First Lessons in Agriculture

Gulley

FIRST LESSONS

IN

AGRICULTURE

BY

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PREFACE.

The first edition of this book has been introduced into several colleges and schools as a text-book, and it has seemed best to revise and enlarge the work somewhat for the second edition. Illustrations have been prepared, and, besides extending several of the chapters, three chapters on the domestic animals have been added.

In the preparation of the new matter on domestic animals we have consulted the writings of Youatt, Stewart, Allen, Curtis, Sanders, and others, and also the agricultural journals of the country.

F. A. G.

January, 1892.

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PREFACE TO FIRST EDITION.

In 1885 the Board of Trustees of the Agricultural College of Mississippi instructed its President to devise some means for giving instructions in agriculture to students in the preparatory class. In accordance with the request of President S. D. Lee, the author prepared the first draft of this work, and had a sufficient number of papyrograph copies struck off to supply the members of the preparatory class of 1886. The students evinced so much interest in the study that the author felt encouraged to revise the matter, and to have it published in book-form for further use.

The writer has aimed to discuss the more important principles which underlie agriculture, in a plain, simple way within the comprehension of students who have not studied chemistry, botany, and the other branches of science closely related to this industry.

The subject of every chapter is of such importance, and covers so much ground, that it could be fairly discussed only in a volume by itself; hence in this little book but a few points are touched upon. After some years' experience in the instruction of college classes, the author has concluded that impressing facts upon students is of minor importance when compared with awakening interest in the study of agriculture; and this book has been prepared in compliance with that view.

It is believed that the practical farmer may receive suggestions from this work that will be of value to him. It may incline him to study the laws of nature with greater interest, and may lead him to make better use of the knowledge gained from those scientific investigations that pertain to the treatment of the soil for the purpose of securing larger returns in crop.

Not aiming to present a scientific treatise or even a work of reference for advanced students, the author has drawn material from all sources at his command, without referring to or quoting directly from authors in the text of the book. The matter is presented in a more condensed and simple form than would be desirable in a complete work of standard character. Material has been collected from Johnson's "How Crops Feed and How Crops Grow"; "Physiological Botany,"—Goodale; "The Chemistry of the Farm,"—Warrington; "Manual of Cattle Feeding,"—Amsby; "Talks on Manures,"—Harris; "Elementary Principles of Scientific Agriculture,"—Lupton; "The Science of Agriculture,"—L. Loyd; "Stock-breeding,"—Miles; "Draining for Profit and Health,"—Waring; and from the Bulletins of the Connecticut, New York, New Jersey and North Carolina Experiment Stations.

The above works are recommended for a further study of the topics briefly discussed in this little book.

Fearing that a few of the terms necessarily used to convey a technical meaning may be unfamiliar to a portion of my readers, a glossary explaining the meaning of some of them will be found in an appendix.

I am indebted to Dr. W. J. Beal and Dr. R. C. Kedzie of the Michigan Agricultural College, and to President

S. D. Lee and my colleagues, Professors D. L. Phares, J. A. Myers, and W. H. Magruder, of the Mississippi Agricultural College, for many valuable suggestions, and also to Mr. N. D. Guerry of Artesia, Miss.

I am under special obligations to Professor Magruder for help in preparing the matter for publication, and I have also been materially aided by my assistants, Mr. J. J. Huggins and Mr. W. W. Hoskins.

F. A. GULLEY.

Agricultural College, Miss.
April, 1887.

CHAPTER I.

Composition of Matter.

ELEMENTARY SUBSTANCES—COMBINATIONS OF ELEMENTARY SUBSTANCES — LIST OF ELEMENTS — ELEMENTARY SUBSTANCES OF INTEREST TO THE FARMER—THE ATMOSPHERE—LIME—CHEMICAL COMBINATION.

1. The Science of Chemistry teaches that all perceptible matter—the soil, the plant, water, the air we breathe—is made up of combinations of what are called elements.

2. An element is the simplest form of matter. It cannot be subdivided or split into parts composed of different substances. It cannot be destroyed; but it will readily combine with or attach itself to other elements, from which it may again be separated.

3. Something more than sixty-five elementary substances have been discovered or separated from their combinations with other elements, and their qualities and peculiarities studied and determined.

4. Elementary substances are not often found in uncombined forms, owing to the affinity which they have for one another. This attraction causes them to form an endless variety of combinations, producing an almost infinite number of substances.

5. The elements, simple or combined, are found in three forms; solids, liquids and gases—which forms are not permanent, since changes of temperature will cause most substances to appear in all three forms. For example: water, a liquid at ordinary temperatures, becomes ice, a solid, if reduced to a temperature of 32° Fahr., and it becomes steam, an invisible gas or vapor, if heated to 212°. The ice upon being warmed loses its solidity and becomes water again; while steam is again visible if allowed to cool.* In like manner the metals, iron, lead, copper, etc., as well as the soil and rocks, which are solids at ordinary temperature, may be made to pass into the liquid and gaseous forms by applying sufficient heat.

6. Wood or vegetable matter is not melted by the application of moderate heat, but part of the elements of which it is composed is driven off as gases, and the ashes or earthy matter left may be converted into the liquid and gaseous forms by intense heating.

7. The following elements have been separated and named:

Aluminium,	Gold,	Potassium,
Antimony,	Hydrogen,	Rhodium,
Arsenic,	Indium,	Ruthenium,
Barium,	Iodine,	Selenium,
Beryllium,	Iridium,	Silver,
Bismuth,	Iron,	Silicon,
Boron,	Lanthanum,	Sodium,

* When steam escapes from the boiler into the air it can be seen; but it is no longer in the vapor form, having cooled into minute drops of water. If water is boiled in a glass flask or bottle no steam is visible until it escapes and meets the cooler atmosphere.

Bromine,	Lead,	Strontium,
Cadmium,	Lithium,	Sulphur,
Cæsium,	Magnesium,	Tantalum,
Calcium,	Manganese,	Tellurium,
Carbon,	Mercury,	Thallium,
Cerium,	Molybdenum,	Thorium,
Chlorine,	Nickel,	Tin,
Chromium,	Niobium,	Titanium,
Cobalt,	Nitrogen,	Tungsten,
Copper,	Osmium,	Uranium,
Didymium,	Oxygen,	Vanadium,
Erbium,	Palladium,	Yttrium
Fluorine,	Phosphorus,	Zinc,
Gallium,	Platinum,	Zirconium.

8. Less than one-fourth of these elements are known to have any influence on the soil or the plant, from an agricultural standpoint, but the list is given to enable the student or the reader to refer to it, if desired.

9. The student of agriculture is concerned with but fourteen or fifteen of the elementary substances, as from these are formed the animal, the plant, and the soil-constituents that enter into the composition of the animal and plant.

Plants are composed of:

NON-METALS:		METALS:
Oxygen,	Sulphur,	Potassium,
Hydrogen,	Phosphorus,	*Sodium,
Nitrogen,	*Silicon,	Calcium,
Carbon,	*Chlorine.	Magnesium,
		Iron.

*Silicon, chlorine and sodium are not believed to be essential to plant-growth, although found in most plants.

Besides the above, aluminium, manganese, iodine and some others are found in minute quantities in plants, but are not supposed to be necessery to their development.

10. The atmosphere, or air we breathe, is composed principally of two elements in the gaseous form, oxygen and nitrogen: four parts of nitrogen to one part of oxygen. Oxygen and nitrogen are invisible at ordinary temperatures, either when alone or when mixed as in the atmosphere, yet they will change to liquids if subjected to intense cold. They may be found in nature combined with other elements in the liquid and solid form.

11. Pure water is a chemical combination of oxygen and hydrogen, both of which will assume the gaseous form if separated.

12. Limestone, a hard and widely distributed kind of rock, is composed of the elements carbon, oxygen and calcium, with some other matter that may happen to be present as impurities, and is known as carbonate of calcium.

13. The lime of commerce, such as is used for making mortar, if pure is composed of oxygen and calcium. It is made by burning limestone in a kiln, the burning simply driving off the carbon and part of the oxygen. The lime differs from the limestone from which it is made in having strong caustic or corroding properties, and a strong affinity for water.

14. When water is added to fresh lime, heat and steam are produced by the combination of the elements contained in the water with those of the lime, and the

lime is said to be "slaked." If not too much water is added, a dry, fine powder is the result, which consists of lime and water; but in the process of combination the water is changed from a liquid to a solid, adding weight and bulk to the lime.

15. If fresh lime is exposed freely to the air, moisture is slowly absorbed from the atmosphere, producing what is known as "air-slaked" lime. At the same time carbon and oxygen in the form of carbonic acid (a compound always existing in small quantities in the atmosphere) are also absorbed, changing the lime back again to carbonate of calcium or carbon, oxygen and calcium, the same material (limestone) from which the lime was originally derived.

16. In like manner two or more of the elements are combined together to form all substances with which we are familiar. Soils, plants, trees, animals, liquids, etc., are simply several elements combined. Elements that are in the soil in the spring may pass into the plant during the summer, be absorbed into the animal that eats the crop, and the manure from the animal may go back to the soil and carry the same elements back to supply the succeeding crop, the same round being repeated again and again.

17. The changes just referred to are chemical combinations, a process by which the elementary substances contained in one material combine partly or wholly with those of another; and it differs from what is termed a mechanical combination or mixture, although in the latter we may have a compound that is quite unlike the materials from which it is made.

18. One substance may dissolve and disappear in another without changing the bulk or appearance of the latter materially, as when salt or sugar is added to water, but the weight of the liquid will be increased. If the solution of salt or sugar and water is raised to boiling heat, the water may be driven off as vapor and the sugar or salt will remain.

19. In practical agriculture, when we grow a crop, feed it out to stock, and apply the manure made to the soil for the succeeding crop, we are simply putting back what the crop had taken from the soil and air; but owing to the changes in the combinations of the elements contained the substances appear in a different form. The crop itself, if applied as a fertilizer, would after decay have nearly the same effect as the application of the manure made by feeding the crop to stock.

20. The elementary substances are themselves unchangeable; that is, one will not turn into another. An atom of oxygen is always an atom of oxygen, no matter what it may combine with, and the same is true of all the elements, but they may not appear the same in the different combinations.

21. The elementary substances cannot be destroyed. If we take a stick of wood, which is composed of carbon, oxygen, hydrogen and some mineral or ashy matter, and burn it, we simply cause the gaseous elements, carbon, hydrogen and oxygen, to pass off into the air, while the mineral matter remains as ashes. If the ashes are applied to the soil they become soluble, and may in time be taken up by the roots of plants to help make new wood, while the three gases may be taken up

by the leaves, or, if carried down to the soil by rain, by the roots of plants, and again appear in the solid, woody form.

22. Polished iron exposed to moist air is covered with a coat of rust produced by the oxygen of the air combining with the iron. The iron is oxidized, or burned just as wood is burned in fire, but the combustion is very slow and does not produce sensible heat. Chemical changes are constantly taking place in nearly all matter exposed to the air, owing to the tendency of the oxygen in the atmosphere to combine with other elements. What is known as decay of matter, such as grass, leaves, fruits and other perishable substances, is caused by the tendency of the elements of which they are composed to separate and form new combinations. These changes are hastened or retarded by changes of temperature, condition of the atmosphere, and the influence of minute organisms developing in the substance, producing ferments, molds and more rapid decomposition.

CHAPTER II.

Origin and Formation of Soils.

ROCK-FORMATION—CONVERSION OF ROCK INTO SOIL—MECHANICAL AND CHEMICAL DECOMPOSITION—ORGANIC AND INORGANIC MATTER.

23. Geology teaches that the earth was once an immense body of melted matter. As the molten mass cooled, a crust of rock was formed on the surface, and this rock, broken up by the action of moisture, heating, freezing, the wearing effect of running water and moving ice, and decomposition due to the action of the atmosphere, has been changed into soil.

24. Rain falling on the crumbled rock has washed the finely broken particles down the hillsides to the lower places, and the running water has carried much of the material into the streams, to be finally deposited as sediment when the streams ceased to flow. From the action of the atmosphere, flowing water and moving ice, the original rocky surface of the earth has been broken down and moved, until we now have a layer of soil varying from nothing to hundreds of feet in thickness, spread over all the earth that is not bare rock.

25. The breaking down of solid rock and formation of soil is constantly taking place, and may be seen

wherever rock is exposed to the action of the air, water, heat and cold.

26. The stone building or bridge, the monument, the hardest granite, all slowly crumble down unless protected from the action of the weather, and even the soil itself decomposes, breaks up into finer particles, although the finely broken rock may again unite and become a solid mass if protected from the weather and allowed to remain undisturbed.

27. In addition to the material formed from the finely broken rock, most soils contain more or less of the remains of plants and sometimes animals, so that ordinary soil is made up of mineral substances called inorganic matter, and vegetable and animal remains, called organic matter.

28. Plants, either growing or decaying, help to form soil from broken rock, while the worms and minute organisms in the earth aid in the same way to make the soil fine, and fit it for the better growth of plants.

29. Soil is formed from rock and fitted for the growth of plants through mechanical decomposition—simply breaking up into small particles, and chemical decomposition—separation of the elements that enter into the composition of the rock.

30. Organic matter, as generally understood, means material formed or collected in animal or plant-growth that can be driven off by heat.

31. To determine the amount of organic matter contained in a soil, a sample of the soil is thoroughly dried, carefully weighed, then heated to a low red heat. After having been heated, it is again weighed, the loss in

weight from the portion driven off by burning represents the organic matter.

32. The inorganic matter of the soil or of a plant is the part that remains after the organic material is burned off. Pure and clean sand, clay, etc., are samples of inorganic matter, while the remains of the roots, stems and leaves of plants, and skin, hair and tissues of animals, contain the organic matter.

33. All soils that have been recently covered with any kind of plant-growth contain organic matter varying ordinarily in amount from one to ten per cent., while marshy or peaty soils may contain several times as much.

34. Continuous clean cultivation of land will reduce the amount of organic matter in the soil, unless some means are taken to renew the supply, while in woodlands and land allowed to grow up in grass and weeds the organic matter will increase from the decay of the roots and leaves left on and in the soil.

CHAPTER III.

Composition of the Soil.

CLASSIFICATION OF SOILS—HEAVY SOILS—LIGHT SOILS—FERTILE SOILS—PRODUCTIVENESS—CONDITION OF ELEMENTS REQUIRED TO SUPPORT PLANT-GROWTH — RENDERING SOIL-ELEMENTS AVAILABLE.

36. Soils differ widely in composition and condition, varying according to the materials from which they are formed, the fineness of the soil-particles and the conditions under which the soil has existed. We find certain elementary substances in nearly all soils, but the substances vary in proportion and condition, so that analysis of a soil to learn of what it is composed will not of itself determine the fertility or crop-producing capacity.

37. A soil composed largely of pulverized limestone is called a marl, calcareous, or lime soil; of sandstone, a sandy soil; of alumina, a clay soil; of partly decomposed vegetable matter, such as we find in swamps and marshes, a peaty or mucky soil. Many soils are composed of a mixture of the above formations where soil is made of sediment deposited by water flowing from upland levels to lower places.

38. If the soil contains a large proportion of clay, it is sticky when wet, dries out slowly, is hard and com-

pact when dry, and is called a heavy soil. If made up largely of sand it dries out more rapidly, is not sticky when wet, remains loose and porous when dry, and is called a light soil. All of these soils may be productive if they contain a sufficient amount of the elements required in plant-growth, which are in the right condition and do not contain materials that are injurious to plant-growth.

39. The term light soil, as ordinarily used, means simply a loose or coarse-grained soil. A cubic foot of dry sand weighs from 110 to 120 pounds; of loamy soil (sand and clay mixed) 90 to 100 pounds; a nearly pure clay soil 70 to 80 pounds; and peat or muck from 30 to 50 pounds.

40. All fertile soils contain more or less aluminium, calcium, carbon, chlorine, iron, magnesium, manganese, phosphorus, potassium, silica, sodium and sulphur, in their combined forms, and organic matter containing nitrogen, oxygen and hydrogen. The other elements are found more or less widely diffused in soils, sometimes in considerable quantity and variety, while again they may be entirely lacking or found only in minute traces. They are not of special importance in agriculture, unless found in sufficient amount to be injurious to plant-growth.

41. The productiveness of the soil depends more upon the condition than upon the quantity of the elementary substances in it. Soils may contain large amounts of all the elements required for plant-growth, yet if the elements are not in the proper condition the plant or crop may not be able to make use of them.

42. A rock may contain elements that will make plant-food, but unless the rock is broken up and made soluble the plant cannot absorb them. Two or more elements may be combined in such a form that they are not available to plants, and a new chemical combination must take place to fit them for plant-food.

43. The application of barn-yard manure, commercial fertilizers, lime, ashes, plowing and cultivating, turning under green crops, in fact the addition of any substance to the soil that will form new combinations of the elements in it, or any treatment that will give access to the air to promote decomposition of soil matter, tends to prepare inert matter in the soil for plant-food. Filling the soil with the roots of plants and then allowing them to decay will have the same effect. Shading the soil by growing such crops as cow-peas, clover, grass and weeds, or covering it with straw and litter of any kind, will tend to increase the amount of available plant-food and make the land more productive. The farmer should study all these methods of improving the condition of the soil to enable him to increase the fertility in the most economical way.

CHAPTER IV.

Composition of the Plant.

REQUIREMENTS OF THE PLANT—ELEMENTS FOUND IN PLANTS—ENRICHING THE SOIL—EXHAUSTING THE SOIL—WHAT SHOULD BE SOLD FROM THE FARM—NATURAL RESTORATION OF THE SOIL.

44. Plants are composed of combinations of certain elements that are drawn from the soil and atmosphere. These elements must exist in available form in the soil and air, or the plant will not grow. All of the ordinary farm crops contain the same elements, in different proportions; but one plant may have the power to take from the soil material that is not accessible to other plants, to make growth. For this reason some soils are best adapted to one crop and some to another.

45. It has been found in planting seed in prepared soil that ten elements are required to enable plants to grow. Four of these elements may be supplied from the atmosphere, but the other six must be present in the soil.

46. The elements believed to be necessary for plant-growth are: oxygen, hydrogen, carbon, nitrogen, calcium, potassium, phosphorus, magnesium, sulphur and iron.

Sodium, manganese, silicon and chlorine are generally found in plants, besides traces of several other elements, but these are not thought to be necessary to their growth.

47. Oxygen, hydrogen, carbon and part of the nitrogen are supplied by the air and rain; the remaining elements, by the soil.

48. Animals live on plants or on other animals; hence the body of the animal is composed of the same elements that are found in plants, and the remains of animals and plants applied to the soil as a fertilizer will furnish plant-food to growing crops.

49. Well-cultivated soils generally contain a sufficient supply of the elements named, in an available form, except potassium, phosphorus and nitrogen. Four-fifths of the atmosphere is composed of nitrogen; yet the plant cannot use this nitrogen unless it is combined with hydrogen in the form of ammonia, or with other substances in the soil, and made soluble so that the roots of plants can absorb it.

50. Crops that draw large amounts of the nitrogen compounds, potash and phosphates from the soil, exhaust the soil rapidly; while crops that contain only small amounts of these three materials, and do not remove much besides carbon, oxygen and hydrogen—elements supplied by the air—do not exhaust the soil rapidly.

51. The marketable parts of some crops contain only small amounts of the elements that exhaust soil by being removed; hence, if the remainder of the plant is returned to the soil, fertility is retained. Two marked examples of such crops are cotton and flax. The lint

and fiber is composed almost entirely of carbon, oxygen and hydrogen, elements supplied by the air and rain; therefore, if the seeds, leaves and stems are returned to the land, fertile soils may be cropped for years without much deterioration.

52. Cotton-seed and flax-seed, and the meal or cake made from the seed, are rich in fertilizing materials and valuable stock-feed. They should therefore be used for feeding when they can be procured at low cost, and the manure returned to the land. The oil contained in these seeds is composed of carbon, oxygen and hydrogen, and is of no particular value for manure; hence there would be no loss of fertility if the seed were sold and as much meal and hulls as the seed contained purchased and returned to the land.

53. Wheat-flour is made up largely of carbon, hydrogen and oxygen; therefore if the wheat-bran and wheat-straw are fed to stock, and the manure produced returned to the soil, but little loss of fertility will occur.

54. The leaves of the tobacco-plant contain large amounts of the fertilizing elements; and, as the leaves constitute the part that is sold, tobacco wears out land rapidly.

55. A study of the composition of plants will enable the farmer to grow and sell such crops, or such parts of the crop, as will not remove any considerable fertility, and it will suggest the importance of returning to the land such part of his crops as contain considerable fertilizing material, either direct or in the form of manure, after having been fed to farm stock.

56. It will be noticed from what has been said in this

chapter, and in the chapter on Soils, that plants are composed of elements drawn from the soil, with the addition of such elements as are supplied by the air and rain. If, therefore, a plant grows and remains on the land to decay, the soil will receive back what the plant has taken up and also what the atmosphere has supplied. In addition to what the plant gives back to the soil, the decay of the stems, roots and leaves renders soluble inert material in the soil. In this way nature restores the worn out lands that have become impoverished by continual cultivation without the application of fertilizers. The growth and decay of grass and weeds on land that has been "turned out," slowly enriches it, and, if the soil is not washed away will in time make it again productive when cropped.

CHAPTER V.

Plant-food in the Soil.

SUPPORT OF THE PLANT—FERTILE SOIL—WHY NEW LAND IS PRODUCTIVE—RETAINING FERTILITY—VALUE OF NATURAL FERTILITY.

57. Plants, like animals, must be supplied with food to live and grow. The food of the plant is taken up by the roots from the soil, and absorbed through the leaves and green parts from the atmosphere. In practical agriculture we are chiefly concerned with what is taken up by the roots, that is, with the plant-food in the soil.

58. If a soil contains an abundance of all of the elements that enter into the composition of the plant, and if these elements are combined in the proportion to pass into the condition that will permit of absorption by the roots of plants, the soil is said to be fertile, provided the temperature of the soil and air is suitable, a proper amount of moisture present, and there are no substances in the soil that may act as a poison to the plant.

59. A totally barren soil (one containing no plant-food) can be made to grow plants by supplying the above requisites.

In practical work the cost of the material added to produce the crop might exceed in value the product secured; therefore land may be too poor to be worked profitably.

60. New land, when first broken with the plow, contains usually an abundant supply of plant-food and will produce large crops. In forest and wild prairie growth the leaves, stems, etc., of the trees, grasses and other plants, fall on the ground, decay, and constantly add plant-food. In growing a crop and removing the product, plant-food is carried away and thus the soil is exhausted.

61. If the crop is fed out to some kind of stock, and all the manure made is carefully saved and returned to the land, the soil receives all that has been taken away except the small amount stored up in the body of the animal.

62. Land may be cultivated for any length of time without loss in producing capacity, if plant-food in the the form of barn-yard manure or other fertilizers is supplied from some outside source. The manure simply contains the elements that the crops require, or it has the power to make available to the plant what the soil contains. Under an intelligent system of farming the soil should not become less productive.

63. From what has been said it will be understood that some plan for restoring fertility to land from which crops are removed becomes necessary. It may be done by feeding the crop to stock and returning the manure, by procuring manure or commercial fertilizers from outside sources, by growing crops to plow under or leave to decay on the surface, or by the purchase of feed-stuffs to increase the manure made by stock on the farm.

These several methods of preventing land from becoming less productive should receive the careful attention of every farmer.

64. The solid rocks are made up partly of elements that enter into the composition of plants, but in the form of rock the plant cannot make use of them. The elements in the rocks and in the soil are often combined together in such a way as to be out of the reach of plants. The rocks are pulverized by being exposed to the sun, rain, heat, cold, etc., and particularly to the action of the oxygen of the air, and the elements of which these rocks are composed form new combinations. Ploughing land, and repeated cultivation of the crop while growing, though they add no new material to the soil, furnish plant-food by making available that which is already in the soil. Applications of lime, plaster (sulphate of lime), salt, ashes, etc., will often aid plant-growth and increase the crop, not so much from the plant-food they contain as from the decomposition of inert matter in the soil caused by the application just mentioned.

65. Certain soils that have been cropped for many years without the application of any fertilizer still produce large crops. This is true where a considerable amount of plant-food is stored in the soil, which slowly becomes available through chemical changes in its condition. Examples of such soils are found in valleys and bottom-lands where a thick layer of rich soil has been deposited by overflow.

66. Soils that contain considerable amounts of clay or lime are usually lasting soils, while sandy soils, as a

rule, soon wear out unless fertilized, notwithstanding the fact that they are generally more productive when fresh than are the heavy soils.

67. Low, wet lands, as a rule, contain more plant-food than uplands, and will be found most profitable to work, provided they can be effectually drained at an expense not too great.

68. In purchasing land for a farm, the choice should be governed largely by the amount of plant-food the soil contains, or the facilities for supplying fertilizing material if the soil is not naturally productive as this will determine to a considerable extent the cost of keeping the land in a profitably productive condition.

CHAPTER VI.

Mechanical Condition of the Soil.

EFFECTS OF COMPACT SOIL ON THE PLANT-FOOD CONTAINED IN IT—HOW TO IMPROVE HEAVY SOILS—DRAINAGE—SHALLOW AND DEEP CULTIVATION—FALL PLOWING—TREATMENT OF SANDY SOILS—MUCK AND PRAIRIE SOILS.

69. It is stated in the preceding chapter that soils may contain large amounts of all the elements required by plants to make growth, and yet may fail to produce profitable crops. This result is often due to the fact that the soil is not in a proper mechanical condition.

70. A close-grained, compact soil will not freely admit air, water and heat—requisites for supplying the roots of plants with plant-food, nor can the roots penetrate the soil readily. The feeding power of the plant is governed largely by the extent of its root-growth; hence, if the roots cannot spread all through the soil, full development will not take place.

71. If the air cannot enter the soil, chemical decomposition of substances that contain inert plant-food will be prevented, and from this source the crop may be largely supplied. Fertilizers applied to such soils give light returns unless they change the texture of the soil; hence the improvement of the mechanical condition of many soils is of prime importance.

72. The compact condition of the soils referred to is due to several causes, but more often to excess of water in the soil (lack of drainage) during portions of the year than to any other.

73. Soils composed largely of clay and containing but a small proportion of sand or of vegetable or organic matter become compact from working when too wet, or allowing stock to run on the land when the soil is saturated with water. Such soils tend to become more close and compact and more difficult to work, if kept in clean cultivated crops for several years in succession, thereby decreasing the organic matter contained.

74. If the cultivated crops alternate with grass, clover, peas, or any growth that will fill the soil with roots, or which leaves a considerable quantity of vegetable matter on the soil, this material when plowed up or under, will slowly decay, and will keep the particles of the soil separate and loose; green crops plowed under, the application of coarse manure or litter of any kind, such as leaves, straw, weeds, etc., will have the same effect.

75. Clay land plowed, worked, or tramped by stock, when wet, is puddled, the particles of soil being pressed firmly together and remaining so when dry, as in brick-making. It is also injured if plowed when too dry, the earth being thrown up in large clods which remain dry and hard during the season, preventing germination of seed planted and interfering with cultivation of the crop. If the soil contains considerable lime the injury is not so serious, since in drying the lime will cause the soil to crumble and will thus break up the clods.

76. Heavy, compact clay soils are benefited by the application of sand to lighten them up; but such an application is usually too costly to be practicable except on high-priced lands, such as may be used for gardening or fruit-growing, or for making lawns near buildings, when the cost is immaterial. An application of lime to a heavy soil is often found profitable for the same purpose.

77. Shallow plowing, and cultivating only two or three inches deep, will stir the surface only, and will compact the subsoil, often forming a hard-pan a few inches below the surface, almost impervious to air, water and the roots of plants. The serious effect of such cultivation is shown in the "burning" of the crop in dry weather.

. The thin layer of loosened soil holds but a scanty supply of moisture which is soon evaporated in dry weather, and the root-growth, being confined near the surface, soon feels the effect of the heat and lack of moisture and is unable to support the plant, resulting in its rapid maturity before it has perfected its growth.

78. When the heavy condition is due to excess of water, this being the most common cause, the only remedy is drainage, which subject will be discussed in a chapter by itself.

79. From what has been said it will be understood that the way to improve heavy, compact soils, is, first to drain them; second, to give deep and thorough cultivation when neither too dry nor too wet and to keep stock from running on the land when wet; third, to alternate clean cultivated crops, like corn, cotton and potatoes and

grain crops, with grass, clover and other hay crops, or to plow under an occasional crop growing on the land, such as grass, clover, peas, grain, or even weeds.

80. Fall and early winter plowing, after land is well drained, will be found beneficial on most heavy soils, simply breaking the land with double plows and leaving it without harrowing, so that the loose turned up soil may be broken up and pulverized by freezing, thawing and the action of the weather during the winter months. In some sections of the country where heavy beating rain-storms prevail during the winter, soils are found that are not benefited by fall plowing, owing to the tendency of the soil to run together into a solid mass when so treated. Such soils are exceptional.

The author has added 25 per cent. to the succeeding crop by plowing heavy bottom-land in the fall.

81. Sandy lands require different treatment from heavy clay soils. They generally need compacting instead of loosening. Shallow plowing and cultivation, and even working when quite wet, are often beneficial. The addition of vegetable matter in the way referred to in the treatment of heavy soils will also be of great advantage in filling the open spaces in the soil with a fine material that will help to retain moisture and prevent fertilizing matter from leaching out.

82. Muck soils, marsh, and fresh prairie-land are too open and porous, and they contain too much organic matter to grow large crops. They require different treatment from either light sandy or heavy clay soils to be made productive. If wet they must first be drained, and after that the more thoroughly the surface soil can

be exposed to the action of the oxygen of the air, to decompose and get rid of the excess of organic matter, the sooner will they produce good crops. Plowing should be shallow at first, and as long before planting as possible.

CHAPTER VII.

Effect of Water on the Soil and Crop.

ABSORPTION OF WATER BY THE PLANT—WATER IN THE SOIL—INFLUENCE OF WET SOIL ON CROPS—ROOT-GROWTH IN WET SOILS—AMOUNT OF WATER NEEDED BY PLANTS—EFFECT OF DRAINAGE IN DRY SEASONS—DRAINAGE.

83. Plants require considerable quantities of water during the growing season, when the leaves are exposed to the free air.

84. The water is absorbed from the soil by the roots and thrown off from the leaves. If the supply of water becomes exhausted or is not sufficient for the requirements of the plant, it wilts, growth is checked, and the plant may finally die. If the leaves on the plant are removed, evaporation of water is stopped, and in this leafless condition the plant may be kept alive, but in a dormant state, for a considerable time. In a moist atmosphere, evaporation from the leaves is checked and less water is taken up from the soil by the roots.

85. Soils that dry out rapidly by evaporation from the surface, or from drainage through a coarse and loose subsoil, cannot be relied upon to grow satisfactory crops in dry seasons. An example of the former may often be seen when a heavy compact soil is plowed and

cultivated shallow, thus forming an impervious hard-pan a few inches beneath the surface. If the land is not drained and a wet spring precedes the dry summer the injurious effect on the growth of the crop is increased.

The latter class of soils includes light sands and soils where a thin layer of fertile soil rests on quicksand or gravel. In these the water rapidly sinks below the reach of the plants and the crop suffers at the period of growth, when water is most needed.

86. An excess of water in the soil is injurious to many plants. With the exception of the coarser grasses and sedges and a few other plants, farm crops will not grow and thrive on land that is saturated with water.

87. If the soil is wet during the spring and early summer, and dry the remainder of the season, it will not produce abundant crops. As a rule, crops planted on such soils suffer most during droughts. This result is due to several causes:

1st. Heavy soil that is wet in the spring cannot be properly prepared for planting.

2d. Heat will not penetrate a wet soil, and where water stands near the surface the rapid evaporation will keep the soil cold, regardless of the temperature of the air, thereby tending to make the seed rot or produce a weak and sickly growth.

3d. The roots of plants growing on wet land will spread out near the surface instead of descending into the soil. The roots do not reach fertilizing material stored in the soil, the plant-food in the soil will not become available so long as it is sealed up by a covering of water; and again, when the soil dries out during midsummer the roots lying near the surface in the hot dry soil cannot take up water, they dry up and the crop is "fired" or burned up before it matures (fig. 1).

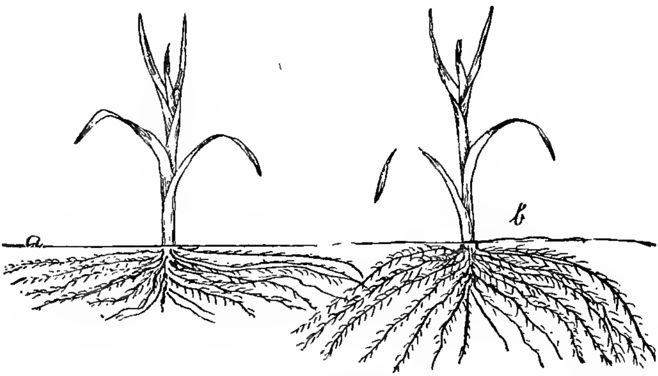

FIG. 1.—Showing difference in root development. *a*, wet, cold soil; *b*, same soil after being drained.

4th. Large quantities of water evaporating from the surface of the soil makes the soil compact and solid, impervious to the air, and heavy to work.

88. To insure rapid growth and development of most farm-crops the soil should be moist but not wet. If the excess of water in the soil is drawn off through underground drains, sufficient water may still rise from the moist subsoil by capillary attraction to supply growing plants.

89. A well-drained soil becomes porous and sponge-like in its character, and will absorb and hold water supplied by rain, that would run off on the surface of any undrained and saturated soil. Thorough underground drainage on heavy soils tends to store up water

and retain it in the soil until needed, and to prevent the rapid filling of creeks and also destructive overflows after heavy rain-storms.

90. Crops on drained land are not liable to suffer from lack of rain in dry seasons, because the land can be more deeply and thoroughly fitted for the crop before planting; cultivation is more effective and less costly, and the roots of plants will be largely increased and will penetrate deeper. As a consequence they will not be affected by dry, hot weather, and there will be less evaporation of water from the surface than on undrained land.

91. A strong, vigorous, well-rooted plant will thrive through a dry, hot or cold spell, where a shallow-rooted, weak plant would die; hence, drainage and good cultivation will carry crops safely through any ordinary dry season.

92. Drainage alone will correct the evils referred to in the preceding paragraphs, and drainage of some kind is the keystone of successful farming on all heavy, close, level, or bottom-lands.

93. On rolling uplands that wash readily, control of the surface water is an absolute necessity to prevent destruction of the land for farming. The fertile surface soil of the hill lands is carried off on the lower places or washed into the streams and carried away, leaving the land poor, and the rich bottom-lands are buried under a deposit of sand and clay. The ditches and creek-channels are filled, thereby preventing drainage, and both hills and bottoms are made unprofitable to cultivate.

94. The effect of uncontrolled surface water washing

over the land has reduced the fertility of the soil over considerable portions of the Gulf States to a much greater extent than has been caused by continual cropping and making no return to the soil in the way of manures.

CHAPTER VIII.

Farm Drainage.

Kinds of Drainage—Depth of Drains and Distance Apart—Tile-Drains versus Open Ditches—Protection of Soil from Washing—Principles that Govern Action of Flowing Water—Formation of Sand-bars—Shape of Ditch—Hillside Ditches—Terraces—Horizontal Cultivation—Construction of Hillside Ditches—Drainage Ditches—How to Make a Level—Leveling for Ditches—Making the Ditch.

95. Drainage may be considered under two heads: Surface-drainage, and Subsoil-drainage.

86. Surface drains are shallow open ditches and they act only to remove water from the surface. They do not drain the land farther than to carry away water that otherwise would have to sink down through the soil or evaporate from the surface, consequently land may have good surface-drainage and still be too wet for profitable cultivation. Subsoil-drainage is where the water sinks down into the ground through a porous subsoil, or is carried off from the subsoil through tile or other underground drains, or seeps into deep ditches.

97. The effect of deep open ditches or tile-drains is practically the same, except that the open ditches occupy a good deal of land, and are in the way of cultiva-

tion, carry off soil and manure by washing, and require constant attention and labor to be kept in order, while tile-drains are permanent and require no room or further attention after being constructed.

98. Ditches and tile-drains two and one-half feet to four feet deep are preferable to shallow drains for the reason that a deeper layer of soil is freed from an oversupply of moisture, and more room given for root-growth.

The depth of ditches and drains, and the distance between them required to secure good drainage, will vary with the character of the soil.

Tile or pipe-drains are usually laid at an average depth of three feet, and from thirty to sixty or more feet apart, where thorough drainage is desired.

99. The discussion of the methods of construction of tile-drains would require more space than can be given to it in this place, and as several books have been written on the subject, we will not go into details.

100. Tile-drains are so generally used at the present time where a system of thorough drainage is attempted, that deep open ditches are seldom constructed except to drain low spots in fields, furnish outlets for tile-drains and for surface ditches.

101. Shallow ditches are often opened on sloping surfaces where the soil tends to wash away, for the purpose of protecting the land. They are known as hillside ditches (fig. 4). A modification of hillside ditching, the object of which is to check the water from flowing off rapidly, is called terracing (fig. 3).

102. When properly located and constructed, hill

side ditches and terraces will prevent the soil from washing, but they do not remove the excess of water in the soil. On cultivated hillsides they are often necessary to protect the land, sometimes even when the land is tile-drained, as during heavy and protracted rains the surface of some soils becomes compact, and the water is forced to run off over the surface, carrying with it more or less soil, instead of sinking through the soil to the drains.

103. In the location and construction of ditches, either for drainage or to protect the land, some of the principles that underlie the action of flowing water should be considered. Without giving explanations or reasons, a few facts will be stated in regard to running water.

1st. The greater the descent of the channel the more rapid the flow.

2d. With any given fall the nearer the channel of the stream approaches a straight line and the nearer equal the depth and width of the body of water the more rapid the flow.

3d. The more rapid the flow and the deeper the stream the greater will be the capacity of the water for carrying along with it particles of soil or other matter.

4th. The finer the particles of the soil forming the bed of the stream, and the more readily they separate when wet, the greater will be the tendency of the running water to scour out a deeper channel, provided the water is not already loaded to its full carrying capacity.

5th. When the flowing water of any stream is carrying with it all the soil that will remain in suspension, it will still carry more if the stream is made to flow faster, but it will deposit part of its load as sediment on the bottom or sides of the channel if the flow is retarded.

104. While the above is not an exact statement from a mathematical standpoint, the rules laid down apply to all streams of water, large and small, from the great Mississippi river down to the ditch made with a single furrow; and applying these principles to our work in ditching, we may to a great extent overcome the tendency of open ditches to wash out in some places and fill up in others.

105. If a ditch is laid off so that the upper part will have a fall of say five feet in one hundred, and the lower part only two or three feet, if the soil is of a kind that washes readily, the upper part of the channel will scour out and the lower part will fill where the current is retarded, in accordance with the rules given, which would not be the case if the fall were uniform from the source to the outlet and the water made to run with the same speed.

106. Any obstructions or checking of the flow of a muddy stream will cause it to deposit part of its load of soil. In this way sand-bars are formed in rivers where floating trees lodge, or where a stream with a narrow channel spreads out over a broad surface, thus producing a slower current.

107. From what has been said it will be understood that before opening a ditch in soil that washes easily the line should be so located that the fall will not materially decrease towards the outlet; unless by narrowing

the channel or bringing in more water the depth, and by that means the carrying capacity, of the water is increased.

108. In all moderate-sized ditches the channel should be cut of triangular form in cross-section, with narrow bottom and sloping sides. This form protects the banks from caving, and holds the body of water in such manner that its depth and width will be somewhat equalized at all times, no matter how full the channel. The greater the slope of the bank the less the tendency to cave in or wash out. A very good rule is to make the ditch twice as wide at the surface as the depth, and the bottom as narrow as it can be made (fig. 2). A ditch of three feet depth should be six and one-half feet wide at the surface and six inches on the bottom if it can be so dug.

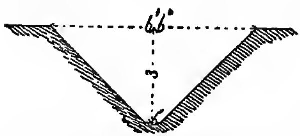

FIG. 2.—Cross-section of properly shaped ditch, three feet deep, six and one-half wide at the surface of the ground, six inches at the bottom.

109. Terracing land means throwing up ridges or embankments of earth across hillsides on a level, or nearly level, and then plowing down the hill until the hillside assumes the form of steps or terraces from bottom to top (fig. 3). The object sought is to make each terrace or step hold the water that falls upon it, and cause it to

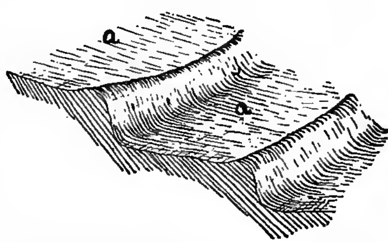

FIG. 3 —Hillside, showing two terraces, *a*, *a*. The terraces are usually laid off so there will be three feet rise from one terrace to the next above. The terrace varies in width with the slope of the hill.

sink into the earth or to flow off slowly to prevent washing.

110. Horizontal cultivation, running the rows of cultivated crops on a level around the hill, has to some extent the same effect as terracing, and should always be practiced where the soil tends to wash.

111. Hillside ditching is somewhat like terracing. Low embankments or shallow ditches are constructed along the hillside, giving, however, sufficient fall to the ditch to allow the water to run off freely (fig. 4). Either plan will protect the soil from washing if the terraces or hillside ditches are properly constructed and kept in order. Terraces are preferable to hillside ditches, requiring but little attention after being made, while the ditches require constant repairing and cleaning to prevent filling or washing out too rapidly. Horizontal cultivation must in all cases accompany terracing or hillside ditching to make the work successful.

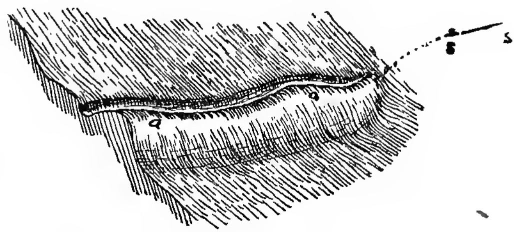

FIG. 4.—Hillside ditch. *a*, *a*, shows finished ditch; *s*, *s*, stakes located with level in laying off ditch.

112. In laying off all ditches the capacity of water for carrying soil should be carefully considered. The more rapid the flow, the deeper the stream, the finer the particles of the soil and the more readily they separate

when wet, the greater will be the capacity of the moving water to wash away soil. From the preceding statement it will be seen that no definite rule can be laid down as to the fall that ditches should have to enable the water to scour them out clean, and yet not cut out deep channels or gullies.

113. In practice it is found that hillside ditches should have a fall of from one to three inches to the rod, varying with the kind of soil, the length of ditch, and amount of water to be carried. Whatever the fall given, it should not materially decrease towards the outlet of the ditch. If the flow of water is retarded at any point by less fall in the grade of the ditch, soil that is washed down from above by the swifter current will be deposited, the ditch will fill up with sediment, overflow, and the water, running directly down the hill, will cut out deeper gullies than would be formed without ditches. Owing to this result from the faulty construction of hillside ditches, many farmers are led to believe that land will wash worse with hillside ditches than without them.

114. The same caution that is required in the location and construction of hillside ditches should be observed in laying off all ditches through nearly level or bottom-lands, otherwise the ditches will fill whenever the current of water is retarded. The course of the ditch should be laid off with some kind of a level in all cases when a new channel is to be located. An engineers' telescope-level is the best instrument for this work, but for farm-ditching an ordinary carpenters' spirit-level may be rigged up. Adjust the level so that the glass tube containing the bubble will be level with the upper surface of the wooden bar

in which the tube is set. Bore a small hole through the bar in the center and attach with small bolt to the side of a light staff about five feet long. Sharpen the other end of the staff, or better, fit on an iron ferule drawn to a point, and the level is ready for use (fig. 5). Make also a measuring-rod of a light wooden strip eight feet long, laid off in feet and inches with the feet numbered, and the outfit is complete.

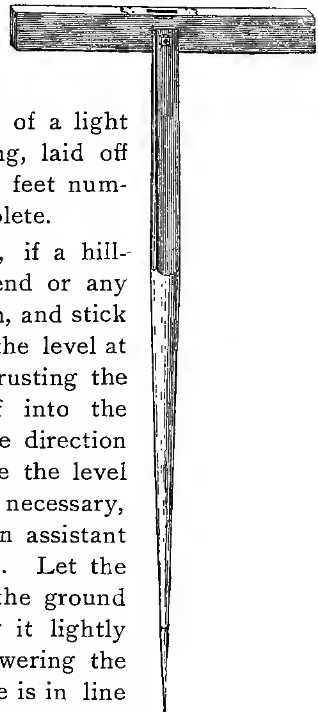

FIG. 5.—Carpenters' level rigged on staff, level attached with small iron bolt.

115. To lay of the ditch, if a hill-side ditch, start at either end or any point on the line of the ditch, and stick up a wooden peg. Set up the level at any convenient point by thrusting the sharpened end of the staff into the ground, point the level in the direction of the wooden peg, and make the level plumb. Two persons are necessary, one to work the level and an assistant to handle the measuring-rod. Let the assistant stand the rod on the ground at the wooden peg, holding it lightly with one hand, raising or lowering the hand until the upper surface is in line with the eye of the person sighting over the level. Notice the height of the hand above the ground, as shown on the rod, then decide upon the fall to be given, to find the next point on the line of the ditch. Suppose the fall is to be two inches in fifteen feet, and that the line

is to be run down the ditch. The man with the rod will raise his two hands two inches on the rod, and carrying it with him step off five paces in the direction the ditch will run; then holding the rod vertical, end on the ground as before, the man with the level will adjust the level pointed at the rod, and will sight, noticing if the hand of the rodman is too high or too low; if too high, the rodman will move down the hill until he finds a place that will bring his hand level with the line of sight, or, if too low, move up the hill. When the point having the desired level is found, stick up another peg which will give the second point on the line of the ditch. Continue on as before, until the entire line is run over, moving up the level occasionally, as the distance becomes too great to take sights readily. In working up the line of the ditch, the rodman would lower his hand at each change instead of raising it; or in running off a level terrace he would not change his hand at all. The distance between the stakes and fall to the rod can be varied to suit the circumstances.

116. The levels completed, the pegs will form a line on the ground with a uniform fall of two inches in every fifteen feet or five paces (fig. 4).

117. To construct the ditch throw up a bed or back furrow with a large two-horse turning-plow on the line of the stakes, leaving an undisturbed foundation two or three feet wide underneath. If a small plow is used it will be necessary to use hoes and shovels to complete the work. The ditch-bank must be high, and strong enough not to give way in a heavy rain. All weak places should be strengthened by building up with spade or shovel.

118. After laying off hillside ditches, the rows of crops should be laid off parallel, or nearly parallel, with the ditches. Some farmers prefer to give the rows or water-furrows a little more fall than is given to the ditches in order to carry the water into these ditches.

119. In laying off drainage-ditches in land that tends to wash readily, the level should be used, and the ditch so located that the fall will be somewhat uniform, otherwise sediment will be deposited wherever the flow of water is retarded and the ditch will fill up. Properly located and excavated, the ditch may be made self-cleaning if the water flows through it with nearly the same velocity from the source to the outlet.

CHAPTER IX.

Preparing the Land for the Crop.

PREPARATION OF THE SOIL—PLOWING—LARGE IMPLEMENTS—DEEP PLOWING—THOROUGH PREPARATION—PLANTING ON RIDGES—VALUE OF DRAINAGE.

120. The cost of cultivating a crop will be governed largely by the method of preparing the land before planting. While different soils require different treatment, the most successful farmers, as a rule, believe in and practice good plowing and thorough preparation.

121. It is not necessary that the soil should always be turned over with the turning-plow, unless sod, weeds, manure, or other material on the surface, is to be disposed of; but unless the soil is loose and fine, it should be thoroughly broken up and pulverized with the plow, harrow, or other implement.

122. No better implement has been found for preparing the soil on the avarage farm than the better style of two and three-horse turning-plows. The steam-plow or cultivator may do better work, but is not as yet found to be adapted to small farms.

123. Large implements and strong teams are cheaper to use than small implements and light teams. One man can work two, three, or more horses on a large

plow as well as he can work but one on a small plow, not only accomplishing two or three times as much work, but the work will be done better.

124. On some soils and with certain crops large yields may be secured with slight preparation and little after-cultivation, as in corn following cotton on clean land ; but the best average results are secured from good, deep plowing two to four or more times in every five years.

125. On nearly all old soils maximum crops can be most cheaply secured by turning under some kind of sod or vegetable growth at intervals of from two to five years, in order to add organic matter to the soil and improve its mechanical condition.

126. The wider and deeper the furrow, the better such work can be accomplished ; hence the necessity for large plows and strong teams.

127. The ground can be broken up more effectually in less time and with less cost before the crop is planted than to attempt to break out the middles between the rows after planting, as is often practiced in the southern states. The best and largest cultivators can be used in working the crop only where the land has been well plowed and harrowed before planting.

128. The proper depth to plow will be governed by the kind and condition of the soil, crop to be grown, season of the year, time that will elapse before planting, and depths of previous plowings. As a general rule, plow sandy, loose and wet soils shallow ; heavy and dry soil deep—shallow if just before planting, deep if some months before planting, as in fall and winter plowing for spring planting.

129. The succeeding crop may be injured by deep plowing, if the land has always been plowed shallow; but unless the subsoil is very poor, land containing much clay will be benefited by setting the plows to run half an inch or an inch deeper each year until the ground is broken eight to ten inches deep.

130. On well-drained heavy soils fall or winter plowing will usually be found beneficial; but there may be some loss of fertilizing material from leaching in wet winter climates, where the land does not freeze. The harrow should be used after plowing and before planting, and on loose or lumpy soils the roller also, to make a fine and yet not too loose seed-bed. The smaller the seeds to be planted, the more thorough should be the pulverization of the surface soil to secure an even stand of plants.

131. Planting on beds or ridges or planting on the level is more a question of drainage and temperature

FIG. 6.—Planted level the ground dries out slowly and remains cold.

FIG. 7.—Shows planting on bedded land. Each furrow acts as a drain to dry out the ridge, while the sun and air dry and warm the seed-bed, making germination more rapid and certain on cold, wet land.

than of soil or crop (figs. 6 and 7). Well-drained soil will dry out and become warm early in the season, while wet land will not. The seeds of corn, cotton and many other plants will rot in cold, wet soils, when they would grow if the land was well drained; hence loose and dry land may be planted on the level, while cold, wet soils must be thrown up into ridges to provide a seed-bed sufficiently dry and warm to insure germination.

132. Level cultivation is preferable if the soil will permit, because the cultivator will do more rapid and effectual work on level land, a matter of considerable importance in the early cultivation of all crops. Tile-drains dry out and warm up the soil early in the spring, and such drainage will enable the farmer to plow his land broadcast and plant crops on the level land.

CHAPTER X.

How Plants Grow.

THE RIPENING OF THE SEED—THE ANNUAL—THE PERENNIAL—REPRODUCTION OF THE PLANTS — SPROUTING OF THE SEED — ASSIMILATION OF FOOD — FUNCTIONS OF THE ROOTS AND LEAVES — MATERIAL DRAWN FROM THE SOIL, FROM THE ATMOSPHERE—SOURCE OF NITROGEN—COMPOSITION OF FERTILIZERS.

133. The ripened seed represents the purpose of the plant's existence and the completion of its growth. The annual plants, such as corn, oats and cotton, die after the seeds are formed, and the material collected during their growth decays, and is returned to the soil to provide plant-food for succeeding plants. Perennial plants, which are such as live more than one year, become dormant for a time after the seed ripens and the leaves drop off; but with the advent of spring new leaves are formed, new blooms put forth, and after a time another crop of seed is ripened, this being repeated year after year, until finally the plant or tree dies from old age or from disease, when the material of which it is composed decays, as in annual plants, and is returned to the soil.

134. To produce new plants, the seed may be planted, or in many plants a piece of limb or root (fig. 8), called a

cutting, may be cut off from the living plant and placed in moist soil, from which roots and leaves will be thrown out and a new plant produced, of like character to those grown from planting the seed.

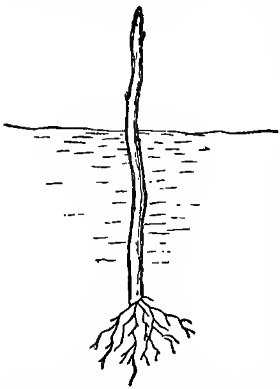

Fig. 8.—Cutting, showing roots starting out from lower end. Leaves will be thrown out from the buds above the ground.

135. Careful examination of a kernel of corn will show that it contains a small chit, or germ, that is in reality an undeveloped plant, and in addition a considerable amount of starchy matter closely compressed into the shell of the kernel (fig. 9). If the kernel is placed in a warm and moist place, as in the soil, it will soon become swollen, the germ will burst its covering, and a sprout will begin to develop. The sprout will appear in two parts, one of which will turn up towards the light, the other descend into the soil (fig. 10). The first is called the plumule, and from it will develop the stem and leaves; while the second, called the radicle, devel ops into the roots of the plant (fig. 11).

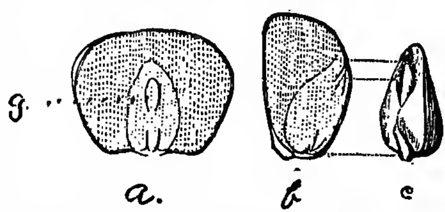

Fig. 9.—(*a*) Kernel of Indian corn, seen flatwise,, divided through the embryo. The embryo or germ, *g*, is nearly surrounded by the starchy part of the kernel.

(*b*) Another kernel cut through the middle in the opposite direction, showing the germ also.

(*c*) The embryo removed, the thick mass is the cotyledon; the narrow body partly enclosed by it is the plumule; the little projection at its base is the radicle.

136. During the sprouting period the plant lives upon the matter stored in the seed; but with the appearance of green leaves and roots, it begins to feed upon material taken from the atmosphere and from the soil. The roots and the leaves or other green parts of the plant act as mouths to take in substances that will build up its structure.

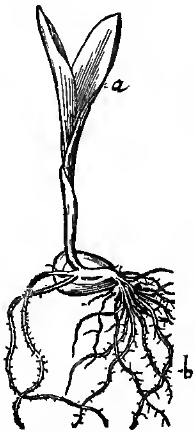

FIG. 10.—Kernel of corn in germination. *a*, plumule; *b*, radicle.

FIG. 11.—Indian corn more advanced in geimination showing *a*, leaves; *b*, cluster of roots.

137. From the roots proper, small rootlets branch out in every direction; and through the delicate outer covering of the root-hairs moisture is absorbed from the soil, and with it plant-food of various kinds which is present in the soil in a soluble condition. By a peculiar process the absorbed liquid is carried up through the parts of the plant, and the water not required is evaporated, and with some gaseous matter is thrown off by the leaves; the rest of the matter is left in the plant and becomes a part of its structure.

138. The leaves have two offices to perform; they throw off the excess of water taken up by the roots, exhale oxygen when exposed to light, and a small amouut of carbon dioxide (carbon and oxygen) during the absence of light. They take up from the atmosphere large quantities of carbon dioxide in sunlight, retaining the carbon and exhaling part of the oxygen. They may

take up ammonia (a combination of nitrogen and hydrogen) when it is present in the atmosphere.

139. The plant receives from the atmosphere more than nine-tenths of its weight, and of its bulk, which consists of carbon, oxygen, hydrogen and possibly a small amount of nitrogen in the form of ammonia.

140. The ash or mineral elements with the greater part of the nitrogen are taken up through the roots.

141. Four-fifths of the atmosphere is composed of free nitrogen; but nitrogen in its uncombined form cannot be assimilated by either the leaves or roots of plants. When, however, the nitrogen is combined with hydrogen, as in ammonia, it may be absorbed by the leaves, or by the roots, if it is in solution. In solution it can also be absorbed by the plant's roots when it is combined with a base, as in nitrate of soda, a combination of nitrogen and sodium.

142. Decomposition of animal or vegetable substances containing nitrogen forms ammonia, which passes off into the atmosphere; but since ammonia has a strong affinity for water, it is carried down to the ground by every rainfall. The nitrogen of the air may also be made to combine with oxygen in the form of nitric acid, by electrical discharges, and may be carried in available condition by rainfall to the roots of plants; while recent investigation seems to show that free nitrogen may combine with some other element in porous soil, and pass into the soluble form required to place it within the reach of the plant.

143. From what has been stated it will be understood that in the preparation of fertilizers it is unnec-

essary to use all of the elementary substances found in the plant. Our manure or fertilizer need contain only such elements as are not supplied by the atmosphere, and not supplied in sufficient amount in the proper form by the soil. Carbon, oxygen and hydrogen are supplied in abundance, and a part of the nitrogen ; the remainder must be contained in the soil in a soluble condition, or supplied as a fertilizer, if we wish to produce a maximum crop. Such substances as oils, fats, sugars, starch, wood and straw, composed almost entirely of carbon, oxygen and hydrogen, have very little value as fertilizers, except to improve the mechanical condition of the soil (see Chapter VI.) ; while lean meat, bones, seeds of most plants, and substances containing considerable quantities of nitrogen, potash and the phosphates, are usually of high fertilizing value.

CHAPTER XI

Fertilization of the Seed.

Length of Life of the Plant—Annuals—Biennials—Perennials—Development of the Seed—Structure of the Perfect Flower—The Stamens and Pistils—Imperfect Flowers—Fertilization of the Flower in Corn—Cross-Fertilization—Mixing of Varieties—Propagation by Budding, Grafting and from Cuttings.

144. Plants vary in their habits of growth and in the length of time required to reach maturity. Some end their existence when they have perfected seed, others continue to live and bear successive crops year after year.

145. Plants that complete their growth and die in one year are known as annuals. Those that form leaves, stalks and roots the first year and fruit and die the second are called biennials, while those that continue to live and bear successive crops of seed year after year are called perennials.

146. Examples of annuals are corn, oats, lettuce, radishes, etc.; of biennials, red clover, black seed-onion, carrot, cabbage and others; of perennials, apple, pear, fruit and forest-trees, shrubs, some of the grasses, and vegetables.

147. The plant springs up from the seed, or takes on

new life after lying dormant throughout the winter, as in the forest-tree. It then throws out leaves and flowers; the flowers fade and in their places we find again the ripened seed.

148. The development of the seed from the flower is as intricate as the production of new life in the animal, and the process is somewhat similar.

149. If we examine a perfect or complete flower, such as may be found on the apple and many common trees and plants, we will find at the base of the flower next to the stem a circle of one or more leaves or parts, usually green in color, called sepals. Inside of these there is another row of delicate leaves, not green in color, called petals, and inside of the petals a cluster of little stems or hair-like projections, resting generally on the base or center of the flower, consisting of an outer row surrounding one or more of different form in the center.

150. The small stems of the outer row are called stamens; the inner, pistils (fig. 12). The stamens and pistils are the important parts of the flower, the sepals and petals simply acting as a protecting covering. The stamens and pistils are the reproductive organs of the plant, and they are as necessary in their functions as the reproductive organs of animals.

151. At a certain stage in the development of the stamens, a fine dust-like substance, generally yellow in color, called pollen, is formed. This is thrown off from the stamens, and if any of the pollen falls upon the pistil, the flower may be fertilized or impregnated when the seed will begin to develop at the base of the pistil, while the remainder of the flower withers and drops off.

152. In the apple, pear, melon and similar fruits, the seeds are surrounded by the edible part of the fruit; while in the strawberry the seed develops on the outer part of the edible portion. In the grains the seed is simply enclosed in a sheath.

153. In some plants the stamens and pistils are found in separate flowers (imperfect flowers) on the same plant, as in corn; and in still others the stamens are found in one plant and pistils in another, as in the willow and some varieties of strawberries. In such plants the pollen is carried from the stamens to the pistils by the wind, insects or other agencies.

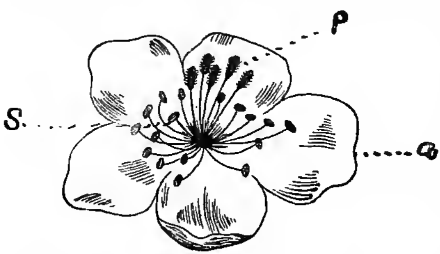

FIG. 12.—Apple-blossom. *a*, petals; *s*, stamens; *p*. pistils. The sepals are not shown, as they are small and hidden by the petals.

154. In corn, the tassels or flowers at the upper extremity of the stalk contain the stamens, while the silk on the young ear represents the pistils. Each fiber of the silk may develop a kernel of corn on the cob if a grain of pollen falls upon it, ; but if we cover the young ear before the silk appears, so that no pollen will come in contact with the silk, we will get simply a bare cob and no corn.

155. Different varieties of corn are found upon one cob when two or more varieties are planted near each other; the pollen of one variety fertilizing the flowers of another variety. This is called cross-fertilization.

Bees and other insects, in entering the flower to collect honey, get the pollen on their bodies and may carry it to the pistils of other flowers ; in fact, in some plants a full crop of fruit or seed will not be produced unless the pollen is carried from stamen to pistil by insects. Red clover, beans and pumpkins are partly fertilized through the aid of insects.

156. Owing to pollen often being carried considerable distances by the wind and by insects, it is very difficult to keep varieties of corn, cotton and other plants pure.

157. In some plants that produce complete flowers the stamens and pistils are so thoroughly enclosed and protected that the pollen cannot readily be carried from one flower to another by insects or the wind ; hence, there is not so much danger of such varieties becoming mixed, even when planted side by side. Wheat is an example of this kind.

158. In many of our improved fruits and vegetables the seeds if planted will not produce the same variety as the plant upon which they grow. The grafted apple and the Irish potato are examples. To secure the same variety in the renewal of such plants, cuttings or buds are grafted upon roots or plants grown from seed, and only the limbs from the budded part allowed to grow. The Irish potato is simply an enlarged underground stem containing buds or eyes that will throw out stems and roots when the potato is planted.

159. Plants may also be propagated by cuttings, *i. e.*, taking off a small piece of stem on which there is a bud, and planting in moist, warm soil (see fig. 8). Roots and leaves will spring from the cutting the same as

from the seed; but while the flower that produces the seed may have been fertilized by another variety, thus forming a different plant, the cutting will produce the same variety of plant as that from which it was taken. Many of the best fruits and flowers have to be propagated from cuttings to retain the variety.

CHAPTER XII.

Improvement of Variety.

Natural Varieties—Improved Varieties of Plants and Animals — Selection—Individual Variation—Cross-Breeding —Improvement of Corn — Cross-Fertilization of Perfect Flowers—Improvement of Grain—Retaining Improvement.

160. The greatest success in farming can be secured only by growing the improved varieties of plants and animals. The improved varieties are made by modifying natural or wild growths. The wonderful improvement in varieties of animals and plants due to the skill of man can be understood and appreciated only when we compare the qualities of our best breeds of animals and varieties of fruits, vegetables and other farm products with the native or wild varieties of the same species.

161. Natural varieties are the result of the influence of climate, food and other natural agencies; while the improved varieties owe their qualities to the influence of man in selection in breeding, in giving a liberal supply of food to make greater and more rapid development, and in elimination of all inferior individuals to stop their further reproduction.

162. In the improvement of the plant, seeds are taken from the best specimens and planted on soil best adapted to promote full development. Continual repetition of this process will insure improvement in the qualities of the plant.

163. In animals, only such are selected to breed from as possess, to some extent at least, the desired qualities, all others being rejected. The offspring from the selected animals are fed and handled in such a manner as to develop the young animal in the desired direction. The treatment would include training (as in the case of the trotting horse, hunting dog and others), as well as liberal feeding. Skill in the selection of breeding-stock, and in feeding, handling, etc., will make some improvement in each succeeding generation.

164. Cross-breeding or cross-fertilization between individuals of different varieties or breeds to combine the merits of both in the offspring, is sometimes practiced successfully.

165. In beginning the improvement, advantage is first taken of the individual variation found to exist in all kinds of plants and animals. In any crop that is grown on a farm an occasional plant may be found that is superior to the average plant. If seed from this plant be saved and planted on selected soil, and if the same plan is repeated year after year, decided improvement may in time be made. By selecting seed continually, from early or late-maturing plants, large or small specimens, etc., a change in the desired direction may be secured.

166. To make rapid and certain advancement in any desired direction in changing the character of a variety

of plants, the fertilization or breeding of the flower must not only be controlled, but artificial or cross-fertilization must often be practiced. In artificial fertilization we may sometimes be able to combine the merits of two plants in the plant grown from the seed thus produced.

167. Suppose that it is desired to increase the yielding capacity of a certain variety of corn, and we attempt to make two or more ears grow on each stalk. If we simply go through the field and select ears for seed from stalks bearing two or more ears, we would get ears containing kernels of corn that were fertilized possibly with pollen from stalks bearing but one ear, or no ear at all. If, however, we plant a small patch of corn off by itself on good ground, and, just before the tassels are fully developed, go through the corn and cut the tassels from all stalks having less than two ears, we would have corn fertilized by two-ear stalks only, and we might certainly look for improvement.

168. By controlling the fertilization of corn for several years in succession, in the manner described, planting on good soil and cultivating thoroughly to develop the growing habit, the yielding capacity of any variety of corn may be largely increased. The productiveness of certain kinds has been more than doubled in this way.

169. Artificial fertilization of flowers having both stamens and pistils is practiced by carefully removing the stamens from the flower with small nippers before they are fully developed, protecting the flower with a paper or cloth covering from pollen floating in the air, and when the pistil is ready, carrying matured stamens from the flower of the plant that possesses the desired

quality, and carefully shaking the pollen off upon the pistil to be fertilized (fig. 12). The plants grown from seed resulting from cross-fertilization may not have the good qualities of either parent, but occasionally valuable varieties are produced in this way.

170. Improvement by the simple selection of seed from the best plants is more certain in close-fertilized flowers, such as are found in wheat, than in plants like corn, where pollen is easily carried from one plant to another by the wind. The quality of the grain may be improved by blowing out light and small grains with a fanning-mill and sowing the heavy grains.

171. A more rapid and certain improvement can be secured by passing through the field of grain after it is ripe and selecting the best heads or stalks from which to save seed. Heavy, plump kernels are often found in inferior, short heads of wheat or other grain; therefore a selection of the best heads is more certain to secure the best seed than simply sorting the seed after threshing the crop. Selecting the best ears of corn from a crib, or from the crop in the field, will make but little, if any, improvement, except what may be due to getting large ears that have been developed on strong stalks grown on the best soil in the field.

172. The valuable qualities of the improved varieties of animals and plants are artificial qualities, produced by artificial treatment. They are not permanent; therefore, when the influences that caused the peculiarities to develop are removed or neglected, the improved variety or breed deteriorates until it again becomes common or native stock.

173. In most improved varieties of plants and animals, early maturity and the increase of size, as well as better quality, are among the valuable things that have been secured through the improvement. This result is due largely to high feeding. The improved variety of corn that has been made to increase its yield two-fold has developed this quality from being planted on fertile soil, and it requires fertile soil to be able to make this large yield. In the same way the beef breeds of cattle, or large butter-yielding cows, have developed the habit of eating and digesting a large amount of food; hence they require liberal feeding to bring out their valuable qualities.

174. The man who half cultivates his land, or who works poor soil without fertilizing, or who half feeds his stock, gains nothing in attempting to grow any of the improved varieties of plants or animals.

175. The improved plant and the improved animal will require better treatment than the common varieties, but when supplied with this extra care they will make larger return in proportion to amount of land occupied, and labor and food consumed, than the common varieties under any system.

CHAPTER XIII.

Cultivation of the Crop.

Object of Cultivation—Preparation before Planting—Good Plowing—Depth of Cultivation—Fall Plowing—Cultivation of Corn—Shallow and Deep—Hilling—Turn-Plow Cultivation.

176. Crops are cultivated by hand or by team-work to keep down weeds and promote rapid growth.

During the growing season the crop should be kept clean from weeds to enable the plants to secure all of the available plant-food and moisture that the soil will supply. Oft-repeated cultivation of the soil, if begun before the land becomes too dry, will tend to keep the soil moist through a dry season.

177. Plowing and thorough harrowing of the land, just before planting a crop that requires hand labor to destroy weeds, will reduce the cost of cultivation by enabling the crop to get the start of the weeds. Land infested with rapid-growing perennial weeds should always be planted when the soil is freshly plowed, and especially if the seed to be planted germinate and grow up slowly. Seeds will germinate in less time if planted in specially prepared soil, than they will if planted some time after preparation, owing to the freshly plowed soil being moist and breaking the outer coating of the seed at once. Cultivation may then commence before the weeds

get well started and the ground becomes hard and difficult to work.

178. Thorough preparation of the land before planting enables the farmer to work the crop with implements like the cultivator, that will cover a wide surface and do rapid work. *Good plowing* is the foundation of successful farming, and its benefits are apparent in all seasons and during all stages of the growth of the crop.

179. When land is drained and thoroughly prepared before planting, deep working of the crop is unnecessary. The one or two-horse cultivator with wide shovels, taking a row at one time going over, and cutting two or three inches deep, gives better results and does much more rapid work than such implements as the one-horse plow or the bull-tongue.

The first working of the crop may be deep (three or four inches), but after that, as a rule, shallow cultivation (about two inches deep) is not only sufficient but is better for the crop, as it does not cut off the roots of the plants, thereby reducing their feeding powers.

180. From our own experience we find that but two implements in addition to the plow and harrow are necessary in working corn, cotton and similar crops if the land is properly prepared, that is, drained and thoroughly harrowed. In corn, unless we can have a sod or some green growth to plow under for late planting, we invariably get the best results on heavy soils with least expenditure for labor, from deep fall or winter plowing, and shallow replowing or fitting with the two-horse cultivator just before planting.

181. After planting, the land is harrowed broadcast

with a Thomas smoothing-harrow, before and after the corn comes up, loosening the surface soil and destroying any weeds that may start with or before the corn. The loosening of the surface-soil with the harrow causes the young corn to come up quick and grow off rapidly, and does away entirely with the "barring off" practiced in some states (fig. 13). The broadcast harrowing with a two or three-horse team may be quickly done, and it keeps down the weeds until the corn is large enough to be worked with the cultivator without covering the young plants. The first working is done with a one-horse or two-horse cultivator with sharp, narrow teeth; the later working with wide-cutting, narrow-winged sweeps that cut not more than two inches deep and throw but little dirt to the rows.

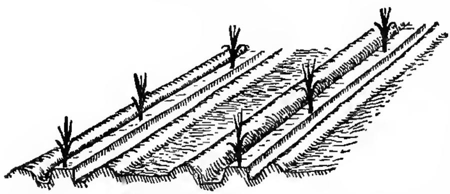

FIG. 13.—Young corn barred off with one-horse plow. In this method of working two furrows are run with each row and not more than half the space between has been stirred. With a cultivator in place of the plow the middle would have been broken also.

182. Besides destroying weeds, oft-repeated shallow cultivation of the crop retains moisture in the soil by checking the evaporation of water; it causes a more rapid decomposition of plant-food in the soil, converts nitrogenous matter into a soluble form, holds water deposited by showers and dew, warms up the soil in spring, and keeps the lower soil moist and cool in dry, hot weather.

The more often the crop is cultivated, the more rapid the growth.

183. Deep cultivation after the crop is partly grown, especially in very dry weather, will almost invariably injure the crop by cutting off the feeding-roots (fig. 14).

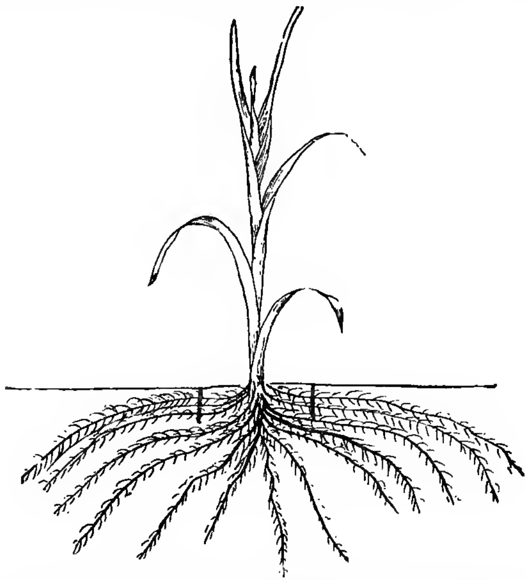

FIG. 14.—Root-development of corn when three to four feet high. If the crop is plowed or cultivated deep at this stage of growth, near the row, the roots will be torn off at the place shown by the heavy lines.

Late deep cultivation should not be practiced unless the crop is growing too rank, running too much to stalks and leaves.

184. The experience of our best farmers shows that on deep-plowed and well-drained land, hilling, or throwing dirt up to the plants, except in small quantities to smother small weeds, is an injury rather than a benefit.

185. Cultivating a crop with a turning-plow is a slow process and should not be practiced unless the weeds and grass get such a start that smothering by burying is the only economical way to get rid of them. Such a condition is inexcusable, except in very wet seasons when continued rains for a week or two keep the land so we that all work on the crop must cease.

CHAPTER XIV.

Manures.

WHAT IS MEANT BY MANURE—THE VALUE OF MANURE—VALUE OF FOOD AND EXCREMENTS FOR FERTILIZERS—NUTRITIVE AND MANURIAL VALUE—VARIATION IN VALUE OF MANURE FROM DIFFERENT ANIMALS—HOW TO RETAIN FERTILITY—LIQUID EXCREMENT—WASTE PRODUCTS—MANURE ON GOOD AND ON POOR LAND.

186. Manure is a term applied to any material that will, if added to the soil, supply plant-food in an available condition to the crop, as well as to any material that will render soluble inert plant-food already stored up in the soil.

187. As commonly understood, manure means animal excrements; or these excrements mixed with the litter that accumulates in stables and barn-yards. The value of any manure is determined by the condition, the kind and the amount of elementary substances it contains. The manurial value of animal excrements is determined largely by the kind of food the animal eats, as the excrement will contain nothing that is not found in the food. The value of any manure is largely determined by the amount of combined nitrogen, phosphates and potash it contains; other elements required by plants are usually supplied by the soil and air; hence a food

rich is these materials will make rich manure, and a food containing but small quantities of them will make poor manure, without regard to the kind of animal.

188. Except to make it more readily available to plants, the animal adds nothing to the fertilizing value of any food-stuff by eating it and converting it into manure. A ton of hay or a bushel of corn applied to the soil has as much fertilizing value as the manure made from feeding it to an animal, but the hay or corn might require more time to decompose and become soluble.

189. Wheat-bran, cotton-seed and linseed-meal—valuable feeding-stuffs for farm stock—are often applied directly to the soil as fertilizers and are found to make profitable returns for the cost.

190. All food-stuffs have two values: a nutritive, or feeding value; and a manurial value (see par. 271). If the food contains considerable quantities of nitrogen, of potash, or of the phosphates, it will make rich manure; and may also have high nutritive value. If made up almost entirely of starch or oily matter, it may still have a high feeding value, but be almost worthless for making manure.

191. The starch and oil which make up the principal part of corn have little if any manurial value, but are worth a good deal for food; hence it would not be advisable to use corn for manure, and the same is generally true of all farm products.

192. By feeding crops to animals, we may convert material in the crop of low fertilizing value into work, beef, milk, etc., and still have the greater part of all that is valuable for plant-food left in the manure.

193. A young, growing animal stores up nitrogen, phosphoric acid and potash, in building up the skin, lean meat and bones ; while the same materials are used by the cow in the production of milk. A grown animal, at rest, at work, or being fattened, uses or stores up carbon, oxygen and hydrogen, the fertilizing elements of the food passing off with the manure ; therefore food consumed by such animals produces richer manure than if fed to growing or milking animals.

194. Such foods as wheat-bran, cotton-seed, or linseed-meal, make rich manure, while corn, wheat-flour, straw, poor hay or any starchy or oily food that is made up almost entirely of carbon, hydrogen and oxygen, makes poor manure. Some foods are rich both in food and manurial matter, cotton-seed and flax-seed meal ranking high in this respect. Hence to get the full value of cotton-seed it should be fed to stock, and the manure made should be carefully saved and applied to the soil instead of using seed for manure direct.

195. The most successful system of farming is that in which such farm products are sold as contain small amounts of fertilizing material, the remainder being converted into animal products and manure.

196. In growing cotton, if the lint only is sold, if the seed is fed to cattle, and if the manure made is saved and applied to the land with the stalks, leaves, roots, etc., the planter could realize cash returns for the lint and for the animal products, while but a small amount of fertilizing material would be removed from the farm.

197. In wheat-growing, if the straw is used for feed

and bedding, and as much wheat-bran as the wheat contains, or concentrated food of any kind containing the same manurial elements, purchased and fed out to stock, and the manure applied to the soil, wheat would not be an exhaustive crop.

198. Milk contains considerable quantities of fertilizing material, therefore growing crops to feed the cows to make milk to sell exhausts the fertility of the land nearly as rapidly as selling the crops, unless fertility is restored through the purchase of feed-stuffs. On dairy farms where the sales are limited to butter, and the skim-milk is consumed by calves or pigs, and the manure applied to the land, the fertility of the land need not be exhausted, as butter has no manurial value. Growing animals store up fertilizing material in their bodies, but the amount is small compared with the total amount in the food consumed. Fattening animals excrete nearly all of the fertilizing material.

199. In considering the manure question it should be borne in mind that the liquid excrement of animals is of as much value as the solid excrement, and special pains should be taken to prevent its loss.

200. All the waste products of the farm should be converted into manure by being fed to some kind of stock or used as litter to absorb liquid manure, and a considerable portion of most farms should be devoted to growing crops for stock-feed to make manure, looking to returns from animal products sold to pay for cost of growing. On the majority of farms, stock-growing of some kind is necessary to keep up the fertility of the soil and reduce the expense of labor in order to make the farm profitable.

201. The manures make better returns when applied to good land that is well cultivated, than they do when used on poor land poorly cultivated, if we except new land in which there is sometimes an excess of organic matter and plant-food.

202. On large farms, with moderate working capital, or meager equipment, the most profitable returns will be secured by concentrating the manure produced and the labor expended in growing crops on the best land, and devoting the balance to pasture. The thoroughly tilled and liberally manured land will return a profit; while the poor land, even if it does not make large returns, costs almost nothing in the way of labor, and, if not too heavily stocked, will slowly improve in condition.

CHAPTER XV.

Commercial Fertilizers.

COMPOSITION OF FERTILIZERS—LAND-PLASTER—GUANO—MATERIALS FROM WHICH FERTILIZERS ARE MADE—PHOSPHATES—KAINIT—NITRATE OF SODA—VALUE OF FERTILIZERS—FERTILIZER LAWS—VALUE OF GUANO—BONES—ACID PHOSPHATE—COTTON-SEED MEAL—STANDARD FERTILIZER—VALUE OF COTTON-SEED—BARN-YARD MANURE—LIME—SPECIAL MANURES—QUANTITY TO APPLY.

203. Commercial fertilizers is the name given to the artificial manures that are offered for sale in our markets. The fertilizers are made from materials containing more or less combined nitrogen, phosphates, potash and lime. Lime alone, either fresh or air-slaked, is used to improve the fertility of land, but is more often used in the form of land-plaster, also known as gypsum (sulphate of lime), or in the form known as phosphate of lime, an ingredient of most fertilizers sold on the market.

204. The first commercial fertilizer to come into use on the farm was guano. This material consists of the excrements of birds. It is or was found in large quantities in countries where there is little or no rainfall,

where these deposits have been accumulating for many years. The largest deposits are found in Peru; hence, the name Peruvian guano. The best guano contains in some cases eighteen per cent. of ammonia and five and one-half per cent. of phosphoric acid. It is a very strong and active manure.

205. At the present time the supply of guano is nearly exhausted, therefore the limited supply and cost of transportation have led dealers in fertilizers to seek other sources of supply for materials rich in plant-food.

206. All kinds of refuse products that contain one or more of the three valuable manurial elements and lime are now used in the manufacture of fertilizers. Phosphate-rock, bone-ash from the sugar-refiners, bones, kainit (sulphate of potash), muriate of potash, dried blood, fish-scrap, dried refuse from slaughter-houses, refuse from gas-works, nitrate of soda, cotton-seed meal, and many other materials. Gypsum and marl are often added to highly concentrated matter to give bulk and weight to the compound.

207. The fertilizer manufacturer uses any of the above materials which supply ammonia, potash and available phosphates at the least cost.

208. The phosphate-rock consists of fossil animal remains, or rock containing large amounts of phosphate of lime. The same material makes up the principal part of bones. Large deposits of phosphate-rock are found in the Carolinas and other places. The rock is ground up fine and treated with sulphuric acid to make the phosphoric acid soluble, and after being thus treated it is considered equal to bone-meal for fertilizing purposes.

209. Kainit, or the German potash salts, is found in extensive deposits in Germany. Kainit supplies the larger part of the potash used in fertilizers, owing to its low cost as compared with other material containing potash.

210. Nitrate of soda is found in Peru, but not in sufficient quantities to make it cheap enough to be largely used in compounding fertilizers. It is valuable for the large amount of readily available nitrogen it contains. One of the cheapest sources of nitrogen for the southern fertilizer manufacturer at present is cotton-seed meal.

211. The value of commercial fertilizers is determined by the amount of combined nitrogen, soluble phosphoric acid and potash they contain, each ingredient being estimated at so many cents a pound.

212. The average price of these materials for 1887 at some of the manufactories is estimated at sixteen cents a pound for nitrogen, seven and one-half cents a pound for available phosphoric acid, and five cents a pound for potash. The value of these three ingredients varies to some extent when derived from different materials, but the above represents average values.*

213. In the older and more progressive states laws have been enacted requiring manufacturers of fertilizers to have their goods inspected by a competent chemist, and to furnish a statement with each package showing what proportion of the three manurial elements the fertilzer contains.

*The retail price for 1891 is nitrogen, 17½ cents a pound; phosphoric acid, eight cents a pound; potash, four cents a pound.

214. From the above estimate the value of good Peruvian guano is rated as follows:

2000 lbs. 1 ton.	18 per ct. nitrogen=360 lbs. @ 16 cents=..........	$57 60
	5½ per ct. phosphoric acid = 110 lbs. @ 7½ cents=	8 25
	Value of 1 ton..............................	$65 85

215. Fresh-ground bones treated with sulphuric acid contain about two and one-fourth per cent. of nitrogen, and seventeen and one-fourth per cent. of soluble phosphoric acid. One ton would therefore contain:

45 lbs. ammonia @ 16 cents =....................	$7 20
345 lbs. soluble phosphate @ 7½ cents = ...	25 87
Value of 1 ton..............................	$33 07

216. Acid phosphate (Carolina rock) ground and treated with acid contains about 11.4 per cent. of available phosphoric acid and 1.1 per cent. of potash. One ton would contain:

228 lbs. phosphates @ 7½ cents = ...	$17 10
22 lbs. potash @ 5 cents = ...	1 10
Value of 1 ton..............................	$18 20

217. One ton of kainit contains about 230 pounds of potash, which, at five cents a pound would be worth $11.50.

218. Cotton-seed cake or cotton-seed meal contains to the ton about

134.6 lbs. of nitrogen @ 16 cents = ...	$21 54
60.6 lbs. phosphoric acid @ 7½ cents = ...	4 54
35.8 lbs. potash @ 5 cents =..	1 79
Value of 1 ton..............................	$27 87

219. Cotton-seed meal sells now for about $20 a ton in the vicinity of the oil-mills in the southern states, and acid phosphate and kainit sell for about the values given, at seaport towns. Cotton-seed meal at the present price is one of the cheapest fertilizers that can be purchased. It contains too much nitrogen in proportion to the amount of the phosphates and potash to give the best results on some soils and with some crops; but any desired proportion can be readily obtained by mixing cotton-seed meal with acid phosphate or bone-meal and kainit or muriate of potash, thus making a complete fertilizer

220. A standard fertilizer, containing eight per cent. to eleven per cent. of phosphoric acid, two to two and one-half per cent. potash, and two and one-half to three per cent. of nitrogen in the form of ammonia is sold by dealers at from $28 to $35 a ton. Eight hundred pounds cotton-seed meal, 1,000 pounds acid phosphate and 200 pounds kainit well mixed together, will make a fertilizer containing nearly the above proportions of a value nearly equal to the goods prepared by the manufacturer, and at a cost considerably less.

221. In the process of milling the cotton-seed oil manufacturer extracts about 250 pounds of oil, and 750 pounds of cotton-seed meal from one ton of seed. The hulls make up the remaining 1,000 pounds. The oil has no value as a fertilizer, and as the hulls contain not much besides carbon, hydrogen and oxygen and a small amount of potash, they have a low manurial value. The cotton-seed meal in the ton of seed, estimated as before (see par. 218), would be worth about $11; 1,000

pounds of cotton-seed hulls about $1.25, making a ton of seed worth $12.25 for manure, estimated in the same way that the factory value of commercial fertilizers is determined.

222. According to Dr. Voelcker, chemist of the Royal Agricultural College, England, one ton of good barn-yard manure, composed of horse, cattle and hog excrements, with the litter used for bedding, was found to contain twelve and three-fourths pounds of nitrogen, six and one-half pounds of phosphoric acid, and thirteen and one-half pounds of potash.

12¾ pounds nitrogen @ 16 cents = ...	$2 04
6½ pounds phosphoric acid @ 7½ cents = ...	48
13½ pounds potash @ 5 cents = ...	67
Value of 1 ton of manure	$3 19

223. It must be remembered that the values given above are comparative values, based only on the nitrogen, phosphoric acid and potash contained. Besides these elements the lime in barn-yard manure and cotton-seed has some value and the litter and hulls add organic matter to the soil, thereby improving its mechanical condition and its productiveness.

224. Lime alone is sometimes used as a fertilizer. It acts as plant-food on land deficient in lime, but adds to the crop usually by helping to decompose material already in the soil. On soil filled with organic matter, it will often produce very marked results ; but on old, cleanly cultivated land it will not take the place of the combined fertilizers. Land-plaster, applied as a top-dressing after the crop is up, promotes the rapid growth

of certain plants on some soils. On young clover, beans, peas and similar plants, it will sometimes give as good results as the complete fertilizers, and often better results, at much less cost. Plaster is used extensively by farmers who grow wheat, corn and clover in rotation; on the young clover to increase the growth of the clover.

225. Some soils and crops require only nitrogen, others potash and others phosphates in order to get the best results for the expenditure. Small plats of ground should be fertilized with manures containing a large amount of each one of these ingredients, and the yield of the different plats compared to learn which mixture or proportion will give best results on the soil tested. The farmer can then mix his fertilizer to suit his land and crop.

226. The quantity of fertilizer to apply to an acre of land cannot be definitely stated. In garden-farming 1,000 pounds is sometimes used with the most profitable results. On average farm-land for the ordinary crops from 200 pounds to 300 pounds of a standard fertilizer (see 220) is the quantity most commonly used.

227. Chemical analysis of the crop and determination of the quantity of each element drawn from the soil and removed will by no means indicate the quantity or proportion of manurial elements that should be applied to the soil to give the best result in growing the crop. The soil may contain in available condition all that is needed of one or more of the substances required, and again some crops will utilize material that other crops cannot appropriate, owing to the difference in feeding-power of the roots.

CHAPTER XVI.

Care of Manure: Composting.

STABLE MANURE — FRESH MANURE — SOLUBILITY — LITTER — COMPOSTING — WHEN DESIRABLE — COMPARATIVE VALUE OF STABLE MANURE AND CONCENTRATED FERTILIZERS — CARE OF — TIME TO APPLY — HOW TO APPLY — TOP-DRESSING — PLOWING UNDER — HILL APPLICATIONS — PLAN FOLLOWED BY AUTHOR.

228. Stable manure decomposes rapidly and is subject to loss of valuable constituents if it is not properly handled. If allowed to heat, nitrogen, in the form of ammonia, will escape, and if the manure is thrown out into an open yard, soluble matter will be washed out with every rainfall. To prevent loss of fertilizing value, manure should be handled in one of the following ways: 1. Allowed to accumulate in the stables until needed. 2. Hauled direct to the field from the stalls every day as fast as it is made. 3. Piled up in the yard in compact heaps. 4. Piled up under a shed to protect from the rain until convenient to spread upon the land. To prevent loss from leaching, the winter and spring rains make it necessary, in some of the states, to keep manure under shelter until it can be put upon the land. If stored it should be tramped down and moistened sufficiently to prevent overheating.

229. Green or fresh stable manure must decompose

before it will become soluble and furnish available food to the plant: hence composted manure gives more immediate returns than fresh manure. Stable manure from horses or mules will heat if piled in large heaps, and ammonia will escape into the air. Cattle and hog-manure, containing more water and being less active, will not heat readily, and mixing it with horse-manure will prevent rapid decomposition of the mass.

230. Leaves, dirt, trash and refuse of all kinds are often used to make the animal comfortable and to absorb and hold liquid manure. Such refuse materials are sometimes added to manure in making compost-heaps. When used to absorb and hold liquids that would otherwise be wasted, such practice may be profitable; but when added to manure in a compost-heap to increase the quantity of the compost, the extra cost of labor in handling the added material may exceed the value of the increase in crop resulting from the application, unless the refuse materials contain considerable amounts of fertilizing elements.

231. On garden farms, where land is costly and the manure is hauled but a short distance, composting refuse material with stable or concentrated manures is usually found profitable; but on large farms the same results may be secured with less expenditure for labor by using the concentrated fertilizers in connection with green manuring, growing clover, cow-peas, and similar crops, to rot on the ground or plow under.

232. A ton of good stable manure has been found to contain from twelve to fifteen pounds of nitrogen, six to eight pounds of phosphoric acid, and thirteen to fifteen

pounds of potash, which, estimated at the same rate as was given for commercial fertilizers in the last chapter, would make the ton of manure worth about $3.50 and equivalent in manurial value to about 175 pounds of cotton-seed meal and 80 pounds of kainit. Stable manure made by feeding corn and a poor quality of hay, and using straw for bedding and for a liquid absorbent, would not be worth more than $2 a ton, estimated as above; and it would be equivalent to not more than 100 pounds of cotton-seed meal and 50 pounds of kainit.

233. The organic matter in the manure would improve the mechanical condition of the soil and add organic matter to it, but on good average soil the application of a mixture of cotton-seed meal and kainit would give a larger increase in crop owing to its being more readily available. It would also cost much less to apply it.

234. One of the best plans for handling manure on the farm, when it cannot be hauled direct to the fields, is to wheel or cart the manure from the horse and cattle-stalls and from the hog-pens, with an occasional scraping up of the barn-yard, to a pile under a shed. The liquid manure should be added to the pile and the mass should be tramped down and kept just moist enough to prevent overheating, but not to prevent a slow decomposition. Treated after this method, the ingredients that contain plant-food would break up and become soluble, the excess of water would evaporate, and the pile of manure would decrease in weight and bulk, and increase in richness, thus reducing cost of hauling and application. Bones may be utilized by breaking them up with a heavy hammer and burying in such a compost-heap. Car-

cases of dead animals may also be cut up and added to it with good results.

235. From the protected compost-heap just described, the manure may be hauled to the field at any time in the year that is most convenient.

The time of year to apply manure to get the best results from the application is not a matter of serious importance on farms where diversified crops are grown. Readily soluble, quick-acting fertilizers should not be applied any considerable length of time before a crop will be growing on the land, as loss may occur from the soluble part of the fertilizer being washed out in the drainage-water, or carried too deep to be reached by the plants. Such fertilizers as fresh stable manure, the phosphates, cotton-seed, and other slow-acting manures, had better be applied some time before the crop is planted, to give time for decomposition. Grass-lands may be fertilized at any time in the year with good results.

236. Manure is applied to the soil in a variety of ways; distributed broadcast upon the surface, called top-dressing; plowed under, applied in the hill, or several applications made during the season to the growing crop. All of the different methods of application are advocated, and each one may be found desirable in certain circumstances.

237. In the method of applying manure two things are to be considered: first, benefit to the crop; second, cost of application. The cost of manure and expense of application will have a good deal to do in determining the quantity to be used, system of farming, and crops to be grown. Indirectly it may influence the entire management of the farm.

238. The cheapest method of applying coarse barnyard manure is to spread it over the ground broadcast; and the practice of letting it lie on the surface, or simply harrowing it in after the ground is plowed, is becoming more popular every year with our best farmers. Treated in this way the manure as it decomposes is washed into the soil with each rainfall, and evenly distributed to the roots of plants. Plowed under, decomposition takes place slowly, and a considerable part of the manure may be buried below the larger part of the feeding roots of the plants. This is especially true on deep-plowed, heavy, close soils that are not well drained.

239. Plowing under a large quantity of coarse litter, or crop grown on the land, may lighten up a heavy soil and give good results from the improvement made in its texture, but the plant-food will not become so quickly available as from surface application. Simply covering the soil with anything that will shade it seems to be beneficial, so much so that it is a debated question as to there being any gain in plowing under a crop of clover, cow-peas or similar crop, when nearly or fully matured, over letting it rot on the surface.

240. With a limited amount of manure the best returns for one year may be secured from hill-and-drill application, as the roots of the plants reach the manure at once; but coarse manure applied in the hill may cause the soil in which the plant is growing to become too dry during a drought, and reduce the crop. Hill-and-drill application makes extra labor unless the concentrated fertilizers are used, and put in with the drill along with the seed at one operation.

241. In our own practice we have adopted the plan of

applying all stable manure as a top-dressing, broadcast, and the concentrated fertilizer in the drill with the seed, or just as the crop is coming up. We use no refuse material for making composts, except the litter used for bedding for the stock, and apply the concentrated fertilizer alone to the soil, rather than go to the expense of employing labor to combine them with material not rich in plant-food, and the added labor necessary to apply the compost. Our system of farming includes growing clover, cow-peas and other crops that leave organic matter in the soil on all land cultivated, thus obviating the necessity for supplying it in the manure.

CHAPTER XVII.

Rotation of Crops.

Effect of Rotation—Why Rotation is Desirable—Difference in Assimilation—Root-Growth—Material Left in Soil—Diversity of Foliage—Red Clover—Cow-Pea—Value of Roots—Rotations—Other Advantages.

242. Experience has shown that, as a rule, when one crop is followed by a crop of a different kind, land will be more productive than under the single-crop system. The best results are secured both in the increase of yield and economy in labor by having clean-cultivated crops such as corn, cotton, Irish potatoes, etc., alternate with grain, clover, cow-peas and grass crops. A crop of weeds allowed to grow and decay on the land will be beneficial so far as adding to the fertility is concerned; but if the weed-seeds are allowed to ripen, it may add to the expense of keeping succeeding crops clean.

243. Plants vary widely in the following particulars:

1. Power of assimilating, by means of their roots, the plant-food in the soil.

2. In the proportion of the several plant-food elements taken up.

3. In the extent and depth of root-development.

4. In the amount of plant-food left for succeeding crops in the roots that remain in the soil.

5. In the density of foliage and consequent power of shading the soil, or in paucity of foliage, thus leaving it exposed freely to the sun and air.

244. Careful study of the above peculiarities of plants shows why a rotation of crops may be more profitable than planting the same crop continually; and it will suggest a desirable rotation to the intelligent farmer.

245. The two most valuable plants for improving the fertility of the soil, and, consequently, for inclusion in the rotation practiced on American farms, are red clover and the cow-pea. The former is valuable over nearly the entire country; the latter in the Southern States. Red clover and the cow-pea are deep-rooting plants, and have strong feeding powers. They shade the soil with a densely matted growth that will choke out weeds; they furnish a large amount of either hay or ensilage of the best quality, which is rich in both nutritive and manurial matters, and they leave in the soil for succeeding crops a large quantity of roots, rich in plant-food.

246. The cow-pea, of which there are a number of varieties, has some advantages over the red clover on farms in the South. It will grow on poorer soil, and it makes full development in from four to six months; consequently two crops can be grown within the year, and the growth may be cut for hay, pastured off by stock, or plowed under. The red clover is a biennial requiring two years to make full development in the northern half of the country.

247. When either red clover or the cow-pea is grown on land of average fertility, after cutting off the crop for hay the stubble and roots on and in one acre of soil

contain as much nitrogen, potash and phosphoric acid that may become available to the succeeding crop as will be found in 300 to 600 pounds of cotton-seed meal, or one-fourth of a ton of a good standard fertilizer. In addition to supplying available plant-food to succeeding crops, the red clover and cow-pea roots leave large quantities of organic matter in the soil, thereby improving its mechanical condition.

248. A rotation that is found desirable in some of the Northern States runs five years: first year, corn; second year, oats or barley; third year, winter wheat, on which clover is planted in the spring; fourth and fifth years, clover, or clover and timothy together.

This rotation provides a clover sod to plant corn on, and insures a good crop of corn with a moderate amount of labor; while the sods, roots, etc., have time to become thoroughly broken up and decomposed, and the soil can be made clean for the succeeding grain-crops. A four-year rotation may include only corn, wheat and clover.

249. In the Southern States, where red clover will grow, a five-year rotation might include: first year, corn; second year, clover sowed on the corn-stubble in the spring; third year, clover, cutting first crop for hay, second for seed; fourth year, oats, followed by cow-peas as soon as the oats are harvested; fifth year, cotton. Either the cotton or the oats may be left out, and the rotation allowed to run but four years. Different rotations may be planned to suit the needs of the farmer.

250. Other advantages of the diversified system of farming and the rotation of crops over the single-crop

system are gained in having the work spread over the entire year, and in having less land planted to crops that require cultivation. With the farm-work so arranged that one-third of the land will be planted to cultivated crops, one-third to hay and forage crops, and the remaining third set in pasture, by carrying enough stock of some kind to consume all of the food grown on the farm, the cost of labor may be very much reduced, and the fertility of the soil retained and even increased without materially decreasing the returns from crops grown and sold.

CHAPTER XVIII.

Diversified Farming.

SPECIAL FARMING — DIVERSIFIED FARMING — ADVANTAGE OF DIVERSIFIED FARMING—WHEN MOST DESIRABLE—SAVING IN LABOR—COST OF PLANT-FOOD—RETURNS FROM ANIMAL PRODUCTS—CHEAP SOURCES OF PLANT-FOOD—CONCLUSION.

251. Farming, as generally practiced, may be classed either as special or as diversified farming. The former means devoting the farm to one or two crops ; the latter to a variety of crops. The cotton-plantation of the Southern States, where cotton and corn are often the exclusive crops, and the wheat-farms of the northwest that are planted entirely to wheat, are examples of special farming.

252. Diversified farming as generally understood means growing several crops, and also stock of some kind to convert a portion of them into animal products, such as butter, meat, wool, etc., that may have a higher market value than the crops would sell for, and at the same time furnish manure.

253. A variety of opinions is found to exist among the most intelligent and successful farmers as to which system is preferable. It is held by some men that the diversified system should always be practiced, although they may not all agree as to the extent of the diversifi-

cation; while others claim that a farm devoted to a specialty can be conducted with greater economy and more profit than if the labor of the farm is diverted in several directions. Some agricultural writers advocate combining the two systems in such a way as to make some one product a specialty, devoting to it the main energy of the farm with the expectation of deriving from this product the cash income of the business, while at the same time they advise us to practice diversified cropping to the extent of supplying the farm with renovating crops, food-crops and manure.

254. Some of the advantages that may be derived from the alternation of crops have been shown in Chapter XVII.

It may be found, however, that in some localities all of the benefits to be secured from rotation and diversity of crops may be secured in a more economical way, and the farm made more profitable, by confining the work to special crops. Such may be, and often is, the case on high-priced land near cities, from which garden-truck may be easily sent to market, and where the rental value of the land makes it cheaper to buy manure to supply plant-food to the soil than to resort to restorative crops.

The same may be true on new and highly productive soil, such as is sometimes found in rich river-bottoms and prairie-lands that are specially adapted to growing some crop commanding a high price in the market, and also on lands where labor can be secured whenever it is required.

255. Diversified farming is generally desirable on land that has been under cultivation for a long time, and especially so on light soils. Where a variety of crops are

grown, the preparation of the land for planting, the cultivation and the harvesting, occur at different seasons of the year, thereby giving steady employment to a regular number of men and teams. When combined with stock-growing, a home market is provided for the consumption of the heavier and coarser products of the farm, which are costly to transport to market.

256. Of still greater importance in the economy of the farm is the low cost of plant-food that may be supplied by diversified farming and stock-growing, and the amount of land that may be made profitably productive in proportion to the expenditure for labor.

257. If the larger part of the farm is planted to corn, cotton and other crops that require cultivation, the work of one man and team will be expended on a small area of ground; and after the virgin fertility of the soil is partially exhausted, fertilizing material must be procured from some outside source to supply the plant-food required to produce a profitable crop. If, instead of cultivating so much land, one-half of the farm is utilized for pasture, hay and grain-crops, the labor will be much less, the forage may be converted into animal products and manure, and the fertilizers required from outside sources to prevent exhaustion of the soil largely curtailed in amount.

258. By contracting the area of cultivated crops still further, turning say one-third or even one-half of the farm into pasture, and planting one-half of the remainder in hay and forage-crops, and the remaining portion in cultivated crops, and by increasing at the same time the number of stock to the extent of consum-

ing all the food that the farm will supply, the cost of labor may be still further reduced, and sufficient fertilizing material to prevent deterioration of the land supplied from the farm.

259. Owing to the fact that an acre of land may be made to make as large a return by growing a crop that may be converted into beef, milk or other animal product, and selling these, as by growing a sale-crop—counting the cost of labor and rental value of the land on the average farm—the advantages of growing feed-crops over growing exclusively sale-crops are evident when we remember that under the former plan the land will increase in productiveness if the manure made is returned to the soil, while in growing sale-crops it must deteriorate, unless we resort to the purchase of fertilizers that are not made on the farm.

260. The productiveness of the soil of the farm may often be increased by purchasing concentrated foods that are rich in nitrogen, phosphates and potash, and by feeding to stock.

261. Such feed-stuffs as cotton-seed, cotton-seed meal, linseed-meal, wheat-bran, glucose-meal and the by-products of distilleries, malt-houses and the like, as well as some of the cereals, are rich in both nutritive and manurial matter. Some of the above or similar feed-stuffs can be purchased in almost any part of the country at a cost that will enable the farmer to convert them into animal products at a profit, and add largely to the supply of manure at the same time.

262. It often happens that a concentrated food may be purchased so much below its value for fertilizing

purposes that the manure resulting from its consumption will be worth more than the cost of the food, while at the same time the food will more than pay for its cost in animal products. For the reason set forth, the shrewdest farmers of England and America prefer to purchase concentrated foods to feed to stock for the purpose of enriching their lands, rather than to buy the commercial fertilizers.

263. To reap all the advantages of diversified farming, the farmer should include the pasturing of stock and the growing of hay-crops to reduce the labor of the farm; the alternation of crops to secure the benefits of rotation and renovation of the soil from the root-growth of certain plants, and the purchase of concentrated feed-stuffs to enable him to carry more stock and make more manure.

CHAPTER XIX.

Food and Manure Value of Farm Crops.

NUTRITIVE VALUE—WHAT FOOD IS CONVERTED INTO—DIGESTIBILITY—ANIMAL WASTE—VALUE OF SOME KNOWLEDGE OF CHEMISTRY—SELLING FERTILITY—FARMING BY RULE—EFFECT OF FEEDING THE CROP GROWN ON THE FARM—TABLE OF MANURE-VALUE OF FEED-STUFFS—LOSSES IN FEEDING—MARKET VALUE VS. FEEDING VALUE—VALUE OF PERMANENT MEADOWS AND PASTURES.

264. The several products of the farm have a double value ; first, to supply nutrients to support animal life ; second, to supply plant-food to the soil. The nutritive value of any farm product is determined by its composition and the digestibility of the materials of which it is composed.

265. Starch, fat and other combinations of oxygen, hydrogen and carbon in the food are converted into animal heat, muscular force and fat ; the nitrogenous portion into lean meat, skin, hair, gelatine of the bone-tissues, and all parts of the animal containing nitrogen ; the ash elements of the food into bone and into the ash element found in the different parts of the body. The food eaten is not all digested and assimilated, a portion, varying from ten to seventy per cent., passing through

the animal as inert matter, and appearing in the solid excrements.

266. The different parts of the body of a living animal are constantly wasting away, while at the same time they are building up again from material supplied by the food.

With the exception of the carbon, oxygen and hydrogen of the food, the waste material of the body, including the undigested food, is thrown off in the solid and liquid manure, unless the animal is giving milk. From the above statement it will be seen that all that portion of the food consumed by the animal which is valuable for manure is either stored up in the body, converted into milk, or it is excreted as solid and liquid manure.*

267. To enable the farmer to grow and feed crops in such a manner as to secure the largest returns for his labor and at the same time retain fertility on the farm, some knowledge of chemistry is required, that he may know what he should feed and what he may sell. As a general rule no crop valuable for feeding, and at the same time containing considerable matter valuable for fertilizing purposes, should be sold unless it will sell for a price exceeding the cost of some other feed-stuff that contains a still larger amount of fertilizing material. Again, no sale-crop should be grown and sold continually that removes considerable quantities of nitrogen, phosphates and potash, unless an equivalent of these substances can be returned to the farm from some cheaper source, either in feed-stuffs or in fertilizers.

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*Carbon, hydrogen and oxygen are supplied to the plant from the atmosphere, hence are not necessary in the manure.

268. Drawing fertility from the land to be sold in the crop, and purchasing fertilizing material from outside sources to supply the loss, can hardly be compared to depositing money in a bank and checking it out again; for in the former case it is impossible to strike a balance-sheet to learn how the account stands. We have no means of ascertaining the amount and value of the original deposit, nor can we estimate the losses that may occur through the washing out of available plant-food, atmospheric dissipation of gaseous matter, or the accumulation of nitrogen from the atmosphere. These gains and losses are influenced to so great an extent by the peculiarities of the season, rainfall, temperature, system of cultivation, chemical changes taking place in the soil, and difference in the soil, that we cannot determine the exact condition of the land at any one time, nor can we control, except partially, the changes liable to occur.

269. While our present knowledge will not enable us to farm by rule, practical experience and scientific investigation have conclusively demonstrated certain general rules that may be modified by a thoughtful man to fit most cases. We find, almost without exception, in growing crops which contain large quantities of the valuable manurial elements referred to through this book, that selling these crops and making no return to the soil will in a few years reduce the productive capacity of the land to the extent of making the land unprofitable to cultivate. Again, we find that when the mechanical condition of the soil is right, and the requisite amount of water is supplied, it may be made highly productive, no matter how poor, if the chemical con-

stituents of the crop are added in sufficient quantity and in available form.

270. Practical experience has also shown that where the larger part of the crops grown on the farm are fed to stock and the manure is saved and applied to the land, the farm gains fertility and increases in productiveness, and scientific investigations explain why these results follow and they suggest how farming may be conducted so as to secure the best results. Tables are published in our agricultural journals and in books by various authors which treat of agricultural subjects, giving the composition of all farm crops, and of the commercial products sold for feeding purposes and for fertilizers.

271. The following table gives the average amount of nitrogen, phosphoric acid and potash found in some of the farm products common to the country and in a few of the concentrated feed-stuffs offered for sale in our markets, with their manurial values. The nitrogen is estimated at 16 cents; potash, at 5 cents; and phosphoric acid at 7½ cents a pound:

Table showing the average amount of nitrogen, phosphoric acid and potash found in one ton (2000 lbs.) each of some of the common feed-stuffs.

	Nitrogen. lbs.	Phosphoric Acid. lbs.	Potash. lbs.	Value.
Clover-hay	39.4	11.2	39.	$9 09
Timothy-hay	19.2	7.2	29.6	5 09
Corn-ensilage	4.8	2.2	7.8	1 32
Corn-stalks	13.2	7.8	17.2	3 55
Oat-straw	10.0	5.0	20.8	3 01
Wheat-straw	9.6	5.2	11.6	2 50
Cow-pea vines	50.2	8.2	28.0	10 05
Cow-peas	66.4	20.2	20.2	13 14
Corn (Maize)	33.8	14.2	8.0	6 87
Oats	41.2	12.4	9.0	7 96
Sorghum-seed	28.4	16.2	6.6	6 09
Corn and cob meal	22.9	10.9	9.2	4 94
Wheat-flour	37.8	7.4	5.6	6 88
Wheat-middlings	41.4	25.2	13.4	9 18
Wheat-bran	47.4	60.2	32.0	13 69
Gluten-meal	94.8	9.0	1.2	15 90
Linseed-meal	95.0	39.2	29.4	19 61
Cotton-seed meal	134.6	60.6	35.8	27 87
Cotton-seed hulls	7.0	1.8	26.4	2 57
Turnips	4.2	1.6	5.8	1 08
Cow's milk	10.2	3.4	3.0	2 05

272. The value given in the above table may not represent the actual value of the several substances for manure, but they do represent approximately their value, compared with the commercial fertilizers sold in our markets. In other words the values are determined in the same way.

273. In feeding a certain amount of clover, hay, oats, cotton-seed meal, or other feed-stuffs to farm stock, it is estimated that from 60 per cent. to 90 per cent. of the

fertilizing value of the food may be secured in the manure if it is protected from loss. It follows, therefore, that a feed-stuff or farm product may, at times, have a higher value for manure when fed to stock than it will sell for in the market, in addition to its actual food-value. We notice that timothy-hay is worth but little more than one-half as much as clover-hay for manure, yet timothy generally commands from 25 per cent. to 40 per cent. more a ton in the markets. Straw has a low manure-value, yet it often sells as high as clover-hay. Corn has a moderate manure-value, while cotton-seed meal and linseed meal have high values. Fed in the right way the cotton-seed and linseed meals are worth nearly twice as much, pound for pound, as corn for stock-feed, yet in some sections of the country these meals cost but little more a ton than corn.

274. A careful study of the food, manure and market values of crops grown, and feed-stuffs that can be bought, will often enable the farmer to sell some portion of his crop and with the return purchase its equivalent in food-value, often more, and at the same time get double the manure-value in the material purchased.

275. During the winter season in many places in the southern states, a bushel of corn can be exchanged for cotton-seed, which will contain not less than three times its equivalent in cattle-food, and four times its value for manure.*

276. The practice of selling large quantities of hay

*** In feeding milk-cows and fattening cattle, our experiments at the college show that one pound of corn is equivalent in food-value to not more than two and one-fourth pounds of cotton-seed During the winters of 1884-5-6, we sold corn at an average price of $20 a ton, and bought cotton-seed at $6 a ton.—*F. A. Gulley, Agricultural College, Miss.***

from a farm is not to be commended, unless some means are taken to replace the loss of plant-food. If, however, cotton-seed meal, wheat-bran, or any feed-stuff rich in plant-food is purchased and consumed, a part of the farm may be converted into permanent meadow, and the hay sold without injury to the place. Meadow-lands become impoverished as readily as land under cultivation; hence, if it is desired to make the meadow permanently productive, the soil must be enriched the same as for cultivated crops. Permanent meadows and permanent pastures, well set in valuable perennial grasses, may often be made even more profitable than land under cultivation, as there is but a small expenditure for labor. With an outfit of haying implements the entire labor on one acre of good meadow in growing and harvesting a crop of two and one-half tons of hay may not cost more than from three to four dollars. The actual cost of cutting and storing hay is sometimes reduced to one dollar a ton with hay worth from $8 to $14 a ton. The cost of production in proportion to the value of the crop is less than with almost any crop that can be grown.

277. Pasturing land economizes labor to a greater extent than growing hay. With this crop there is no outlay for harvesting. The crop is put into condensed form for marketing by being converted into animal products, and even the manure from the consumption of the crop is returned to the land without expense. Pasturing land is the most economical method of making it productive; and, properly managed, the soil (unlike cultivated land) improves with use. The value of a good pasture is not so generally appreciated in America as in the older countries. In England the pasture-lands

command the highest rents, because the farmer has learned that grazing-lands may be made to yield a greater return than the lands under tillage.

CHAPTER XX.

Farm Live Stock.

Origin — Wild and Domestic Animals—Wild State—Natural Variation—Race Qualities– Peculiarities of Breeds—Breed Defined—Formation of a Breed—Improvement—Retention of Qualities—Prepotency—How to Improve Common Stock—Effect of Neglect.

278. From the earliest times domestic animals, the live stock of the farm, have been used by man for various purposes. It is supposed that all of the domestic animals existed first as wild animals, but were caught and trained as men found they could be made useful.

279. Cattle, horses, sheep and hogs that are believed to be similar to the animals from which our present families of live stock have descended are still found running wild in some parts of the world. Among half-civilized tribes and semi-barbarous nations, animals that seem to be intermediate between the wild and the fully domesticated animals are common.

280. The domestic animals, with the exception of the dog and cat, include only such as feed wholly or in part upon vegetable products. These animals have been so modified by domestication that they often possess qualities not found in the wild varieties of the same species.

281. In the wild state animals simply have the power

of securing a living and reproducing their kind. Under domestication they acquire new habits and the power of making some return in the way of work, flesh, milk, or wool in addition to the preservation of existence. The wild cow simply furnishes enough milk to rear her calf, but under domestication she is able to provide for her calf and supply milk for the use of man. The sheep has been made to produce heavy fleeces of wool, and the meat-producing animals large quantities of meat.

282. In a wild state animals are modified by food and climate. In a temperate climate, with food plentiful and easy to be secured, animals tend to increase rapidly, and grow to a large size, and are of a quiet disposition. In a cold climate, where food is scanty and not easy to be secured, animals grow slowly, are small, active and hardy, and do not increase as rapidly as they would under more favorable conditions.

283. The same effect is produced under domestication, and from the same causes where man does not counteract these influences by selection in breeding and varying the food and shelter supplied.

284. The qualities of a race are the result of natural influences, but the qualities of an improved breed are artificial, being developed only by special treatment

285. The difference in the breeds and families of domestic animals is due to the influence of man. By persistent and systematic treatment the characteristics of our breeds of stock may be changed to meet our wants. In this way have been produced the trotting and running horses, possessing wonderful speed; the draft horse, with great strength and large size; the Jer-

sey cow, yielding from two to four pounds of butter a day ; the shorthorn, producing its great mass of flesh ; the merino sheep, a heavy fleece of the finest wool ; the remarkable intelligence of the hunting, shepherd and watch-dogs.

286. These changes can be accomplished only by long-continued exertion on the part of man, and when established are retained only so long as the animal is subject to the same conditions under which they were produced.

287. Turned out to run wild, the improved breeds of animals will lose their valuable acquired qualities, and deteriorate in a few generations to the condition of the animal from which they descended.

288. Breed is the name given to a class of animals that have acquired new and valuable qualities through the agency of man. Before any family of animals can properly be classed as a breed, they must have been bred by themselves until they are similar in shape, size, color, habits of growth, etc., and they must have these qualities so well fixed that they will be transmitted to the offspring with a good deal of certainty. Breeds are made by deciding first, upon the type of the animal to be produced ; second, by selecting such animals, male and female, as come nearest to this type, and breeding them together ; third, by selecting such of the offspring as approach still nearer to the type, and rejecting all others. In addition to breeding from selected animals only, a system of feeding, training and general care must be adopted that will help to develop and fix the qualities desired.

189. Formation and improvement of any breed of

animals should be sought first in the careful selection of the breeding-stock. To enable one to make a proper selection requires a degree of skill and soundness of judgment, such as can only be obtained by long experience in handling and caring for stock. Careful selection of the stock to breed from is necessary not only in the formation and improvement of the breed, but it must be kept up continually after the breed is established, to prevent deterioration and loss of qualities that have been secured by a long and careful system of breeding. The improvement in a breed being due to food and care as well as to selection in breeding, the improved breeds must have a more regular and better supply of food than is often thought necessary for common stock. The improvement made in the native animal in the formation of a breed consists of artificial qualities that have been developed under artificial conditions. The tendency of the animals thus formed is to breed back to the starting-point whenever the conditions under which the artificial qualities were produced are removed.

290. The older the breed, or, in other words, the longer the time during which a family of animals have been kept under the same conditions as regards selection in breeding and care, the more fixed will be the characteristics of the breed. This applies to inferior animals as well as to those possessing most desirable qualities. Purely-bred animals of the well-established breeds will transmit their peculiarities to their offspring, even when a male or female of the pure breed is bred to an animal of a different kind that is not purely bred. This power of an animal to transmit the qualities it possesses is called "prepotency," and it is one of the things that makes

the improved breeds of so much value to the grower of common stock.

291. The farmer may lack the skill and taste that are necessary to enable him to retain the good qualities possessed by an improved breed of stock, but by the occasional purchase of pure-bred males to breed to his native or grade females, he may secure to a considerable extent the merits of the pure breed in the offspring produced, owing to the pure-bred sire having greater prepotency than the inferior female, and thereby impressing more of his peculiarities on the offspring than will be inherited from the dam. The purchase of one pure-bred male will enable the farmer to improve the offspring of a large number of inferior females. The improvement that can be secured in this way is so marked that the most intelligent class of farmers in the country will use only pure-bred males if they can be procured by any reasonable expenditure of time and means.

292. It has been stated that the longer the time a breed has been purely bred the stronger will be the prepotency of the individuals of the breed. For this reason a grade, the offspring of a pure-bred animal and a native, will not transmit his qualities with such certainty as a pure-bred animal, although he may in appearance, growth, etc., closely resemble his pure-bred sire. No greater mistake can be made than to select a male to breed from and judge him by his appearance without regard to the way in which he was bred. Yet the appearance of the animal is the one thing that governs the choice of a sire with too many farmers. All skillful stock-breeders carefully examine the pedigree of

animals selected for breeding purposes, and reject any animals not descended from well-bred ancestors, without regard to his excellence as an individual. They have learned that individual excellencies may be accidental, and are not apt to be transmitted, while qualities inherited from pure-bred ancestors are almost certain to be impressed upon the offspring.

293. In the improvement of common stock by the use of pure-bred males, it must be remembered that the good qualities of the pure-bred male are partly the result of extra food and care ; therefore, if the grade offspring are expected to develop and possess the qualities of the improved breed instead of the native, they must to some extent be supplied with the conditions that helped to make the improved breed.

294. All of the large-yielding varieties of plants require good soil and thorough cultivation ; and all of the large and rapid-growing breeds of animals, and the cows that yield large quantities of milk and butter, are great eaters. The improved plant, set in fertile soil, and the improved animal, supplied with plenty of food, will make better returns for material consumed and labor required than the inferior varieties that flourish under less favorable conditions. The careless and indifferent farmer who practices poor cultivation and compels his stock to make their own living will gain little in adopting either improved varieties of plants or improved breeds of stock. On the other hand, the thrifty and careful farmer cannot afford to make such poor use of his time and opportunities as to expend them in growing and caring for an inferior class of stock which at the best will make but light returns.

CHAPTER XXI.

Breeds of Horses.

DOMESTICATION—EARLY HISTORY—THREE TYPES OF HORSES—ORIGIN OF THE ENGLISH THOROUGHBRED—THE AMERICAN TROTTER—DRAFT BREEDS—CLASSES OF HORSES IN THE UNITED STATES—PONIES—HORSES THAT HAVE VALUE, AND HOW THEY ARE BRED—SELECTION OF STALLIONS.

295. Horses are spoken of in the Bible and they are pictured in the earliest drawings and paintings and shown in the oldest sculptures. When and to what extent they were first domesticated is unknown.

296. The first authentic description of the different kinds of horses dates back to about the beginning of the Christian era. At that time a race of horses of medium size, noted for their speed and endurance, existed in northern Africa, southwestern Asia, and to some extent in southern Europe. Reference is also made to horses of large size in western central Europe, and to small horses, or ponies, in northern Great Britain and northern Europe.

297. These horses are all supposed to have descended from the same stock originally, but owing to difference in climate, supply of food, and treatment in the several countries, the three types were produced from causes explained in chapter XX.

The Shetland ponies are the descendants of the small horses of northern Europe; the large draft-breeds, of the large horses of western Europe; while the Arab, Barb and Turk, sometimes called "the horses of the desert," the foundation stock from which the running and trotting horses were developed, come from northern Africa and southwestern Asia.

298. The original stock of horses of Great Britian was improved by horses brought in at different times from western Europe, and from the countries bordering on the Mediterranean sea, from the time of the Roman invasion, B. C., down to the middle of the 18th century. Horse-racing, the great national sport of England, led to the importation of the Arabian horse, the Barb and Turk, to increase the speed of the English horses.

299. The imported horses were bred together by themselves, and to the best English stock, and in this way was developed the breed of horses known as the English thoroughbred.

300. With the general improvement in agriculture the large horses also received attention, and by careful selection for breeding and good treatment the English and Scotch breeds of draft horses were produced. At the same time the large horses of France and Germany were improved, some Arabian blood being mingled to give the large and clumsy horse more activity.

301. Horses were brought to America by the colonists: French horses largely into Canada, horses from Great Britain mostly to the States, while horses from Spain were introduced into Mexico.

302. After 1750 some of the better class of English

horses were imported, and towards the close of the century some of the best of the English thoroughbreds were introduced.

303. The English thoroughbred is the offspring of the Arab, Barb and Turk, with some slight mixture of the blood of the original English horses, and he was bred and trained with special reference to speed as a running horse. The American thoroughbred is the direct descendant of the English thoroughbred.

304. The English race-horse is a running horse, but from 1820 down to the present time, horse-breeders of this country have paid more attention to developing trotting horses.

305. Thoroughbred horses were bred to the best American mares, the offspring trained to trot, and bred together again; so that while the American trotters get their speed and other valuable qualities almost entirely from the thoroughbred horses they are not purely bred, and are not therefore thoroughbred horses, and they have been trained to trot instead of to run. The trotting horses have not been bred by themselves without other blood, and are not classed as a breed.

306. The early improvement of the native American horses was made by using thoroughbred stallions imported from England, and later from using horses bred in this country, the offspring of imported thoroughbred stallions and mares.

307. But little attention was paid to the draft breeds of horses before 1860. Since then large and frequent importations of French and British draft-horses have been made, and numbers of American mares of all kinds bred to draft-stallions.

308. We have then at the present time in this country:

1. Thoroughbred horses, descended from the Arab, Barb and Turk, through the English thoroughbreds; horses of medium size, light build, weighing from 850 to 1,050 pounds, noted for their intelligence, speed and endurance.

2. The American trotters, made up largely from the thoroughbreds, and like them in nearly every respect, except that they have been trained to trot instead of to run.

3. The pure-bred draft-horses, largely imported as yet; but great numbers are now being bred, of which the best-known breeds are the Percherons and French draft-horses, from France, and the Shire horses and the Clydesdales, from England and Scotland. Importations of other draft breeds from England, France and Belgium are being made. The draft-horses are large, heavy horses, weighing from 1,600 to 2,000 pounds.

4. The grades, or horses of mixed blood, the offspring of native and grade mares bred to thoroughbred trotting and draft stallions.

5. The unimproved common horses of all sizes and conditions.

6. The "Texas ponies" of the southwest, and the "Indian ponies" of the northern states and Canada, both of which are becoming extinct owing to the use of thoroughbred and grade stallions to improve and increase the size of the pony stock.

309. The Texas ponies are supposed to have come from the Spanish horses brought into Mexico at an early date, and as the Spanish horses are supposed to have

descended to some extent from the Barb, the ponies and the thoroughbreds may have a common origin, and, although the ponies have lost size, they still retain considerable activity and are noted for endurance.

310. The Texas ponies are of all colors, weigh from 600 to 800 pounds and, while they are of considerable value for riding on the plains, and make very good light carriage-horses where long drives are common, they are too small for general use. When crossed with animals of the improved breeds, they produce good general-purpose horses.

311. The Indian ponies of the north are supposed to have descended from the early importations of French horses into Canada. Many of the latter ran in a half wild condition, without owners, for years before the country was well settled, and from the effects of cold climate and scanty food were reduced in size, but they were hardy, tough little animals and like the Texans, the mares drop good colts when served by well-bred stallions.

312. There is an increasing demand in the country for horses fitted for some one particular purpose. To secure the best prices for his colts, the farmer should therefore breed his mares with reference to supplying this demand.

313. An ordinary farm-mare, bred to a stallion possessing no improved blood, will produce a colt of no special value, and as the country is overstocked with this class of horses, they command but a low price in the market.

The same mare, served by a good stallion of the improved breeds, will drop a colt having to a greater or less extent the qualities of the sire, and the colt will have more value.

314. The horses that have value are :

1. Race horses, bred from thoroughbred stallions and mares. If, however, the colts do not develop speed, they will not have special value for other purposes, unless they will make good riding or driving horses.

2. Trotters, bred from high-bred trotting stallions and trotting-bred mares, or mares that are fully or nearly thoroughbred. Like the thoroughbreds, the colts must develop high speed to have special value, unless they are of good size, stylish in appearance and good travelers, when they may sell for roadsters or carriage-horses.

3. Driving-horses, now in demand by all people who are able to support a turnout. This class of horses is bred from good mares having some running or trotting blood, coupled with showy, high-bred trotting stallions of good size. Driving horses must have size, style, good color and fair, but not necessarily great speed, and they must be sound to sell well. Should, however, any of these qualities be lacking, the horses sell as ordinary animals.

4. Heavy draft-horses. This class of horses is in demand, at good prices, for dray work in all our cities. They must be sound and heavy, weighing from 1,600 to 2,000 pounds. They are produced from pure-bred draft stallions and mares having one-half or more draft blood.

5. Light draft horses. These are now in demand for light dray work in the cities and for farm-horses all over the country, owing to the fact that all the large farm implements now in use, plows, harrows, mowers, reapers, binders, etc., are too heavy for light horses to handle.

315. Horses weighing from 1,200 to 1,600 pounds are the kind wanted. They must be sound; fast walkers; but are not expected to have trotting speed. This class of horses is produced by coupling pure-bred draft stallions that are not too large, with good ordinary mares, or mares having some improved blood. Good results are often obtained from breeding pony mares to draft stallions, but larger mares are preferable.

316. Of the five classes of horses, the trotters and runners command the highest prices, if they have speed, but they are the most difficult to produce, even when bred from the best stock. Of the offspring of the best bred stallions and mares, but a small proportion of the colts will develop the necessary speed to give them high value, and the skill required to handle and train such colts, to fit them for the market is not possessed by many farmers, nor have they often the capital to invest in the mares, and secure the services of stallions, that will produce this class of colts.

317. The roadster, or driving-horse, is bred with more certainty and from less costly breeding-stock, but considerable skill is required to breed and fit the horses to make them sell well as carriage-horses. Colts from fair-sized mares, bred to well-developed trotting stallions, will have sufficient weight to make a very good class of work-horses, if they lack the style demanded in driving-horses, and will be worth more than the inferior light-weight running and trotting colts.

318. The heavy and light draft horses are bred with even more certainty than the roadsters, as the qualities required in these horses are transmitted more readily

than speed and style, if well-bred stallions of the right kind are used, and the capital invested in mares need not be so large.

In the breeding of draft-horses considerable difference of opinion prevails as to which is the best breed to use. Each breed has its advocates, and men who are engaged in importing, breeding and selling draft stallions and mares claim superior excellence for the particular breed in which they are interested.

319. There are both good and poor horses in all of the draft breeds. Many of the horses have been imported to sell to any one who will buy, and they are kept in the most showy condition possible to cover any defects in structure.

320. It is undoubtedly of more importance to use a stallion that is sound in every respect, well built, active, not too large and beefy, of good disposition and from a family that possesses those qualities—regardless of whether he is a Percheron, Clydesdale or other particular breed—for grading up common mares, than to confine oneself to any one of the breeds.

321. The most certain method of determining the breeding qualities of a stallion is to examine his colts, and next to that, if he is a young horse, is to examine the get of his sire, and as many of his near relations as possible. Good feet, legs, eyes and lungs are prime requisites in any class of horses, and if the stallion is at all defective in any of these parts, his colts will be apt to inherit the weakness.

CHAPTER XXII.

Breeds of Cattle.

Classification of Breeds—Breeds—History and Description of the Beef Breeds—Shorthorns—Herefords—Aberdeen Angus—Galloways—Sussex—Dairy Breeds—Jersey—Guernsey—Ayrshire—General Purpose Breeds—Holstein—Friesians—Devons—Red-Polled Cattle—What Breeds to Select.

322. There is at the present time a considerable number of breeds of cattle in the country, but we will not attempt to describe more than a few of the best known.

For convenience, the breeds are divided into classes :

1. The beef breeds, or cattle that have been improved with special reference to the production of beef.

2. Dairy breeds, the cattle whose milking qualities have received special attention.

3. General-purpose cattle, those in which both beef and milking qualities have been sought.

Beef Breeds.

Shorthorns (also called Durhams).
Herefords.
Aberdeen-Angus, } polled cattle.
Galloway, }
Sussex.

DAIRY BREEDS.

Jerseys,
Guernseys,
Ayrshires.

GENERAL-PURPOSE BREEDS.

Holstein-Friesians,
Devons,
Red-polled.

Some breeders would, perhaps, class the Shorthorns as a general-purpose breed, and some admirers of the Holstein-Friesans would include them in the dairy breeds.

323. Some families of the Shorthorn are good milkers, and grade Shorthorn cows, as a rule, are very good dairy animals, but for fifty years and more the great majority of the Shorthorn breeders have paid attention to beef qualities alone.

324. In Holland the Holstein-Friesians are known as a dairy breed, but the steers are of a large size, feed well and make a good quality of beef.

Holstein-Friesian breeders of this country, while asserting that the Holstein-Friesian cow has no superior in the dairy, also claim that the steers are good feeders.

325. The Shorthorn breed originated in Durham county, in the fertile Tecs Valley, in the northeastern part of England. Tradition says that Dutch cattle, brought into England several hundred years ago, helped to make the foundation of the breed.

326. The earliest reference to this breed is in the early part of the last century, but they did not become well known until after 1775. They were then large,

rather coarse animals, did not mature under five or six years and were noted for being deep milkers. In the latter part of that century and the early part of the present, attention was paid to developing the beef quality and early maturity of the breed. The improvement of this breed in both England and America, up to the present time, has been in the same direction.

327. Just when the first Shorthorns were brought to America cannot be determined, but importations were made into several of the states before 1825, and a good many herds were established before 1850.

328. Up to 1850 no other improved breed of cattle was generally known in this country, and by that time a considerable portion of the cattle of Virginia, Kentucky and the country north of these states and east of the Mississippi river, had more or less Shorthorn blood.

329. The Shorthorns vary in color from all white to roan and dark red, hence the name "red, white and roan" is sometimes given to them. The popular color in this country is deep red.

330. The English breeders, from 1780 to 1825 and later, not only improved the qualities of the breed, but they took pains to advertise their cattle, and make them more generally known than any other breed, and the same has been done by American breeders.

Mature bulls weigh from 1,700 to 2,100 pounds, and heavier weights are not uncommon. The horns are short, bodies heavy and compact, legs of medium length; and as a breed they are quiet in disposition, slow in movement and fatten well at any age. Bred on native or inferior cattle, the offspring make good cows, and the steers feeders that are hard to excel.

331. That the Shorthorns take first rank in the estimation of the people of the country, is partly due to their excellent qualities, and partly to the fact that they are better known than any other breed of cattle

HEREFORD CATTLE.

332. The Herefords came from Herefordshire, in the western part of England. Not much is known of this breed prior to 1750. They were much improved in the latter part of the century, by judicious selection for breeding and good care, as were the Shorthorns.

Only a few of these cattle were brought to this country before 1850; in fact, not many herds were established before 1865, but from 1870 to 1885 a good many were imported and numerous herds started in the central and western states.

333. The Herefords are essentially beef animals. No claims for valuable milking qualities ever having been made. The Herefords at the present time are about the same size as the Shorthorns, somewhat similar in shape, except they may have shorter legs and a little longer horns. They are perhaps a little more active in their movements, and it is claimed by Hereford breeders that they are hardier and better adapted to life on the western prairies. Color is from red to dark red, with white faces, white stripe running from back of the neck over the shoulders, white belly, feet and brush on end of tail.

334. The white face is a characteristic mark and is usually transmitted to the offspring when native cows are served by pure-bred Hereford bulls.

The breed has become very popular for grading up native cattle for beef-growing where it has become known.

ABERDEEN-ANGUS AND GALLOWAY CATTLE.

335. The polled Angus and Galloway cattle come from Scotland. They are now recognized as separate breeds, but up to 1870 they were classed together. The early history of these cattle is buried in oblivion, but it is known that cattle without horns have existed in Scotland for more than two centuries. Considerable improvement has been made in these breeds since 1850, and particularly with the Aberdeen-Angus, in the way of early maturity and tendency to fatten.

336. The Aberdeen-Angus have round compact bodies, short legs, heads pointed on top, hair longer than on the Shorthorns, but fine and soft, and they are entirely black. Mature bulls weigh from 1,700 to 2,000 pounds, cows 1,200 to 1,500. As feeders they rank fully equal to the Shorthorns and Herefords. And the meat is of the best quality.

337. The Galloways are like the Aberdeen-Angus, except that the hair is longer and coarser; they are not quite so large, perhaps do not fatten quite so readily, although they rank high as feeders. They are said to be hardier, and they adapt themselves readily to any part of the country and are good range cattle.

338. Both the Angus and Galloway cattle have strong prepotent power, transmitting the beef quality with a good deal of certainty to their calves when pure-bred bulls are used for grading up common cows.

These breeds have become popular in the west since

1870, and the pure and half-bred bulls are sought by many of the ranchmen for use in their herds.

SUSSEX CATTLE.

339. The Sussex cattle take their name from Sussex county, England. They are similar to the Devon breed, except that they are of larger size and the beef quality has been more developed and the milking habit allowed to deteriorate.

340. They are supposed to be an offspring of the Devon family, modified by changed surroundings. They are not quite so large as the Shorthorns, but rank with them in early maturity and tendency to fatten at any age. They were first brought to this country within the last ten years and are beginning to attract considerable attention.

DAIRY BREEDS.

341. The islands of Jersey, Guernsey and Alderney, lying off the coast of France, in the English Channel, are the home of what are known as the Channel Islands cattle. Each island has its family of cattle, to which it gives its name. These cattle are supposed to have come from the same source, and it is thought that they are descended from the cattle of Normandy.

342. Soon after the middle of the last century the importation of cattle into the islands was prohibited, so that for more than 100 years, and probably much longer, the Islands cattle have been bred by themselves. Each island has its distinct family, and although they are somewhat alike and undoubtedly have the same origin, they are recognized as distinct breeds.

343. The largest of the islands, Jersey, is only some eleven miles long and six miles wide, but on this small tract of land a great many cattle are kept. Some writers estimate the number as 10,000 head, and during the past 30 years several thousand head have been exported, mostly to the United States.

344. It has been the aim of the Jersey and Guernsey breeders to produce cows that would give rich milk, and the largest amount of butter of fine quality, from a given amount of food.

345. Quantity of milk has not been so much sought, and size of the animal and production of beef has been entirely ignored. The result of this breeding for a special purpose is a cow weighing from 650 to 950 pounds and the bulls from 900 to 1,400 pounds.

346. The cattle are of light build, bones somewhat prominent, rather delicate in appearance, not much tendency to gather flesh, but nevertheless, animals of good constitutions, healthy, good eaters, with a faculty for readily adapting themselves to any portion of the country, if properly handled.

347. Their color runs through light cream to fawn, light and dark brown, sometimes almost black, many of a nearly solid color; but more often runs from one shade into another and occasionally is spotted. The horns are light and short, heads small, eyes bright, neck and fore-quarters light, stomach large, hip-bones prominent, udder large and full.

348. The cows and young cattle have a deer-like appearance, and a herd makes quite an ornament to a lawn. Judged from the beef standard, the Jersey cattle would

be considered almost worthless, but for making butter the Jersey cow has no superior.

349. The Guernsey does not differ materially from the Jersey, except in being larger and some coarser. Not nearly so many of the Guernseys have been brought into this country, and they are therefore not so well known.

350. Only a few cattle are kept on Alderney Island, and not many have been exported.

351. The introduction of the Channel Islands cattle into the United States began about 1850. For some years they were looked upon as "the gentleman's cow," more ornamental than useful, but as their merits became known, they rapidly gained popularity and now fill an important place in the butter-dairy herds of the country. Perhaps no breed and its grades is so generally spread over the country, unless it may be the Shorthorns, and no cattle are more popular with their owners.

352. The Jersey bull has strong prepotent power and transmits the qualities of the breed to his get from native cows. The grade bull-calves from such breeding are of little value for steers, and such of the heifers as do not make good cows are likewise inferior for beef. This is an objection to the farmer who wants both milk and beef, but not to the dairyman who purposes to keep cattle for the sole purpose of butter-making.

AYRSHIRE CATTLE.

353. The Aryshire breed, of Scotland, is of recent origin. No mention is made of it before 1800. The breed is of mixed blood, some holding that it is made up largely of Shorthorn blood, others that the Alderney or Jersey contributed, while others believe that both

breeds were used, in connection with the native cattle as a foundation.

354. For the past fifty years or more the Ayrshires have been bred with reference to the milking qualities, and the breed has a favorable reputation as dairy cattle in Great Britian and in this country.

355. The shape of the Ayrshire is somewhat like that of the Jersey, broad behind, narrow in front, the general form of all the milk breeds. They are larger, and give perhaps more milk, but the milk is not so rich in butter.

356. The color is somewhat like that of the Shorthorns, varying from brown to red and white, and roan.

The cows have large udders, are active, hardy, do fairly well on rough land and coarse food, and are of special value in cheese-making districts.

357. Quite a number of these cattle were imported into this country before 1860, and a few since, but while they have many admirers they have not become generally popular like the Jerseys and Holstein-Friesians.

General-Purpose Breeds.

HOLSTEIN-FRIESIANS.

358. For several years that portion of Europe known as the Netherlands has been noted for its dairy products, and while the early history of the cattle is somewhat obscure, it is known that special attention has been given to the breeding and improvement of cows that yield large quantities of milk and at the same time produce steers of large size, that fatten readily and make good beef.

359. Black and white are the prevailing colors, but red and brown are occasionally found.

In size the Holstein-Friesian breed ranks with the Shorthorns. Bulls weigh from 1,600 to 2,200 pounds, cows from 1,200 to 1,600 and heavier weights are quite common. The cattle are hardy, active animals, thrive well in all the countries they have been carried to, where food is abundant, are large eaters, rapid growers, and the cows rank first in the production of quantity of milk. The milk lacks the superior richness of Jersey milk, but it compares favorably with that of the Ayrshire.

360. Not much was known of these cattle in this country until after 1860. From 1870 to 1885 large numbers were brought in. Size in any breed of cattle is thought desirable by most American stockmen, and the large size and handsome appearance of the Holstein-Friesians, added to their many other valuable qualities, has made them exceedingly popular with farmers and dairymen over a considerable portion of the country.

DEVON CATTLE.

361. The Devon is one of the oldest breeds of English cattle and has received no infusion of other blood since the history of breeds of cattle has been written. The breed takes its name from Devonshire, the home of a race of red cattle for several centuries. The breed was much improved during the latter part of the last century, the same as in the breeds that have been described, but the milking qualities were not entirely lost sight of in the improvement of the breed for beef.

362. The cattle are of medium size, have always been noted for their activity and their ability to keep in good

condition, even when the pastures were not of the best. They are good dairy cattle. The cows give a fair quantity of milk of good quality.

363. The color is invariably red, except white spots on belly and brush on end of tail, the bodies round and well filled out, legs of medium length, head not heavy, horns long and graceful, eyes bright, quick walkers, good rangers, and they take on flesh readily when supplied with plenty of food. They lack the size of the Shorthorn, will not give so much milk as the Holstein-Friesians, and the milk is not quite so rich as that of the Jersey, but as a general-purpose breed for hilly countries, where the pasture is not of the best, the breed is not excelled. For working oxen they take first rank, owing to their quick motions and muscular bodies. Mature bulls weigh from 1,300 to 1,700 pounds, cows from 900 to 1,100 pounds.

364. This breed was introduced in the early part of this century and has been quite popular in New York, Pennsylvania and in the New England states, and also in some of the southern states. They have not found favor with the stockmen of the west, where larger size is considered important, and have not therefore attained the popularity of the large breeds.

RED-POLLED CATTLE.

365. The Red-polled cattle, another English breed, are much like the Devons, without horns. Of late years attention has been paid to increasing the weight, so that they now rank between the Devon and the large breeds in size. They are valuable for both milk and beef, and their larger size, and the absence of horns, make them them more popular with many than the Devons.

366. The Red Polls have been known in this country only since 1875, but quite a number of herds have been established. The absence of horns commends them to those who prefer cattle without this useless appendage, but who do not admire the black "muleys" from Scotland. The steers feed well, mature young, and as a breed they promise to fill an important place in the fertile lands of the great corn-growing states.

OTHER BREEDS OF CATTLE.

367. Besides the breeds mentioned, several others are gaining or have gained a foothold in the country, and are found of value for certain purposes in some localiries:

368. The West Highland cattle, a medium-sized and very hardy Scotch breed, noted for fine quality of beef, promises well for the rougher and colder portions of the country.

369. The Brahman cattle from India, a peculiar race with a large fleshy hump over the shoulders, and drooping ears. A few of these cattle have been brought into the southern states and crossed on the native stock, and quite a good many of the southern cattle have a small infusion of this blood. The effect of the cross is shown in increased size, hardiness, and better feeding qualities. They are noted for being exempt from certain diseases of cattle common to warm countries.

370. Of dairy cattle, the Dutch Belted cattle, a branch of the Holstein-Friesian family, and much like the latter in every respect except in the marking. They are black with a broad white band running around the central part of the body.

341. The Brittany cattle from France, a smaller dairy breed than the Jerseys, whose principal value is said to consist in their ability to yield a fair quantity of rich milk on very scanty pasture. In appearance they resemble the Holstein-Friesian very much degenerated. They may prove to be of considerable value for dairy purposes in rough mountainous parts of the country not adapted to larger breeds.

372. The Swiss cattle, a breed resembling the Jerseys somewhat, but with heavier bodies, stronger legs and darker color, are noted for their dairy qualities in Switzerland, and prove satisfactory in this country so far as tried.

WHAT BREEDS TO USE.

373. The selection of animals to start a herd of pure-bred cattle, and the breeding, handling and selling of such stock, is a business of itself. We might say it is a profession, which, to be made successful, will require the personal supervision of the owner and a continual study of the art of breeding. Besides this, he must have a fondness and ability for the work.

374. The breeding of dairy stock or beef-cattle by using pure-bred bulls on common or graded cows, and the handling of such cattle successfully, requires much less skill, judgment and capital. It is work that is not beyond the capabilities of the average farmer. The value of the expert skill of the professional stock-breeder may be secured through the purchase of pure-bred bulls from well-established herds, adapted to the special line of work to be pursued.

375. The grade offspring sired by pure-bred bulls, and

having one-half, three-fourths, or more improved blood, is nearly, if not quite, equal to the pure-bred animals for either milk or beef production, and with the present competition and low prices of cattle products, the man who keeps cattle for any purpose must grade up his stock if he expects to make it profitable.

376. Before selecting a bull of any breed, the object for which the cattle are to be bred, and facilities for supplying the conditions under which the breed to be selected has been developed, should be carefully considered.

377. With good pastures and an abundance of food, the large breeds, the Shorthorns, Herefords and Angus cattle will give good results in beef-production. If, however, the cattle will have to range over considerable ground to get their food, the smaller and more active breeds, such as the Galloway and Devon will thrive better. If the cattle are to be exposed to cold weather, the Galloway or the West Highland may give best results. For the extreme south and southwest, cows that have a dash of Brahman blood may supply the best foundation to build on for grading up with bulls of the improved breeds.

378. For grading up a dairy herd, where the sole object is butter-making, and the male calves and old cows are to be killed off or disposed of in some way other than attempting to feed for beef, and the cows are to be well handled, the Jerseys or Guernsey will fill the bill better than any other breed. But if the sale of milk, the making of cheese, or the growing of beef-cattle is to be carried on with dairying, the Holstein-Friesian will take

first rank where the food-supply is abundant. The Shorthorn bull, to grade up common stock for a general-purpose animal, will also succeed under similar conditions.

379. For the hilly country of the eastern states, the Ayrshire may answer the purpose as well as any other breed, while the small Brittany, or the hardy and strong Swiss cattle, may be better for the broken country lying along the sides of the Alleghanies or the Rocky mountains.

380. Each one of the improved breeds of cattle has been developed for special purposes, and it is adapted to live under certain conditions of climate, food and care. It is therefore less difficult now to find a breed fitted to our surroundings and to our needs, in any part of the country than to modify a breed that does not possess these characteristics.

381. Superior excellence must not be sought in cattle not bred for a special purpose. While the general-purpose breeds are essential to meet the wants of many farmers, the best breeds, or families of breeds, of beef-cattle will not make superior milkers, and the best dairy breeds and families will not furnish animals that will rank high for beef.

CHAPTER XXIII.

Sheep.

NATIVE SHEEP OF THE UNITED STATES—IMPROVED SHEEP—CLASSES—MERINO SHEEP, SPANISH, FRENCH, SILECIAN, SAXON AND AMERICAN — COARSE-WOOLED OR MUTTON SHEEP, LINCOLN, LEICESTER, COTSWOLD, SOUTHDOWNS, HAMPSHIRE, SHROPSHIRE, OXFORDSHIRE—SELECTION OF A BREED.

382. The so-called native sheep of the United States are the descendants of sheep brought into the country by the colonists from Europe. At the present time nearly all of these sheep have some of the blood of the pure breeds, but where they have been bred together promiscuously they are classed as native.

383. The improvement of the sheep of the world has changed the covering or fleece from part wool and part hair to all wool; made the wool longer, thicker, in some breeds finer; and in England, especially, increased the size of the sheep, made them better feeders, and improved the quality of the mutton.

384. Sheep are classed as fine-wooled sheep and coarse-wooled sheep. The latter are also known as the mutton breeds of sheep. The oldest improved breed of sheep is the Spanish Merino.

385. Spain was noted for its fine-wooled sheep before the Christian era, and for many centuries the breeding of this family of sheep was confined to that country. In the latter half of the last century Spanish Merino sheep were carried to France, to Silesia and Saxony, two German provinces; and about the first of the present century they were brought to America. From these exportations the French, Saxon, Silesian and American breeds of Merino sheep originated.

386. Prior to 1825, several thousand Spanish Merinos were brought to this country from Spain, and from these sheep, with occasional additions of Silesian and Saxon Merinos to some of the flocks, we get our present celebrated American Merino sheep.

387. The American Merino sheep are of medium size, mature rams weighing from 110 to 150 pounds; ewes from 90 to 100 pounds. The entire body is covered with a close compact fleece of fine wool, about two and one-half inches in length. The rams shear from 15 to 25 pounds, and ewes from 9 to 15 pounds, of unwashed wool. The wool is oily, giving the sheep a dark appearance when compared with other breeds. Some families of the Merinos have deep wrinkles or folds of the skin running around the neck and body.

388. In hardiness and in ability to live on scant pasture, the Merinos stand at the head of all the improved breeds. They also thrive in large flocks, which is not true of the larger mutton sheep. Owing to their hardy qualities, ability to live without much care, and adapt themselves to almost any portion of the country, and to the fact that the majority of the American people are

beef and pork, rather than mutton eaters, and pay more attention to wool than to mutton-growing, the Merinos have been the most popular breed of improved sheep.

389. At the present time the greater part of the native sheep have some Merino blood, so widely has the breed been disseminated and used to improve the fleeces of the common sheep of the country.

390. The average fleece of a flock of unimproved native sheep weighs from four to six pounds, while the average weight of the wool of one-half and three-quarter bred Merino sheep is from seven to nine pounds.

COARSE-WOOLED SHEEP.

391. The coarse-wooled breeds of sheep are of English origin. They are the native sheep of the country that have been bred for many years with special reference—first, to mutton; second, to wool. They may be divided into long, short and middle-wooled breeds.

392. The long-wools include the Lincoln, Leicester and Cotswold breeds, of which the last is best known in this country. In the improvement of these breeds, in the latter half of the last century, the blood of the three breeds was intermixed to some extent, but each breed has its distinct and well-marked characteristics.

393. The Lincolns are the largest and have the longest wool. Mature rams and wethers weigh from 250 to 300 pounds, and the wool often reaches 12 and 13 inches in length.

394. Leicesters and Cotswolds are not quite so large as the Lincolns, and the wool is not quite so long, but the comparative size of the three breeds is perhaps more a

question of how a flock has been bred and handled than one of breed.

395. The Cotswold is the most popular of these breeds in this country and is being used to a considerable extent in grading up smaller sheep for the production of mutton.

396. The short and middle-wooled breeds include the Southdown, Shropshire, Hampshire and Oxfordshire-Down sheep. The Southdown is one of the oldest of the English breeds, and one of the most noted for its fine quality of mutton. It is also the most popular of the English breeds in America.

397. The Southdowns are round-bodied, compact-built sheep, rather short legs and short wool. Mature rams and wethers weigh from 150 to 200 pounds, ewes about 100 pounds. They shear from 6 to 9 pounds of wool. The sheep are white, with dark brown or black faces and legs. They are hardy, prolific, and thrive with moderate care in all parts of the country, and the mutton is of the finest quality.

398. The Hampshires and Shropshires are larger than the Southdowns, but somewhat like them in appearance otherwise, having the dark faces and legs. They are supposed to have come from a combination of the Southdowns with some of the larger families of native sheep. They have longer wool than the Southdowns and the fleeces are heavier. Mature rams weigh up to 200 pounds, and fat wethers sometimes 300 pounds.

399. The Oxfordshires rank perhaps next to the largest breeds of sheep. They are marked like the Southdowns, with dark faces and legs, and are said to have

both Southdown and Cotswold blood in their composition.

400. For quite a number of years each of the several breeds of "Down" sheep has been bred by itself, and the peculiarities of the breed have become fixed, so that when crossed on mixed or inferior sheep the valuable qualities are transmitted to the offspring with a good deal of certainty.

401. The three large breeds of the "Downs" sheep are gaining in popularity in this country, due to their large size, and the readiness with which they grow and fatten.

402. The mutton-sheep are becoming more profitable in certain parts of the country than the fine-wooled sheep, and not a few wool-growers are crossing Southdowns and the larger coarse-wooled rams on grade Merino ewes with good results.

403. As in the breeds of cattle, each one of the several breeds of sheep has certain characteristics that makes it of value for certain purposes under certain conditions.

404. The selection of the breed should, therefore, be considered in the manner referred to in the chapter on Cattle (page 127).

Like cattle, the large breeds of sheep require better pastures, more food and better care than the small breeds.

405. The improved breeds of all kinds of stock, with the possible exception of the Merino sheep, are designed to accompany an improved system of agriculture.

APPENDIX.

To the Teacher.

In teaching, the faculty of stimulating the ambition of the student and creating in him a desire to learn is the first requisite. The most learned persons are by no means the best teachers, and especially in the primary branches.

For some years the author, with others, has believed that study of the sciences should begin with the primary classes; that the study of plants, of animals and nature generally, is no more difficult to young people than the rules of arithmetic and grammar; that something the boy can see and feel and reason about will awaken interest, stimulate the mind, discipline the will, and supply the very best mental culture to the inquisitive young scholar.

In soliciting opinions as to the advisability of a primary text-book on agriculture for the common schools, I have been told that the teachers in our public schools are not prepared to teach such matter, and that *things*, not *books*, are essential in such studies. Some considerable experience has shown that agriculture can be successfully taught to the preparatory classes in our colleges, and it follows, therefore, that it may be done with the advanced classes in our public schools, if the teacher will qualify himself. If the teacher has not gone outside of English, mathematics, geography and history, he will have to take up a new line of reading and observation, but any progressive, wide-awake teacher can soon qualify himself to carry a class over such a book as this and make the study interesting and instructive.

In such study, *objects* must be considered, the text-book should be used simply as a guide, and the more the text can be illustrated by things the student can see, and even put his hands on, the better.

A little apparatus should be borrowed or purchased, but it need not be expensive. An iron tablespoon, an annealed glass flask for boiling water, a couple of 6-inch glass test-tubes, a kerosene lamp—an alcohol lamp is better, but not essential.

For showing that change of temperature will cause some substances to pass from solid to liquid and then to gaseous form, an ounce of chloride of ammonia or chlorate of potash, costing together about ten cents, at any drug-store, may be used. A couple of test-tubes and flask will cost 25 cents, and may be procured at the same place. Lime, samples of soil, fertilizers, plants, etc., may be picked up with a little trouble, with the aid of the students. Some of the teacher's time will be required, but no good instructor will feel that work that interests his students is time lost.

The more the students aid in collecting objects, the greater will be their interest.

A few suggestions are made to aid the teacher in illustrating the lessons. It is hoped these few hints will call up other thoughts that may add interest.

ILLUSTRATIONS.

CHAP. I. Place a small lump of chloride of ammonia, or chlorate of potash, in an iron spoon and heat over a lamp. The substance will first melt, then pass off as vapor. A lump of ice will act in the same way. Show that water-vapor is invisible, as explained in foot-note, par. 5. Burning a match will illustrate. Par. 6. Exhibit a piece of limestone, and a lump of fresh-burned lime; slake the latter before the class. Partially slake a little lime a day or two before the lesson, to show combination of lime and water. Par. 18. Fill the test-tube within one inch of the top with clear water, add a teaspoonful of salt or of sugar, and show that after it has dissolved the bulk of water will be but slightly increased.

CHAP. II. Call attention to the round pebbles found in streams, which show the grinding effect of running water. Broken rocks have sharp edges and corners until so worn off. Pars. 25, 26. Call attention to old rocks, stone buildings, old headstones, to show that all rocks are slowly crumbling away when exposed to the atmosphere.

CHAP. III. Exhibit and explain difference in samples of different soils—sand, loam, dry. Wet them and show how they differ when moist.

CHAP. IV. Exhibit wheat-flour and wheat-bran, and give the amounts of nitrogen, phosphoric acid and potash they contain; see par. 271 to explain why one draws more from the soil than the other.

CHAP. V. Show leaf-mold from the woods or piece of sod; and compare with sample of soil from old cultivated field.

CHAP. VI. Exhibit clay, loam, sand and leaf-mold; show that the first will adhere like putty, when wet and pressed together, while the others crumble to pieces. Prepare some of each the day before the lesson, to show how they act after drying.

CHAPS. VII. AND VIII. If in summer time, the attention of the students should be called to the growth of crops in fields near by on wet and dry soils, also to ditches or creeks where the effect of running water may be shown. The washing out and filling in may be seen in the dry bed of a stream, where water has recently been flowing. If possible, rig up a level and rod and give a practical lesson in laying off a level line, or line with fall.

CHAP. IX. Call attention to implements in use on neighboring farms; if in a town, visit a store where farm tools are sold, and explain the use of different implements.

CHAP. X. Some ten days before the lesson is to be studied, prepare one or more small boxes of earth—old vegetable or fruit-cans will answer—and plant a half dozen or more kernels of corn. Every other day make a new planting. Place the boxes in a warm place and keep the soil moist. Wet the soil, and before the class carefully remove the young plants and show the different stages of germination. Have the students cut up kernels of corn, beans or other large seeds and examine the structure.

CHAP. XI. Have the students examine such flowers as may be collected and study the structure. Point out sepals, petals, stamens and pistils; compare different flowers.

CHAP. XII. If possible, get samples of both inferior and improved varieties of grain, vegetables, or any plants to compare. Students will often bring in specimens, if requested to do so.

CHAP. XIII. Call attention to different methods of cultivating crops practiced in the vicinity. Call upon students to explain methods followed at their homes.

CHAP. XIV. Explain more fully than given in the text, what it is in manure that is of special value, and why some feed-stuffs make richer manure than others. Refer to table (par. 271), for manurial value of the feed-stuffs mentioned in this chapter.

CHAP. XV. AND XVI. Get samples of a few fertilizers for the students to examine, if they can be procured. In many towns and country places, fertilizers are kept for sale, and the agents will gladly supply samples. Explain why it takes a good many pounds of barn-yard manure to equal one pound of commercial fertilizer.

CHAPS. XVII.-XVIII. Call on the students to explain systems of farming practiced at their homes. If they do not know, have them inquire of their parents. Ask for statements of results and opinions of the people at home ; this will lead them to think of these questions.

CHAP. XIX. Discuss with the students, methods of stock-feeding practiced in the vicinity. Solicit opinions of stablemen and stock-feeders and report to the students.

CHAPS. XX.–XXIII. If any good stock are owned in the vicinity, take the class out and visit the place after school-hours, or on a Saturday or other holiday, and get their owner to give the students a talk. Report to students weights of cattle, yield of milk, speed of horses, anything that will interest them about stock; samples of wool of different breeds of sheep may be brought in for inspection.

The teacher will find that the discussion of subjects pertaining to everyday life, will awaken an interest far beyond the study of books, and a conscientious trial of this method of teaching will prove satisfactory to both instructor and scholar.

THE AUTHOR.

GLOSSARY.

Absorb—To drink in ; to suck up ; to imbibe, as a sponge.

Ammonia—A chemical combination of hydrogen with nitrogen.

Analysis—To determine the elements that enter into the composition of any material.

Artificial—Made or contrived by art, or by human skill.

Assimilate—To convert into the tissues and structure of the plant or of the animal.

Atom—The smallest particle of matter than can enter into combination.

Available—In condition to be used.

Bull-tongue—A one-toothed implement for breaking-up and cutting the soil.

Calcareous—See Par. 38.

Chemistry—A science relating to the composition of substances.

Compact—Close together, firmly united.

Compost—To mix together.

Compost-heap—A mixture of stable manure, or any material containing plant-food, with earth, leaves, refuse and trash of any kind.

Combination—Joining together.

Constituents—The parts that enter into the composition of any material.

Concentrated—Condensed, very rich, boiled down.

Cross-breed—A plant or animal produced by parents of different breeds or races.

Cross-fertilize—In plants—to fertilize the pistil of a flower with pollen from another flower.

Cotton-seed meal—After removing the hull, the kernel of the seed is subjected to heavy pressure to extract the oil. After pressing, the residue is left in hard masses called cotton-seed cake. The cake is ground up fine and it is then known as cotton-seed meal.

Cotton-seed oil. Oil extracted from the seed of the cotton-plant.

Cotton-seed hulls—The outer envelope of the seed, to which the cotton-lint is attached. Several seeds with a quantity of lint are enclosed in a spherical-shaped pod, the whole being called the cotton-boll.

Cow-pea—A plant belonging to the bean family (not a pea), common in the southern states. The peas are used on the table, are valuable for stock food, and the vines cut and cured properly make an exceedingly nutritious and palatable hay. As a renovating crop the cow-pea is nearly, if not quite, the equal of the red clover. It will grow on very poor land. There are several varieties.

Deteriorate—To grow worse, lose quality, run down.

Digested—To separate into nutritive and non-nutritive parts in the stomach. The former may be assimilated into the circulatory system, while the latter are thrown off as an excretion.

Dormant—Not active, asleep.

Edible—Fit to be eaten as food.

Evaporate—The act or process of turning into or passing off in vapor. To change from liquid or solid to the gaseous state.

Exhale—To breathe out, to throw off as vapor.

Excrement—The waste matter thrown off from the body of an animal.

Feed-stuffs—Any product used for feeding stock.

Fertilize—To enrich soil; to make productive; to bring pollen in contact with the pistil of the flower.

Fertilizer—Any material that will enrich the soil and supply plant-food.

Fertilizers—Commercial—Fertilizers sold in the markets.

Fertility—Fruitfulness, richness, power to produce.

Fossil—The remains of plants or animals found in the earth.

Gaseous—Having the form or state of gas or vapor.

Geology—The science which treats of the formation and structure of the earth, its rocks, etc., and the changes undergone.

Germinate—To grow.

Glucose-meal—Refuse matter from the starch and glucose factories, used in some parts of the country for stock food.

Gluten-meal—A concentrated food-stuff derived from the wheat germ. The germ is separated from the kernel of wheat in the modern process of milling in making the finer grades of flour.

Grade—The offspring of a pure - bred or improved parent, and a native, inferior, or impurely bred parent.

Gypsum—Also called Land-plaster, a combination of sulphuric acid and lime, a valuable fertilizer on some soils for certain crops.

Harrow—An implement consisting of a frame of wood or iron filled with teeth, for making the soil fine. The harrow is made for one, two, or more horses, and is used principally to break up the lumps and compact the soil broken up by the turning plow to fit the land for planting.

Inert—Not active, unchangeable, sluggish.

Insoluble—Not readily dissolved.

Inorganic—See Par. 33.

Kainit—A salt found in large deposits in Germany, which contains about 25 per cent. of sulphate of potash, mixed with sulphate of magnesia and common salt. Kainit is valuable for the potash it contains.

Land-plaster—A kind of rock found in large quantities in many places, composed largely of sulphate of lime. The plaster is prepared by simply grinding the rock fine. At the mills the plaster sells at from $1.50 to $3 per ton.

Level cultivation—Plowing broadcast and keeping land level instead of throwing it up into narrow ridges or beds to plant on, and working out the crop with a cultivator that does not throw dirt up to the plant.

Lint—Referring to cotton, the fibers attached to the seed, that constitute the cotton crop, and valuable part of the plant.

Linseed-meal—That part of flax-seed that remains after the oil is pressed out and the cake is ground fine. This meal makes a very rich stock food, and is used extensively by farmers in this and other countries. It is very similar to the cotton-seed meal.

Maximum—The greatest quantity that can be obtained.

Natural—Produced by nature without being influenced by man.

Native—Belonging to the country. Native stock means the common unimproved stock of any section of the country.

Nitrate—Combination of nitric acid with a metal or salt. Nitrate of soda is composed of nitrogen, oxygen and soda.

Nutritive—Having the power of nourishing or building up the body.

Organic—See Par. 32.

Oxidize—To combine with oxygen.

Pedigree—A statement or list of the ancestors or progenitors.

Phosphate—A combination of phosphoric acid with lime or other base.

Plant-food—Material that can be utilized by the plant in growth.

Propagate—To generate; to increase; to renew; to bear young.

Race—A family of plants or animals having similar qualities, and whose characteristics have usually been developed by natural influences. Several breeds or varieties with artificial qualities may spring from and belong to the same race.

Rotation—The act of turning or changing. Frequent change of crop on the land.

Sediment—The matter which settles to the bottom from water or any other liquid.

Soluble—Capable of being dissolved.

Soil—Heavy—Light. See Pars. 39–40.

Superphosphate—A phosphate rendered soluble by adding sulphuric acid to it. Ground bones and phosphate rock are changed from the insoluble to the soluble and available form in this way.

Sweep—An implement with a broad single shovel, sometimes having narrow wings, for shallow cultivation, used largely in working cotton and corn in the southern states.

Tilled—Cultivated or worked.

Top-dressing—To spread over the surface.

Transmitted—To pass along, hand down, as from parent to offspring.

Turning-plow—A plow that will turn over a furrow.

Vegetable matter—Any substance formed in the growth of plants.

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