventilated buildings. They carry no surplus fat, and therefore do not have the protection beef cattle have.

The island of Jersey has a population of about fifty thousand people, which means nearly one thousand to the square mile. They practice very intensive farming, producing vegetables and dairy products principally. They keep only the very best cows and prohibit coming on the island any foreign cattle, except those which are to be used for meat.

We have in America many of these cows, whose ancestors came from Jersey Island. In color they vary from light fawn to a very dark brown. They are small in size, many not weighing over 700 pounds. No cow produces richer milk than the Jersey. They are valuable, then, for butter. In disposition they are quiet,

which makes them popular for the city man who keeps but one cow and has but little feed.

It is unfortunate that they are inclined to be narrow-chested, therefore rather weak in constitution, and more likely to become diseased. They have never been selected with reference to constitution, as have beef cattle, which accounts for this weakness.

Guernseys.—The Guernseys are a little larger and coarser than the Jerseys, but in other respects they are very similar, as are also the Alderneys. The last two are not very numerous in America.

Ayrshire.—The Ayrshire cattle are more or less spotted in color and a little larger in size than Jerseys. They come from the county of Ayr, Scotland. They are not so good for milk as Jerseys, but better for beef, the Jerseys being very inferior for beef.

Dual-Purpose Breeds.—“Dual” means two, so the dual-purpose cow is one which is suitable for both dairy and beef purposes. Such cows are popular with farmers because they can be milked with profit and their calves will bring fair prices for beef. It is impossible, however, to have cows which excel in both respects. Such cows are less valuable for milk than dairy cows, and less valuable for feeding than the beef breeds.

In form, dual-purpose cows are about midway between beef and dairy type. They are quite narrow in front and rather spare in flesh.

Red Polled.—This breed was developed in England. As the name implies, they are polled, or hornless, and red in color. In size, they are rather small, the cows weighing about 1,100 pounds. They feed into beef

fairly well and make a good quality of meat. Red Polls in our eastern states are better milkers, but not so good for beef as those in the West.

Shorthorns and Polled Durhams.—These breeds were described under beef cattle. Some specimens are good dual-purpose cattle, while others are strictly for beef purposes. The milking Shorthorns are, perhaps, more in popular favor than any other breed. They have size, fatten quite readily, and are good milkers.

Devon.—This breed is small and dark red in color. They have large horns. In many respects they are quite like the Red Polls. They are not numerous in the West.

Brown Swiss.—This breed comes from Switzerland, where cheesemaking is an important industry. The Swiss farmers milk their cows, work them in the fields, and when past their prime for milk they fatten them for beef. They are, then, what might be called triple-purpose. The Swiss people are careful not to overwork their cows. One animal usually works but half of the day.

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1. Compare the cow with the horse as to origin and development.
 2. What wild traits do domesticated cattle retain?
 3. Name two general classes of cattle as to origin.
 4. What are thoroughbred cattle?
 5. What are the three classes of cattle as to use?
 6. How and by whom have good beef cattle been developed?
 7. Describe an ideal beef animal.
 8. What are the essentials of a good dairy cow?
 9. What breeds are best for both dairy and beef purposes?

CHAPTER XVIII

SWINE

The pig, like its remote ancestors, and like its relative, the hippopotamus, is fond of wallowing in mud and water. The pig has changed less in past ages than other domestic animals. It is still fond of flesh and has teeth suited for tearing flesh. Like the cow it once had four toes, the two outer ones being still present, but too high from the ground to be of any use.

Our modern breeds of swine are supposed to come from wild hogs. In their bony framework they are quite the same as wild hogs now living. Domestication has shortened the snout and legs and made the animal less muscular. The habits are also different. The wild boar travels about in the night in search of food, hiding in thickets during the day. He is nearly always found alone. If suddenly surprised by a hunter on horseback, he darts out of his hiding-place and leads the horse a fast race. They are so fleet that few horses or dogs can keep pace with them. They are usually hunted by several men on horses accompanied by packs of dogs. When cornered they fight hard, using their long tusks to good advantage.

The wild boar has long bristles, a thick neck, heavy shoulders, and small hams. Wild hogs are usually dark brown or sandy in color, so they will be less noticeable when hiding among the dead leaves and on brown

soil. The young have stripes of a lighter color running lengthwise of the back. The mothers are very attentive to their young, protecting them long after they are weaned.

Under domestication the hog has become quiet in disposition and has formed the habit of putting on flesh when well fed. He is still fond of rooting in the ground.

As in the case of the cattle, probably most credit should be given the Englishmen for the improvement in swine. Yet much of the improvement accomplished in England was due to the introduction of foreign hogs, as for example, the old Chinese breeds. An abundance of food with intelligent management has transformed the pig from a rough, ungainly animal to the round, fat animal we have to-day.

Modern hogs are now divided into two classes: (1) those best adapted to the production of fat meat, called fat or block hogs; and (2) those best adapted to the production of lean meat, called bacon hogs.

Of the former class those most common in America are the Berkshires, Poland Chinas, Duroc Jerseys, and Chester Whites. The general form of these four breeds is quite alike. In good flesh they are short and thick in the neck, broad over the shoulders, back, and hips; wide and deep in the chest, full in the hams, and short in the legs. All fatten readily.

Berkshires.—This breed was started in Berkshire County, England. In early times some were black, some red, and some white. Now all are black with white markings on the face, feet, and tip of tail. They have a short, turned-up nose and erect ears. They



FIG. 59. Young Berkshire sows.

are excellent feeders and dress well when killed. Ten pigs in one litter is not unusual for Berkshires. They are somewhat shy in disposition, and therefore less easily handled than some other breeds.

Poland China.—This breed was started in Butler and Warren counties, Ohio, by a class of people called Shakers. The native hogs found in that section are thought to have come from Poland. There was introduced later different strains of hogs from other places, such as the Byfield, Irish Grazier, the Big China, and Berkshire.

They are black in color with considerably more white than Berkshires have. They have a rather long, straight nose and ears erect from base to middle and drooping from the middle to tips.

The Poland Chinas are quite similar to Berkshires.



FIG. 60. Poland China sows.

They will fatten at an earlier age, and are more quiet in disposition. They have been reared in the corn-belt, where not much except corn is fed. The lack of mineral matter and albumen in corn has made them small in bone and rather inferior breeders. Poland Chinas often produce only five to seven pigs in a litter.

Duroc-Jerseys.—This is also an American breed. They are called Duroc-Jerseys, because they are a union of two red breeds of swine—the Durocs from Saratoga County, New York, and the Jersey Reds from New Jersey. In size they are about like the Berkshires and Poland Chinas. In color they vary from light to dark red.

They have more bone than the Poland Chinas, and are better able to stand heavy corn feeding. They are more

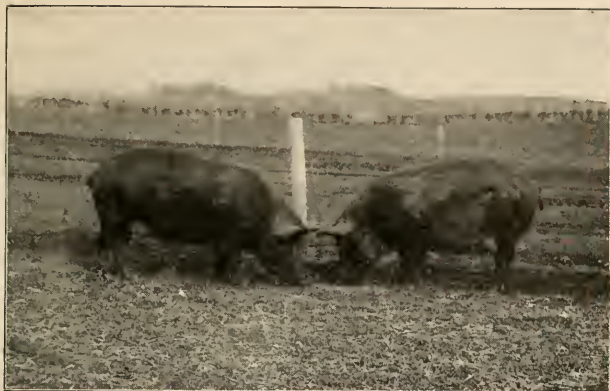


FIG. 61. Tamworth brood sows. Bacon type.

productive, sometimes producing as high as twelve pigs in a litter. The Duroc-Jerseys require a little more time for fattening on account of being somewhat coarser than Berkshires and Poland Chinas. They are well suited for pasturing in fields.

Chester Whites.—This breed was started in Chester County, Pennsylvania. In color they are solid white. They are larger than the three former breeds, but later in maturing. During extremely warm weather they suffer from heat, because they have thin skins. They produce larger litters than do Poland Chinas.

Bacon Hogs.—This class is most common in England and Canada. During recent years there has grown a strong demand for pork in the form of bacon. Bacon is made from the side meat and should be lean rather than fat. The bacon hogs, as we now have them, are

long from the shoulder to ham and very deep. The hams and shoulders are small. These hogs, when fed, take on less fat and more lean. Where the common lard hog has a two-inch layer of fat on the outside the bacon hog has only about one inch.

Tamworths.—These hogs came from Tamworth, England. They are larger than the breeds already described, excepting the Chester Whites. They have long noses, long ears, are narrow in the head and neck, and long and narrow in body, and long in the legs. They are also quite heavy in the bone and like Chester Whites and Duroc Jerseys are well adapted for grazing in the field. They are also very productive. As feeders, they are about equal to the other breeds.

Large Yorkshires.—This breed also has the bacon form. They differ from Tamworths in that they are solid white in color, with turned-up snouts and shorter legs. They are less productive and somewhat more inclined to fatten when heavily fed.

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1. Compare the domesticated hog with his wild ancestors.
 2. What are the two general classes of modern hogs.
 3. What are the qualities desired in each class?
 4. Name four breeds of fat hogs and give the most important facts concerning each.
 5. Name two breeds of bacon hogs and describe each.

CHAPTER XIX

SHEEP

Wild sheep have inhabited Europe, Asia, Africa, and America. In America they are called the Rocky Mountain, or Bighorn sheep. All wild sheep prefer high land or mountainous districts. Our modern breeds still shun low, wet ground.

Sheep have been domesticated since very early times. They have been improved under man's care by the same methods that have been used with other classes of live stock.

All sheep may be placed into two classes: (1) mutton breeds and (2) wool breeds. The former class includes all breeds except the Merinos. A more common classification is made with reference to the coarseness of their wool. The fine-wool breeds include the Spanish Merino, American Merino, Delaine Merino, and Rambouillet, or French Merino. The medium wools, or down breeds, include the Shropshire, Southdown, Hampshire, Oxford, Cheviot, Dorset-horned, and Tunis. The coarse wools are the Lincoln, Leicester, and Cotswold.

The Spanish Merino is the foundation of all the Merino breeds. These were originally small in size, and sheared small fleeces of very fine wool. About one hundred years ago a few were shipped from Spain to America, where with our better food and skill they have developed into a sheep having greater size and longer

and heavier wool. These are called the American Merinos. Many of them are covered with wrinkles, others have heavy wrinkles on the neck with a smooth body, which makes more surface for wool. When mature they weigh from 90 to 150 pounds. They sometimes shear as high as thirty pounds of wool, much of which weight is oil. They are not desirable for mutton purposes.

Delaine Merino.—This is an offshoot of the American Merino, being larger and better for mutton, having but few wrinkles and longer wool, and well suited for making delaine goods, a fine grade of cloth.

Rambouillet.—These sheep were developed in France from the Spanish Merino. They are the largest of all fine-wool breeds, producing a long, heavy fleece of wool and fairly good mutton.

Shropshire.—Among the down breeds the Shropshires



FIG. 62. Cross-bred Shropshire Merino ewes. The black-faced pair in center are pure-bred Shropshires.

are most common in America. They were developed in Shropshire County, England, where with rich and abundant food they have become valuable for mutton purposes.

Mature Shropshires weigh from 150 to 250 pounds. In form, like other mutton breeds, they are broad and deep. They have black faces and black feet and legs. Their wool is coarser in texture than Merino wool, but quite free from oil. A Shropshire fleece will weigh from seven to twelve pounds.

The Southdowns are quite similar, except that they are a little smaller in size and have lighter colored faces. They are also a little finer in bone. The Hampshires and Oxfords are also similar, but larger and coarser than Shropshires. The Dorset-horned have heavy horns and a shorter, denser fleece than the Oxfords.

The Cheviots have a more open fleece, and, like the Dorsets, have white faces and white legs. They come from the Cheviot Hills in Scotland. All the others come from England.

The coarse-wool breeds are all larger than Shropshires, the Lincoln weighing as high as 300 pounds in some instances. The Cotswolds are about twenty-five pounds lighter than the Lincolns and the Leicesters about fifty pounds lighter. All have long, coarse wool, suited for combing purposes. Such wool is valuable for carpets.

The fine-wool breeds have a short wool fiber which makes their wool more suitable for carding purposes. Woolen clothes are made from this short, fine wool, which is not woven in rows, but felted together in a

mass. Wool felts readily because each fiber is a tube covered with small scales like shingles on a house. This makes them adhere together, whereas hair which is smooth would not do so.

Sheep are sheared early each summer, the wool tied in bundles, and sent to the dealers. It is there washed, scoured, and sorted into classes before being manufactured into woolen goods.

Sheep are very timid animals and should be handled quietly. They are valuable for keeping fields free from weeds.

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1. What are the two general classes of sheep as to use?
 2. What are the three classes as to coarseness or fineness of wool?
 3. Name and describe the breeds springing from the Spanish Merino.
 4. Of what special use is the wool of breeds of this group?
 5. Name and describe the leading down breeds.
 6. Name the coarse-wool breeds, and tell for what their wool is used.
 7. What is the chief difference between wool and hair?
 8. What cautions should be observed in the care of sheep?

CHAPTER XX

HOW TO CARE FOR LIVE STOCK

From what has already been said concerning the development of our breeds of stock, we learn that improvement has been brought about by furnishing an abundance of good food, comfortable quarters, and by selecting for breeding purposes the best specimens.

If we fail to give these improved animals as good care as they have had in the past, they will become worse instead of better. The value of our animals then will depend on the care we give them. To be most useful and profitable, all animals should have an abundance of food. It takes about one-half of a full feed to keep the animal's machinery going, i. e., to keep the heart beating and other organs acting. The other half of the food given would go to produce beef in the fattening steer, milk in the dairy cow, pork in the pig, mutton or wool in the sheep, and work in the horse. The animal is like the steam engine in that it requires a certain amount of fuel to get up steam, the rest to produce work. It is therefore, wasteful to feed less than the animal can use. This does not always mean all the grain that can be digested. If the animal is not being fitted for market, perhaps he should have a larger proportion of hay, because it is cheaper. But he should always have all that he wishes, hay and grain in right proportions, without overfeeding to dull the appetite.

If we feed the animal nothing but corn, he gets too much starch and not enough albumen. Corn is our best and cheapest food for animals, but it will go further if fed with some food containing plenty of albumen, like alfalfa or clover hay, wheat bran or shorts, oil meal or milk. For cattle or sheep, corn and alfalfa or clover is perhaps best, since these hay plants contain albumen and have sufficient bulk to make these animals chew their cuds.

A cow has four stomachs, holding in all about fifty quarts. In her first large stomach she stores the food she gathers during the day, then at night or while at rest she brings it up again to chew over before it goes on to the other stomachs. This is her natural way, and if she is deprived of grass or other bulky food she is uneasy, and perhaps becomes sick. Sheep also have four stomachs, and their demands are like those of the cow. When wild hay or straw is given for bulk, then something like bran or oil meal should be given with corn, because wild hay is starchy and lacks albumen.

The pig has only one stomach, and that very small. He should have mostly grain, which might be largely corn with skim milk, shorts, or a little alfalfa or clover.

The work horse prefers oats and corn. Both are good, because considerable starch and oil are needed to furnish energy to drive the muscles. Clover and alfalfa are apt to be too dusty for horses, causing heaves.

All young animals need more albumen, because, while they grow, more bone and lean tissue are being formed. Whole milk is nature's food for the young animal, and is the most perfect. Milk contains much albumen.

Shelter.—Some kinds of animals need more shelter than others. The fattening steer has enough fat under its skin to keep it warm even during cold weather. His food also furnishes a great deal of heat, because very starchy. In this climate a shed open on the south side is warm enough for him. The thin steer needs a little more warmth, and the dairy cow needs careful housing. She carries but little fat and should be given a warm place during winter. The brood sow needs more warmth than the fat hog, for the same reason. Pigs have less hair than cattle and need better housing.

Horses also need warm stables unless they have been out doors long enough to develop heavy coats of hair. Sheep have a heavy coat of wool and need little housing, just a roof to keep them dry and a good windbreak. Young lambs need a warm place. All animals should have clean water and some salt. Regularity of feeding and dry beds are also essential.

Our domestic animals are God's creatures, just as we are. They are often larger and more powerful than man, but of lower intelligence. They are placed under our charge to be our servants and we their protectors. In the wild state they could roam about at will and protect themselves. Under domestication they are entirely at our mercy. We are expected to see them well cared for and not abused. They in turn do our work and furnish us with clothing and food. He who starves a helpless creature is a criminal of the worst kind. The man who loses his temper and beats his dumb animals puts himself on a level with brutes. The

poor, shivering horse, unblanketed and tied to a post on a cold winter's day, is an object of pity. The owner of such an animal is a violater of the law and should be reported and punished. Our dumb animals do not have our pleasures in life; let us at least see that they are always comfortable.

1. How is the development of breeds of stock brought about?
2. Upon what does the value of animals depend?
3. Explain fully, "It is wasteful to feed less than the animal can use."
4. What special care should be taken in feeding stock?
5. What kinds of food are best adapted to the cow? The sheep? The pig? The horse?
6. Why do young animals need more albumen in their food?
7. What is the most nearly perfect food for the young animal?
8. What special care should be taken in sheltering domestic animals?
9. Why should we treat all domestic animals with great kindness?
10. Give common instances of lack of care of domestic animals, and tell how such neglect might be abolished.

EXERCISES — PLANTS

1. Soak some beans, corn, and other seeds for a day or two. Split a bean. What are the two halves? What is their use? Find the second pair of leaves and the stem. Make a drawing of the split bean, and show these parts.

2. Cut across a kernel of corn. Find the outer starchy part and the germ. See if you can find a little roll of leaves in the germ. Split a kernel and find the same parts. Make drawings of each and mark the parts. What difference is there in the place in which the food is stored in the corn and in the bean? What other seeds have food stored in the germ? Around the germ? What is the germ?

3. Plant seeds of various kinds in a box in the school-room window—or better, in a garden in the schoolyard. Compare the ways in which the different seedlings come up. What ones bring the seed above ground like the bean? What ones leave it below ground? What ones come up arched? Why do you think that they have an arch? Which grow faster at first, those that come from large or from small seeds? Do those that grow fastest at first make the largest plants?

4. Plant corn, wheat, and oats at depths of 1, 2, 4, 6 inches, and find how many days it takes for them to come up in each case. What difference does the depth of planting make in the vigor of the young plants?

5. How are the leaves arranged on the stalk? Can you find any small rolls of leaves that look as if an ear had started to grow? What is the position of the ears with respect to the leaves, and the groove in the stalk? How many ears does a stalk usually bear? Cut across the stalk. Notice the threads that extend through it. Split the stalk and see if they go all the way through it. Do they extend into the leaf? What do you think they are for?

6. Cut across a small branch, or get a stick of stovewood that has not been split. Find the pith, wood, bark, and annual rings. How old is the stem? Do the rings have anything to do with the

grain of lumber? Split the stem and see how they appear. Find a board in the floor that was not sawn straight with the log. Does it make a good board? What causes the knots in boards? Is the inner part necessary to the life of a tree? Have you ever seen a hollow tree that continued to grow? Of what value to the tree is the inner part? In what part of the stem does growth take place?

7. Get branches from several kinds of trees, maple, box-elder, cottonwood, etc. What differences in color and shape do you find? How are the buds arranged? Find places where leaves were last summer (leaf scars). What part of the twig grew last year? How old is the plant?

8. Get some flowers of any kind. If it is winter, the "single" house flowers will do. Find the essential parts. What are their names? Why are they called essential parts? What other parts are there? Of what value are these parts? What is the nectar (honey) for? Can you find any pollen? What difference is there between the flowers of plants that have pollen carried by the wind and those that have it carried by insects?

9. Where are the stamens of the corn borne? The pistils? What is the yellow powder that one sees on the ground in a corn-field just as the silks begin to show? Why does there need to be so much of it? Why is hot, dry weather particularly bad for the corn crop at this time? When a stalk of corn grows by itself, what kind of an ear is formed? Why is this? If the tassels were all out just before the silks appear, what effect would it have on the crop?

10. Dig around a hill of corn and see how near the surface the roots grow. How far do they extend from the stalk? How deep could the cultivator go without hurting these roots? What additional roots grow about the time that the ears appear?

11. Why can alfalfa stand dry weather better than clover? What are some of the best pasture grasses of your county? See if you can find what habit of each plant makes it good.

12. How are the following propagated; blackberries, strawberries, apples, cherries? What is budding? Grafting? Why are they necessary? What plants are grown from cuttings?

EXERCISES — INSECTS

1. For the best study of insects we shall need a cage for them in the school-room. Let some boy who knows how to use tools (as all boys should) make a cage. Make a frame about 18 x 10 x 10 inches. The ends and bottom may be made of board, the sides and top of wire screen, or the sides may be of glass. The top should be hinged so as to open readily. If you cannot provide such a good cage, glass jars may be used, or you can fix up a box with mosquito netting. The insects will not be very particular. A cage with soil in the bottom and plants growing is sometimes called a terrarium. In this you can keep many kinds of insects. You must not forget to feed them, and you will have to learn what kind of food each one likes.

2. Bring in enough grasshoppers so that each pupil will have one for study. Into how many divisions is the body divided? How many legs does it have? What difference is there between the hind legs and the other pairs? How many wings are there? Do all insects have this number of wings? How are the wings folded? What difference in color between the outer and inner pair? To what part of the body are the wings and legs attached? Find the antennæ (feelers). Examine the teeth. Do the jaws move in the same way that yours do? If you have a microscope, see if you can find the divisions of the compound eyes. Look between these for simple eyes.

3. What are some of the most musical insects? Put some of them in the terrarium and see if you can find out what kind of instruments they have. Do they have ears? See if you can find the ears.

4. Put some cabbage worms into the terrarium. Feed them on fresh leaves and watch from day to day to see when they change to chrysalides (the pupa stage). In a short time they will probably come out as butterflies.

5. See if you can find some of the butterflies laying eggs on

the cabbages. Look on the underside of the leaf for the egg. Notice that the female butterfly has two black spots besides the tip in each wing, while the male has but one. Compare the caterpillar and butterfly as to the kind of food, the mouth, the wings, etc. Does it seem possible that the butterfly is the same individual as the caterpillar, grown older?

6. Find as many kinds of insect homes as you can. In each case find, if you can, whether the old insect or the larva made the home. Find a yellow-jackets' nest. Yellow-jackets are sometimes called the first paper makers. Why? Do you know what they make their nest from? From what things do we make paper? Find a mud-dauber wasp's nest in which there are spiders. How did the spiders get there? If you can find some cones on willow-trees, open one and see what caused it. Bring in galls from other plants and find out what caused them.

7. Bring in cocoons, chrysalides, caterpillars, etc., whenever you find them. Keep them in the terrarium and see what changes take place.

8. Question for debate; "Resolved, that insects do more good than they do harm."

References. Each school should secure the bulletins from their state experiment station, and should secure the Farmers' Bulletins and the Yearbook from the Department of Agriculture. These will be needed all through the work in elementary agriculture, and will be of use as supplementary reading and in teaching geography to advanced pupils. Write to the Secretary of Agriculture, Washington, D. C., for the "List of Bulletins and Circulars Available for Free Distribution." Select from these all that you can use, they will be sent to you free. The Yearbook of the Department of Agriculture may be secured free by writing to your Congressman. The bulletins from the state experiment station will be sent on application.

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