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Canadian Series of School Books.

FIRST LESSONS

ON

AGRICULTURE;

FOR CANADIAN

FARMERS AND THEIR FAMILIES.

BY

EGERTON RYERSON.

SECOND EDITION.

"The success of a Farmer depends on his understanding and complying with the laws and principles on which GOD bestows a harvest."

Authorized by the Council of Public Instruction of Ontario.

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PREFATORY NOTICE.

The selection of topics, arrangement, many of the definitions, explanations and illustrations of this little book, are my own, but the materials and much of the phraseology have been compiled and condensed from the most approved modern works on Chemistry, Botany and Agriculture.

Should any profits arise from the publication and sale of this book, the Author will not participate in them; the preparation of it is a humble but *gratuitous* contribution to a most important branch of Canadian education and industry.

TORONTO, August, 1870.

DEDICATORY PREFACE.

To the Honorable Commissioner, President and Members of the Board of Agriculture for Upper Canada.

GENTLEMEN,

I beg permission to present to you, and, through you, to Canadian Farmers and their Families, the following book, which I have prepared as an humble contribution to the great work which, by your voluntary and intelligent labours, you have done so much to promote, and which forms the basis and life of our country's wealth and prosperity.

Identified as I am by birth and early education with the agricultural population of this country, I regret to see so many of our agricultural youth leave the noblest of earthly employments, and the most independent of social pursuits, for the professions, the counting room, the warehouse, and even for petty clerkships and little shops. I know that persons in public offices, and inhabitants of cities and towns, who have no farms, must, for the most part, bring up their sons to other employments than that of agriculture; personal peculiarities and relations may prompt to the same course in regard to some farmers' sons; and a *divine* call may select from the farm, as well as from the shop and the college, for a *divine* vocation; but that, as a general rule, the sons of farmers, as soon as they begin to be educated, leave the farm, is a misfortune to the parties themselves, a loss to agriculture, and to the country. A boy's leaving the farm because he has or is acquiring a good education, is an assumption or admission by all consenting parties, that a farmer does not need such an education; and as long as this error is admitted, by farmers not being educated, agriculture will be *looked down upon*,

instead of being *looked up to*, as a pursuit for educated men. Politicians are accustomed to call farmers, by way of compliment, the *bone* and *sinew* of the land; and *bone* and *sinew* they will remain, and never be anything else, without education. It is a supreme law, illustrated by all history, that *head* rules *muscle;* and all farmers who educate only their *muscles*, and not their *heads*, must occupy the inferior relation of muscle. It is true that such farmers, as well as mechanics, may be and feel themselves quite as *good* as other people; but if they are not as *intelligent*—that is, as well educated and informed — their goodness will be associated with ignorance, and their social position will necessarily be one of inferiority. But let the boy *be educated* to make him a *better farmer*, as well as a better citizen; let it be assumed, and become a recognized fact, that a farmer must be educated to be a good farmer, as a lawyer, doctor, or clergyman, must be educated to be master of his work, and agriculture will hold a rank equal to, if not above, that of law or medicine. Educated farmers, educated merchants, and educated manufacturers and mechanics, will not only develope and advance the material interests of the country, but its civil and social interests, by enabling the people to select chiefly intelligent and well-to-do men from these classes as their representatives —men not needing an office for support, or making politics a trade — affording the best chance of practical wisdom and honesty in legislation and government, and the best hope of producing the great public desideratum — a generation of honest politicians and patriotic statesmen.

I know it may be said by some, "Our fathers were not educated, and yet were successful farmers." But those very fathers will bear witness that they would have done and felt much better had they been educated. Besides, the soil was then new and more productive, and the mode of cultivating it most simple; but the culture of the soil, the growing of crops, the raising of stock, and the business transactions and social relations of the farmer, are very different now from what they were in former years. The old methods and instruments of

agriculture can no more compete with the present, than the old modes of travelling or of manufactures. If the farmer keeps not up with the improvements and intelligence of the age, he will sink down into a mere animal of burden, instead of standing among the peers of the land.*

It has indeed been said, that "common sense alone is sufficient to make a good farmer." It is true, a man cannot be a good farmer without common sense; but common sense never manufactured a steam-engine, or constructed a rail-road, or even made a plough, or planted an orchard, without being properly instructed or educated to do it.

In the following pages, after noting the nature and importance of the farmer's profession, and the education demanded by his employment and position, I have sought to prepare an *Elementary Grammar of Agriculture* for his use—interspersing the text with notes (in smaller type) which may be interesting to the more advanced and general reader.

The first and great staple interest of our country requires young men who will devote to agriculture their talents, their attainments, their fortunes, and their lives; and in no other pursuit is a wider and more inviting field of enterprise open to them. If this little book shall, among other things, tend to show how much science, art, refinement, and pleasure, as well as profit, are involved in the true pursuit of agriculture, and thus elevate it in the esteem and occupation of the agricultural youth of Canada, I shall be amply compensated for the labour of preparing it.

I have the honour to be,
Gentlemen,
Your fellow labourer and obedient servant,
E. RYERSON.

TORONTO, August, 1870.

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* In the Lesson on *Economy of the Household*, will be found remarks on the education of farmers' daughters, and of women generally, especially in reference to the *domestic* part of it. See pages 173, 174.

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PART FIRST.

PREPARATORY KNOWLEDGE.

LESSON I.

THE FARMER AND HIS PROFESSION; WHAT HE HAS TO DO; WHAT HE OUGHT TO KNOW; HOW HE MAY LEARN; THE SUBSTANCES WITH WHICH HE HAS TO DO.

1. *What is agriculture?*—Agriculture (from two Latin words, *ager*, field, *cultura*, cultivation) is the art of cultivating the soil, so as to produce the largest crops at the smallest cost and the least injury to the soil. It also includes the raising and feeding of stock, and whatever relates to the farm buildings and domestic economy, the care and improvement of the land. He who thus cultivates the soil is a farmer.

2. *Is not the farmer of great importance?*—The farmer, who understands his business, is of great importance, and is entitled to high honour. It has been well said, that "the first farmer was the first man, and all nobility rests on the possession and use of lands;" and another writer has remarked, that "the social angel, when he descended to converse with men, (Gen. xviii: 8) broke bread with the husbandman beneath the tree." The patriarchs of ancient Scripture tilled the soil. Abraham was a farmer, rich in cattle, gold, and silver; and Job farmed on a large scale—having 7000 sheep, 3000 camels, 500 yoke of oxen, and 500 she asses.

In Greece, agriculture was the theme of the popular poets, and the various improvements in husbandry, such as the introduction of nutritive grains and the invention of useful implements for tilling the soil, were ascribed to the immediate bounties of the Gods. Later, the land was the chief article of property, and the freemen who cultivated it were honoured above manufacturers, mechanics, and traders.

Among the ancient Romans—in the purest times—agriculture was held in still greater honour than among the Greeks. The proudest patricians and most illustrious citizens lived on their farms, and worked with their own hands. In England, at this day, the nobility shrink from manufactures and trades, and stand aloof from the professions of law and medicine; but Earls, Dukes, and even Princes, cultivate lands, preside at agricultural festivals, compete for prizes at agricultural exhibitions, and write treatises on the rotation of crops, the culture of roots, and the manufacture of manures. The most illustrious men in America have been farmers.

3. *Why is the farmer considered as of so great importance?* — There are three reasons why the farmer is considered of great importance. (1) His employment is that first assigned by God to man, and approaches most closely to the works of the Divine Being, who gives to the earth its fertility and adorns it with beauty. (2) His employment is the source of wealth and comfort to the whole country. When agriculture declines, the country declines. When harvests are abundant, the country prospers. The failure of the crops for a single year deranges every branch of trade and commerce, and causes general disaster and suffering. Agriculture furnishes daily bread to the whole population. The chase and the fisheries yield something; but the

produce of the soil, in the form of either vegetable or animal food, spreads the table, and constitutes the mass of the food, for the whole community. The chief materials of our clothing are derived from the same source—wool, flax, leather, and in neighbouring countries, cotton and silk; but cotton and silk are procured by the other productions of our own soil. (3) The employment of the farmer is the true element of independence, freedom, and virtuous enjoyment. It is true, that by the law of our constitution and being, we are all, to a certain extent, dependent upon each other; but, within this divine limitation, none are so independent, and, therefore, none so free, as the farmer; and none so favourably situated for the cultivation of the quiet virtues of the heart and fireside. It is also true, that among farmers, as among merchants and traders, there is great diversity of wealth and fortune—the one owning his thousands of acres, his herds of cattle, his flocks of sheep, his ample range of pastures, and his broad fields of tillage, and another being scarcely able to winter his single cow; and another still, not even able to hire a farm, but must toil as a farm-labourer; yet, in the widely diffused ownership and cultivation of the land by an independent yeomanry, there is the best material guarantee for the freedom and virtuous prosperity of a country, and the most abundant source of individual and social enjoyment.

4. *But has not the farmer often to do hard and dirty work?*—Yes! the farmer often has hard and dirty work to do; but so has the chemist in the laboratory, the surgeon in the dissecting room, the physician often in his practice; and the advocate, and even judge upon the bench, have sometimes much more offensive work to do, both intellectually and morally, than the farmer in his furrows or in his stables. It is not what is worn, or what attaches

from without, that defiles or degrades the farmer; it is that which is wanting, or comes from within.

5. *What should a farmer know in order to succeed in his employment and to fulfil the functions of his social position?*—The farmer should know all that is essential to his employment, the same as a lawyer or physician should know what belongs to his profession, and a carpenter or shoemaker should know what appertains to his trade. Many a man who works on a farm is no farmer, as there is many a quack in trades, law and medicine. A farmer should know something of the nature and formation of the crust of the earth which he cultivates, of the manures which he applies, or should apply to enrich it; of the crops he raises; of the animals he rears, the kinds of food and treatment they require, their milk and other products; of the tools he uses and the principles on which they are constructed; of the food and beverages on which he subsists, and how they are best prepared; of the atmosphere and climate in which he lives, and their influence upon all his operations and interests. He should know the language in which he speaks, and how to keep his accounts. He should know the geography, history and institutions of his own country, and something of those of other countries. He should also know and discharge his religious duties, cultivate and practice the moral and social virtues.

6. *Why should a farmer know these things?*—A farmer should know these things for three reasons: (1) because the knowledge of them will enable him to know the why and wherefore of all he plans and does, to avoid many mistakes and losses, and to employ his strength and means to the best advantage; (2) because such knowledge will convert what seems a mechanical, if not useless drudgery into a rational and noble employment, unfolding the laws and

beauties of the material world; (3) because he will thus be qualified to enjoy the fruits of his industry, and to discharge his personal, social, and public duties.

7. *How may a farmer learn these things?*—Every farmer, with his sons and daughters, has learned some of these things without any apparent study or labour; but, for purposes of both practice and enjoyment, he, with the elder members of his household, can learn all that is contained in the following pages, in the course of three months, by devoting an hour's family study and conversation to them each evening, and that without the aid of teacher or school, other than this little book and their own good sense. The writer of these pages, between fifteen and twenty years of age, learned the greater part of the languages, literature and science that he then acquired, during the evenings, and between the hours of three and six o'clock in the mornings. Any farmer's son who will carry a copy of this little book in his pocket, and learn a section or two of it, at each interval when he is resting his team, &c., will be gratified and surprised to find, at the end of the week or month, how much he has learned that will be useful for life, and how many idle thoughts and idle words he has avoided. When I was a lad, and before I was sixteen years of age, I learned a much larger and more difficult book than this in a single month, and that, too, while working daily very hard on the farm. If a boy is aided by a school and teacher, so much the better; but if he has not such advantages, he can learn what will make him an intelligent and useful man by seizing the odds and ends of time during his daily labour. It is what is in the boy, and what he resolves, and does, and not outward circumstances, that will make the man.

8. *But are not the terms used in the chemistry and science of agriculture very hard words, and*

very hard to learn?—The terms used in the chemistry and science of agriculture appear to be hard words and hard to learn; but they are not so many nor so hard to learn as the alphabet of twenty-six letters, which every child has to learn; not so many nor so hard to learn as the terms which must be got by heart in learning the elements of grammar, or geography, or arithmetic. Besides, every term employed in agricultural chemistry, and in agriculture, represents some substance with which the farmer has to do, and which he can see, or feel, or taste, or smell—which is not the case with the A B C which every child has to learn. The alphabet of agricultural chemistry, like the longer alphabet of our language, has to be learned only once for life, and may then be applied to an endless variety of purposes. The vocabulary of agricultural chemistry consists of the names of fifteen simple substances with which the farmer has to do, and which, with their combinations, constitute the chief parts of all that we see in nature above, around and beneath us. The farmer, and every member of his family, able to read, can learn the names of three of these fifteen substances in a day, and thus learn the names of all of them in less than a week. He can learn and remember them as easily as he can learn and remember the names of his neighbours, or of the kinds of grain, vegetables and trees on his farm.

9. *What are the names of these substances?*—The names of these substances are oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, phosphorus, potassium, sodium, calcium, magnesium, silicon, aluminum, iron, manganese. These fifteen words are the alphabet of agricultural chemistry; and as, by combining in various ways the twenty-six letters of our common alphabet, we express all that we think, or feel, or know, and all that is contained in all the books of our language, so the substances

expressed by these fifteen chemical terms, variously combined, form the chief elements of our own bodies and of the visible world around us.

10. *Will you explain these chemical terms?*—In the following lessons of this book I will explain them, the simple substances they represent, the combinations they enter into, and the terms and symbols employed to express these combinations, in forming the varied materials of the mineral, vegetable, and animal kingdoms with which the farmer has to do. But I will here give familiar examples of the meaning and application of these fifteen terms, which make the basis of scientific agriculture. We all breathe the *air;* and the air is composed of *oxygen* and *nitrogen.* We all drink *water;* and water is composed of *oxygen* and *hydrogen.* Many of us burn *coal;* and pure charcoal or mineral coal is *carbon.* We all use *lucifer matches*, to light fires and lamps; and on one end of those matches is *sulphur*, tipped with *phosphorus.* We all eat common *salt;* and common salt is composed of *chlorine* and *sodium.* We could not get our *soap*, so important to cleanliness, without potash; and potash is composed of *potassium* and *oxygen.* We could not have comfortable houses without *lime;* and lime is composed of *calcium* and *oxygen.* We have all come in contact with *sand;* and sand is composed of *silicon* and *oxygen.* We have all met with *clay*, in more forms than one; and clay is composed of *aluminum* and *oxygen.* We could not be a civilized people without *iron;* and we should be badly off without *glass*, in the manufacture of which *manganese* is much used. Thus, by thinking of air, water, coal, matches, salt, &c., and of what they are composed, we are reminded of the names of the fifteen substances which form the basis of scientific agriculture, and of most of our manufactures. This will be shown in the following lessons.

LESSON II.

ON THE TWO KINDS OF SUBSTANCES WITH WHICH THE FARMER HAS TO DO—ORGANIC AND INORGANIC; THE PEOPORTIONS OF THESE SUBSTANCES IN ROOTS, PLANTS AND ANIMALS.

11. *How is matter divided; and in what form does it exist?*—The matter, or substance, of which the world around us is composed, is either organic or inorganic, and exists in a solid, liquid, or aeriform state; that is, in the form of wood or stone, of water, or of air.

12. *What is meant by organic and inorganic substances?—Organic* substances are such as possess organs, by means of which they grow and continue in being, as the roots and leaves of plants, the lungs, stomach, &c., of animals. *Inorganic* substances are such as have no organs and do not grow, as minerals, water and air.

13. *Of which of these substances are soils, plants and animals composed?*—Soils, plants* and animals are composed of both organic and inorganic substances.

14. *How do you distinguish between the organic and inorganic parts of soils, plants and animals?*—You may distinguish between the organic and inorganic parts of the soil, by placing a portion of it on a piece of sheet iron, or on the end of a knife, and holding it in or over the fire, when the organic part will first turn black and then burn away, evaporating in smoke; and the inorganic part will remain, assuming a grey, brown, or reddish color. If you burn a straw or bit of wood in a lamp or candle, the organic part of the plant burns and passes away

* By the term *plant* is meant all vegetable productions, from the garden rose to the forest oak.

in smoke, the inorganic or mineral part remains as *ashes.* So, if you put into the fire a morsel of the flesh, or bone, or skin, of an animal, the organic part is consumed, the inorganic part becomes an ash, and remains. Thus, the organic parts of soils, plants, and animals, are combustible and may be burned up; the inorganic part cannot be burnt, but are incombustible, and remain as *ashes.*

15. *How can you find out the proportion of organic and inorganic matter in soils, plants, and animals; and what is that proportion?*—You may find out the proportion of organic and inorganic matter in soils, plants, and animals, by weighing the (dried) portions of them used in the experiment before they are burnt; and then weighing the residue or ashes remaining unconsumed. It will be found that rich alluvial soils or loams contain from 5 to 10 per cent. of organic or vegetable matter; that some peaty soils contain more than 50 per cent. and other poor soils, not more than 1 or 2 per cent. of vegetable or combustible matter. It will be found, also, that the ashes, or *mineral* portion, of dry wood is from 1 to 4 per cent.—that dry straw contains 5 or 6 per cent., and dry hay from 8 to 10 per cent. of mineral matter; that the *mineral* matter of dry flesh, skin, or hair, is only 5 per cent. These experiments show, that the *soil* contains much inorganic or mineral matter, and little organic or vegetable matter; that the *plant* contains much organic and little mineral matter; that the *soft parts* of *animals* contain little, and the *hard or solid parts*, much mineral matter.

LESSON III.

ON THE ORGANIC CONSTITUENTS OF PLANTS AND ANIMALS.

(NOTE.—Before noticing the mineral and simple chemical substances which constitute plants and animals, it will be proper to state their *organic* constituents, which may be understood without any knowledge of chemistry or of chemical terms, and which will prepare the way for considering the simple elementary substances of which these organic constituents themselves consist. The organic constituents of the *soil* are, of course, the remains of dead plants and animals, which are mixed with the mineral earth. As the organic substances originate entirely in plants, and then pass, under new modifications, into the systems of animals, we will first consider the organic constituents of plants, and then those of animals; after which we will enquire into the simple elementary substances of which these constituents of both plants and animals are composed.)

16. *What are the organic constituents of plants?*—The organic constituents of plants are four—*woody-fibre*, *starch*, *gluten*, *oil* or *fat*.

17. *What is woody-fibre?*—Woody-fibre is the most abundant product of vegetation, and is the substance which forms the bulk of all trees, giving them firmness and strength; and exists in straw, hay, chaff, the bran of wheat, the husks and skin of seeds, the stones and shells of fruit, and the fibres of flax, hemp, cotton, &c. By nitric acid, these fibres are converted into *gun cotton*.

18. *What is starch?*—Starch is well-known from its use to stiffen cotton, linen, and other cloth; is a white powder with no smell, very little taste, and gives a very peculiar sound when squeezed between the fingers; is the chief ingredient of bread, forms more than three-fourths of the substance of the dried potatoe, and about half the weight of oaten and Indian corn meal, and of rye flour, &c.

19. *What is gluten?*—Gluten is a tough, elastic, grey substance, which forms an essential part of wheat, constitutes the chief nutritious parts of grains, and gives to dough all its tenaciousness. It is also called *vegetable fibrin*, from its identity of

composition with the *fibrin*, or muscular fibre of flesh, or lean meat.

20. *What is the fourth organic constituent of plants?*—The fourth organic constituent of plants is oil or fat, which occurs more or less abundantly in all plants; even in those where we should not expect to find any—such as grains and grapes; but it is generally most abundant in the seeds or nuts of certain plants, as in linseed, hempseed, poppy-seed, walnuts, hickory-nuts, &c.

21. *What are the organic constituents of the dry, solid parts of animals?*—The organic constituents of the dry, solid parts of animals are the same in number as those of plants; namely four—*muscle* or *lean flesh*, *fat*, *bone* and *skin*. (*Johnston.*)

22. *Can you describe each of these substances?*—(1) The dry muscle or lean flesh consists chiefly of blood and a white fibrous substance, called *fibrin*, which enters largely into the composition of the blood, and forms the basis of the muscles. It is nearly identical with the *gluten* of the plant.

(NOTE.—The term dry is used in connection with flesh, because, in its natural state, fresh lean meat contains about the same per centage of water as potatoes—that is, 75 per cent.)

(2) The *fat* of animals is similar in composition and properties to the fixed oils of vegetables, as the solid fat of olive oil.

(3) The organic part of bone consists chiefly of gelatin, or glue, to which bone may be reduced by being boiled long in water.

(4) The skin consists also of gelatin, or glue, like the organic parts of bone. When boiled some hours with water, the skin dissolves into a liquid, which, on cooling, coagulates into a tremulous jelly. This, when dried, forms the well-known glue.

(NOTE.—The relations of plants and animals will be explained in a future lesson.

LESSON IV.

THE FIFTEEN ELEMENTARY SUBSTANCES, THEIR NAMES, SYMBOLS, AND EQUIVALENT NUMBERS.

(NOTE.—Having in the preceding lesson stated that the organic constituents of plants are four—namely, woody fibre, starch, gluten, and oil or fat; and having likewise stated that the organic constituents of animals are also four—namely, muscle or lean flesh, fat, bones and skin; the next inquiry is, of what simple substances are these organic constituents themselves composed, and how are they formed in plants and animals; and then what are the inorganic or mineral constituents of plants and animals, and also of soils and how are they formed? But before answering these inquiries, it will be proper to explain the terms which we must necessarily employ. These terms are the alphabet of agricultural chemistry—indeed of chemistry itself, with respect to agriculture—and must be acquired by all who would learn the materials of earth, air, and ocean, and their productions, the same as every child must learn the alphabet of letters in order to read and understand the interesting things contained in books.

In the last part of the First Lesson (8, 9) it was stated that all the simple substances with which the farmer has to do are only fifteen, and how they might be easily learned and remembered. Chemists indeed have discovered upwards of sixty simple substances; but all are rare and enter little into the purposes of practical life except fifteen. The terms by which the names of these substances are known, and their combinations explained and understood, should be well learned by every student of nature and every intelligent farmer.)

23. *What are the names of the fifteen elementary substances with which we have to do?*—The following are the names of the fifteen elementary bodies which, in various combinations, form all organic bodies on the surface of the earth, all rocks and soils, together with the atmosphere and waters of the ocean:* (See Note 1 on page 84.)

NOTE.—Under the name of each body will be written the letter or symbol by which it is known and read, and the number—called the equivalent number—expressing the quantities according to which each substance unites with other substances, and which will be soon explained. The symbolic letters and equivalent numbers, as well as the names of the elementary substances, should be thoroughly committed to memory.)

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* About fifty other elements have been discovered by Chemists in very minute quantities in rocks, soils, and organic bodies.

NAMES OF ELEMENTARY SUBSTANCES.

1. Oxygen. O=8	9. Sodium. Na=23
2. Hydrogen. H=1	10. Calcium. Ca=20
3. Nitrogen. N=14	11. Magnesium. Mg=12
4. Carbon. C=6	12. Silicon. Si=21
5. Sulphur. S=16	13. Aluminum. Al=14
6. Chlorine. Cl=35	14. Iron. Fe=28
7. Phosphorus. P=32	15. Manganese. Mn=28
8. Potassium. K=39	

(NOTE.—It will be observed that the symbol of Potassium is K, the first letter of the Latin word *Kalium*—the former chemical name of Potassium. So the symbol of Sodium is Na, from the Latin, *Natrium*; and the symbol of Iron is Fe, from the Latin, *Ferrum*. It was by these Latin names that chemists formerly designated those substances; and the symbols of them are still retained in use, though the *names have been changed.*

LESSON V.

EXPLANATION OF CHEMICAL TERMS.

24. *What are chemical symbols?* — Chemical symbols are the first or initial letters of the names of elementary substances, and are a short method of expressing those names. Thus, O expresses Oxygen, H, Hydrogen, Cl, Chlorine, Al. Aluminum, &c.

25. *What are chemical atoms?*—The word *atom* means that which cannot be cut or divided; and a chemical atom is, therefore, the smallest particle in the composition of a body supposed to result from the division of a body.

26. *What are atomic numbers or chemical equivalents?*—Atomic numbers, chemical equivalents, as also definite proportions and combining numbers, are terms used to express the same thing, and mean the *atom*, or *atomic weight*, according to which one simple body unites with other bodies. Experiments have shown that all elementary bodies unite with each other in fixed quantities by weight. Hydrogen being the lightest of all known bodies, is taken as representing 1, or *unity*, and all other elements are compared with it. Thus the water we drink is composed of two gases—Hydrogen and Oxygen—chemically expressed H O. It requires just one ounce of hydrogen to unite with eight ounces of oxygen, to form water, which has this composition the world over; and were these two elements to unite in any other proportion than 1 to 8 by weight, some new compound, different from water, would be the product. Therefore the *atomic number*, or chemical equivalent of H (hydrogen) is 1, and that of O (oxygen) is 8. The same principle, as to the fixed and invariable composition and properties of bodies, applies to all substances, however complicated. The law of definite proportions is universal and permanent, and is the essential basis of the science of chemistry.

(NOTE.—The simplicity, beauty and importance of the application of this principle in matters of practical agriculture, will appear in subsequent lessons.)

27. *Do the figures under the names of the fifteen simple bodies mentioned in the preceding lesson, express these equivalents?*—The figures under the names of the fifteen simple bodies mentioned in the preceding lesson express the equivalent numbers, and are founded upon the fact, ascertained by chemists, that the elements and their compounds unite in constant proportions, or, in other words, "that whatever be the proportion by weight in which any one body

combines with another, it preserves the same relative proportion in its combinations with all other bodies." Hydrogen is assumed as 1, oxygen as 8, carbon as 6, sulphur as 16, and so on with the fifteen substances named in the preceding lesson. These are the *chemical equivalents*, or combining numbers, or atomic numbers. Between these 15 dissimilar bodies there is a peculiar kind of attraction, called *affinity;* and the figures express the number of parts by weight in each body which have an attraction equal or *equivalent* to those of another body. Thus the chemical energy of 1 part of hydrogen is *equivalent* to that of 8 parts of oxygen, to that of 14 of nitrogen, to that of 6 of carbon, to that of 39 of potassium, and so on. Thus also 8 parts of oxygen are *equivalent*, in attractive force, to 1 part of hydrogen, to 14 parts of nitrogen, and so on in regard to the equivalent or combining numbers of all the elementary bodies. Therefore, as has been stated, 8 parts of oxygen unite with 1 part of hydrogen, to make *water*—chemically called oxide of hydrogen; 35 parts of chlorine and 23 parts of sodium combine, making *common salt*—chemically called chloride of sodium; 8 parts of oxygen and 39 parts of potassium combine, making *potash*—chemically called oxide of potassium.

(NOTE.—It is not to be understood that these figures express the absolute weight of the parts of simple bodies, but merely the *proportional* weights in which those bodies combine. It is assumed that every simple substance or element is composed of small particles or atoms, but so minute as not to be visible even with the aid of the most powerful microscope. Nothing, therefore, is known of the size, shape, or absolute weight of those ultimate atoms. Taking hydrogen as representing one, or unity, the figures represent the smallest equivalent or atomic weight in which any body will combine with one part by weight of hydrogen or eight parts by weight of oxygen.)

28. *But do not these elementary bodies combine in more proportions than one?*—These elementary bodies combine in more proportions than one; and several of them present a great variety of combina-

tions in form and colour, as well as in more essential qualities; but the combining proportionals of these compounds are fixed and invariable. For example, nitrogen and oxygen combine in several different quantities; but the larger quantities are *multiples* of the smaller, and take place in the ratios of 1, 2, 3, &c.

(NOTE.—In the five compounds which are formed by the combination of nitrogen and oxygen, the amount of nitrogen is constant, but the quantities of oxygen are as the numbers 8, 16, 24, 32, 40—the last four numbers being multiples of the first; and in no other proportions will nitrogen and oxygen combine. These compounds may be thus stated, omitting fractions: One equivalent (14 parts) of nitrogen, combined with one equivalent (8 parts) of oxygen, forms *nitrous oxide*, or the prot-oxide of nitrogen, called laughing gas, of which the chemical formula is NO. One equivalent of nitrogen (14 parts) united with *two* equivalents (16 parts) of oxygen, forms *nitric oxide*, or deut-oxide of nitrogen—formula NO_2. One equivalent of nitrogen (14 parts) united with *three* equivalents (24 parts) of oxygen, forms *hypo-nitrous acid*—formula NO_3. One equivalent (14 parts) of nitrogen, united with *four* equivalents (32 parts) of oxygen, forms *nitrous acid*—formula NO_4. One equivalent (14 parts) of nitrogen, united with *five* equivalents (40 parts) of oxygen, forms *nitric acid*—formula NO_5. Thus in these five compounds the proportion of nitrogen is the same in all—its smallest equivalent. The smallest proportion of oxygen is its equivalent 8; in the next higher compound it is 16, or twice 8; in the fourth 32, or four times 8; in the fifth 40, or five times 8. Carbon and oxygen combine in two proportions. The union of one equivalent of each forms *carbonic oxide*—formula CO; the union of one equivalent of carbon with two equivalents of oxygen, forms *carbonic acid*—formula CO_2.

29. *What is this principle of proportional combination called?*—This principle of proportional combination is called the law of *multiple proportions*, and teaches, "that when one body combines with another quantity larger than its regular equivalent, or lowest proportion, that larger quantity, whatever it may be, is an exact *multiple* of the single equivalent number;" or, that the other proportions are multiples of the first.

30. *Does this law of definite proportions extend to the union of compound bodies, as well as of ele-*

mentary bodies?—This law of definite proportions extends to the union of compound bodies, the combining proportion of which is the sum of the combining numbers of the elementary bodies of which they are composed. "The equivalent weight of a compound is the sum of the equivalents of its constituents." Thus, as one equivalent of carbon, whose combining number is 6, and two equivalents of oxygen, whose combining number is 8, forms carbonic acid (with which the farmer has much to do) the equivalent or combining number of carbonic acid is 22—the sum of 6 and twice 8. Lime is composed of one part each of calcium and oxygen—chemically called oxide of calcium. The combining number of calcium (see Lesson IV.) is 20, that of oxygen is 8; the equivalent of lime is, therefore, 28—the sum of 20 and 8. The equivalent of marble is 50—it being composed of carbonic acid, whose combining number is 22, and of lime, whose combining number is 28—50 being the sum of 22 and 28. Sugar is composed of 12 equivalents of carbon, each 6=72; 10 equivalents of hydrogen, each 1=10; and 10 equivalents of oxygen, each 8=80. The sum of 72, 10 and 80, is 162—the equivalent number of sugar. Thus, "The equivalent or combining proportions of a compound body is the sum of the combining proportions of its elements."

NOTE.—Some terms have been necessarily used in the foregoing lesson, which have not yet been explained: but they will be explained in the following lesson.

It is the establishment of the above simple and comprehensive laws of numerical proportion, which has led to the invention of the symbolic language of chemistry, explained in Lesson IV., which enables one to express in the shortest manner the constitution of every compound body, and which is used by physicians in prescribing to druggists the preparation of medicines. We will now proceed to explain the chemical terms, without the knowledge of which much that is written on agriculture is utterly unintelligible, and the mastery of which (and this can be accomplished in a single week) will open up to the reader a simple and beautiful language of great practical utility.)

LESSON VI.

DEFINITIONS OF THE ACIDS, BASES, SALTS, ETC., OF THE TERMINATIONS IDE, URET, OUS, IC, ITE AND ATE, OF THE PREFIXES HYPO, PER, PROTO, DEUTO OR BIN, TRITO OR TER.

(NOTE.—The terms defined in the preceding lessons are not repeated in the following lesson.)

31. *What is the result of the union of elementary substances?*—The elements uniting with each other produce *compounds*, and these compounds uniting with other compounds produce more complex compounds.

32. *What are these compounds called?*—These compounds are called *oxides*, *acids*, *bases*, and *salts*.

33. *What is an oxide?*—An oxide expresses a compound (which does not possess acidity) formed by the union of oxygen with another element (called a metal.) Oxygen and all the elements ending in *ine*, when united with one another, taking the termination, *ide*, when the compound is not an acid; as ox*ide* of calcium (lime), chlor*ide* of sodium (common salt), ox*ide* of iron (rust.)

(NOTE.—In some instances, however, the oxygen is not represented by the termination *ide*, but by the termination *a*; as sod*a*, for the oxide of sodium, potass*a*, for the oxide of potassium, silic*a*, for the oxide of silicon.

Other elements, not forming acids, take the termination *uret*, instead of *ide*; as sulph*uret* of iron, carb*uret* of hydrogen. European chemists prefer the termination *ide* to *uret*; but many American chemists use the termination *uret*, instead of *ide*, upon the ground that there is more euphony in sulphuret that in sulphide, though meaning the same thing.)

34. *What are acids?*—Acids, in common language, are sour substances; in chemistry acids are compounds which usually have a sour taste, and change vegetable blues to red, though not always possessing these properties. Acids also possess the property of combining with, and neutralizing alkalies and other bases.

35. *How are acids formed?*—Most of the acids connected with agriculture are formed by the union of oxygen with other bodies. Thus *carbonic acid*, which forms to a great extent the food of plants, gives to water and some other drinks their sparkling brilliancy and agreeable taste, consists of one equivalent of carbon united with two equivalents of oxygen (formula $N\ O_2$). *Nitric acid* (aqua fortis), so essential an element in manures, consists (as was shown in the 5th lesson) of 1 equivalent of nitrogen and 5 equivalents of oxygen formula $N\ O_5$). *Phosphoric acid*, which, in combination with bases, forms salts of the highest importance in agriculture, consists of 1 equivalent of phosphorus and 5 equivalents of oxygen (formula $P\ O_5$). *Silicic acid*, perhaps the most important inorganic acid in its relation to agriculture, consists of 1 equivalent of silicon united with 3 equivalents of oxygen (formula $Si\ O_3$). *Sulphuric acid*, extensively used by some good farmers, either directly as a manure, or for dissolving bones, is composed of 1 equivalent of sulphur united with 3 equivalents of oxygen (formula $S\ O_3$), &c.

NOTE.—It is from this property of oxygen converting, by combination, so many other simple bodies into acids, that it originally received its name, which is derived from two Greek words, one of which signifies *acid*, and the other *to generate*, though some acids do not contain oxygen, as hydrochloric acid, or muriatic acid, which consists of 1 equivalent of chlorine united with 1 equivalent of hydrogen (formula H Cl.). Chlorine forms 65 per cent. of common salt, in union with sodium—chemically called chloride of sodium, as stated in a former lesson, and is also largely used for bleaching and other purposes.)

36. *How are acids named?*—The large number of acids which are formed by the union of oxygen with other bodies, are named from the element with which the oxygen unites; as *carbonic* acid—consisting of carbon and oxygen; *sulphuric* acid—consisting of sulphur and oxygen; *phosphoric* acid—consisting of phosphorus and oxygen. But acids in

which there is no oxygen, are named from *both* their elements; as *hydro-chloric* acid, consisting of the union of hydrogen and chlorine.

37. *But what different acids are formed by the union of the same elements in different proportions, how are they distinguished?*—When different acids are formed by the union of the same elements, in different proportions, they are distinguished by the terminations *ous*, *ic*, and the prefixes *hypo*, *hyper*, and *per*. The termination *ic*, indicates a higher degree of oxidation, or a stronger acid; the termination *ous*, a weaker, and the prefix *hypo* (which means *under*) describes a still weaker acid. It was stated, in illustration, in Lesson V., that nitrogen forms three acids with oxygen—*hypo*-nitrous acid, nitr*ous* acid, and nitr*ic* acid; the first the weakest, and the last the strongest acid, the second between the two extremes of the minimum and maximum. Thus, by the union of sulphur with oxygen in different proportions, we have *hypo*-sulphurous acid, sulphur*ous* acid, and sulphur*ic* acid; the first indicating a smaller quantity of oxygen than the second, and the second than the third. When an acid is discovered which contains a larger amount of oxygen than the highest in a known series, it receives the prefix hyper (above or more), as *hyper*-chloric acid, or more commonly *per*-chloric acid, which contains more oxygen than chloric acid.

(NOTE.—When there is only one acid formed by the same elements, its termination is always in *ic*.)

38. *What are bases?*—Bases in chemistry, are compound substances, consisting for the most part, of the union of oxygen with another elementary *metallic* body, and are called *basic* oxides. The name denotes their supposed functions which are to form the *foundation* of an extensive class of substances, which enter largely into farming operations, and which chemists call salts. Bases are the oppo-

sites of acids, have usually a burning acrid taste, and undo the work of acids by restoring blue to the vegetable red colors caused by acids.

39. *You have spoken of non-metalic and metalic bodies, how are they distingnished?*—The fifteen elementary bodies mentioned in lesson IV, are divided by chemists, for the convenience of study, into two classes—non-metalic and metalic. The latter class are called *metals;* the non-metalic elements are termed by chemists *metalloids;* which means substances resembling metals, the affix *oid* being derived from a Greek word meaning like. Of the fifteen elements referred to, eight are usually classed as *metalloids*, or non-metalics—namely four gases, oxygen, hydrogen, nitrogen, and chlorine, and four solids, carbon, sulphur, phosphorus and silicon. The metals are seven—namely, potassium, sodium, calcium, magnesia, aluminum, iron, manganese.

(NOTE.—Chemists enumerate 51 metals, including copper, lead zinc, gold, silver, &c., but the notice of others than those named above is not necessary to the purposes of agricultural chemistry.)

40. *But what is the difference in the effects of the union of oxygen with metalloids and metals?*—The union of oxygen with metalloids, or non-metallic bodies, produces *acids*, except when the proportion of oxygen is too small to produce an *acid:* but the union of oxygen with metals produces *oxides* of the metals; some of which are *alkalies*, comprising *potassa*, *soda*, to which is added ammonia; *alkaline earths*, embracing *lime* and *magnesia; earths*, including *alumina* (clay), and *silica* (sand); and the metallic oxides of *iron* and *manganese.*

(NOTE.—The properties of these compounds, as connected with agriculture, will be noticed hereafter.)

41. *Does not oxygen combine with these metals in more proportions than one, and thus produce different degrees of oxidation?*—Oxygen combines with

the metallic, as with the non-metallic elements, in more proportions than one, thus producing different degrees of oxidation. When oxygen combines with the same element in different proportions, forming several oxides, its quantity is indicated by words derived from the Greek and Latin; as protoxide, deutoxide, tritoxide—the prefixes to the word oxide being derived from the Greek words *protos*, first, *deuteros*, second, and *tritos*, third. The deutoxide is sometimes called binoxide from *bis*, and the tritoxide, teroxide from *ter*, the Latin words for twice and three times. The deutoxide has twice the oxygen that the protoxide has, and the tritoxide three times—the amount of metal being the same in all cases. The oxide that contains the greatest amount of oxygen is sometimes called peroxide—the prefix *per* being the Latin for through, fully, to the utmost extent. In case of some metals the oxide contains less oxygen than the protoxide, and this is called suboxide—the prefix *sub* being the Latin for under. In case of some metals also, the oxide, instead of having twice as much oxygen as the protoxide, has one and a half times as much, and is termed a sesquioxide—the prefix *sesqui* being the Latin for one and a half, and used when the elements of the oxide are as two to three, as they cannot be divided.

(NOTE.—It is thus seen that *acids* and *bases* are *binary* compounds—each consisting of two elementary bodies—the acid being composed of oxygen united with a non-metallic element, the *base* of oxygen united with a metal. This is the first order of chemical combination, when elements unite with elements, forming *acids* and *bases*. The second order of chemical combination arises from the union of these *acids* and *bases*, forming *salts*, which will next be considered.)

42. *What are salts?*—Salts are compounds of acids and bases. Though acids and bases possess opposite properties, they have a strong affinity for each other, and combine to form a new body which

has no similarity to either of the substances of which it is composed. The acid combining with a base, destroys or neutralizes its basic properties; and the base combining with the acid, neutralizes or reduces its acid properties. By this union the properties of both acids and bases are completely destroyed, and a neutral salt is the result—a compound with new properties. Thus, adding muriatic acid to soda produces common salt (chloride of sodium); nitric acid added to potash produces saltpetre (nitrate of potash); sulphuric acid added to lime produces gypsum, or plaster-of-paris (sulphate of lime); sulphuric acid added to soda produces Glauber's salts (sulphate of soda); sulphuric acid added to magnesia produces Epsom salts (sulphate of magnesia).

(NOTE.—It is thus seen that each salt consists of *at least* three elements. Saltpetre (nitrate of potash) consists of oxygen, nitrogen and potassium; Gypsum, or Plaster of Paris (sulphate of lime) consists of oxygen, sulphur and calcium; and so on.)

43. *How are the different salts named?*—The different salts are named from the acids which enter into their composition by changing *ous* of the acid into *ite* of the salt, and *ic* of the acid into *ate* of the salt. If the acid contains a minimum of oxygen, and therefore ends in *ous* (as shown above, 37), the termination *ite* is employed in the salt; and if the acid contains a maximum of oxygen, and therefore ends in *ic*, the name of the salt terminates in *ate*. Thus, sulphur*ous*, nitr*ous*, and phosphor*ous* acids from sulph*ites*, nitr*ites*, and phosph*ites*; and sulphur*ic*, nitr*ic*, and phosphor*ic* acid form sulph*ates*, nitr*ates*, and phosph*ates*, as in the examples in 42. The basic element of a salt is indicated by the usual prefixes, proto, deuto, &c., as *proto*sulphate of iron, which is a sulphate of the protoxide of iron.

NOTE.—If the base is not sufficient to saturate the salt, there results what is called an *acid* salt, or *super* salt; if, however, the base is in excess the salt formed is called *basic* salt, or *sub* salt.)

44. *But are not salts formed from elements not containing oxygen?*—There is another class of substances which are termed salts, though there is no oxygen in their composition; but only two or three of them are connected with agriculture. Instead of being composed of an oxide of a metal and an acid formed from a metalloid and oxygen, they consist simply of a metal and a metalloid. Thus sulphur and iron united, make a sulphuret, or sulphide of iron; and common salt comes from the union of the metal sodium and the metalloid chlorine, forming a chloride of sodium.

(NOTE.—As oxygen forms oxides, so chlorine forms chlorides, sulphur sulphides, phosphorous phosphides, and carbon carbides. It is in the compounds of the last three substances, that the termination *uret* is generally used instead of *ide;* as sulphuret (instead of sulphide) of iron, &c. The following remarks from the London *Encyclopedia of Agriculture*, in the article salts, form a proper conclusion to this important lesson:—

"The term salt, originally restricted in its application to common salt, was afterwards employed to denote a great many substances, differing very widely from each other in chemical application, and having, indeed, little else in common but solubility in water and being incombustible." "Although the group of salts includes many compounds differing so widely in their appearance and general physical characters, that they would be hardly recognized by the untutored observer as salts; all the members of the salt family present us, nevertheless, with an intimate analogy of composition, which readily enables us to recognize the saline nature of compounds—such as carbonate, or phosphate of lime, which, with the uninstructed, pass for earthy matters. According to the modern acceptation of the term, a salt is always a compound of two substances, or it consists of halves possessing diametrically opposed characters. One of the halves is strongly electro-negative, the other half strongly electro-positive in relation to the first. In the majority of cases, both halves are compounds. The electro-negative half is an *acid*, the electro-positive a *base*. Thus in Glauber's salt, we find an electro-negative substance, sulphuric acid, united with an electro-positive or basic substance—soda. Both are compounds; the one a compound of sulphur with oxygen; the other of the metal sodium with oxygen.

"In other salts, the halves are either simple substances, or compounds acting like simples. One of them, the electro-positive, is a metal, or a body acting like a metal; the electro-negative is likewise an element, or a compound acting like a simple substance. Thus the one-half of common salt is the metal sodium, an elec-

tro-positive element; the other is chlorine, an electro-negative element.

"Chemists accordingly, distinguish two great classes of salts:—1. *Oxygen salts*, or salts resulting from the combination of an oxygen acid, like sulphuric or phosphoric acid, with oxygen base—as, for instance, soda or potash. 2. *Haloid salts*, or salts resulting from the combination of a metal, or a body acting like a metal, with such a substance as chlorine. Common salt is a familiar example of haloid salt."

LESSON VII.

SOME ACCOUNT OF THE NATURE AND PROPERTIES OF FOUR OF THE FIFTEEN ELEMENTARY SUBSTANCES.

(NOTE.—The foregoing lessons have made us familiar with the two kinds of substances (organic and inorganic) with which the farmer has to do; the proportions of these substances in soils, plants and animals; the four organic constituents, respectively, of plants and animals; the names of the fifteen elementary substances, with their symbols and equivalent numbers: some of the acids, bases, and salts formed by their union, and the terms by which their combinations are indicated and distinguished. We are now prepared to inquire into the nature and properties of the fifteen elementary bodies which constitute the great bulk of earth, sea and air. The account of these bodies will be purely elementary, given in as few words as possible, and limited to the purposes of agriculture, except occasional remarks in the notes of a general character. We will treat first of the seven metalloids or non-metallic bodies—namely, oxygen, hydrogen, nitrogen, carbon, chlorine, sulphur, and phosphorus. The first four of these will be the subject of the following lesson.)

OXYGEN. *Symbol* O: *Equivalent* 8.

45. *What is oxygen?*—Oxygen is a kind of air or gas, and, like the air, transparent, without colour, taste, or smell. It is about one-tenth heavier than the air; it cannot be frozen; it is that ingredient in the air which makes things burn, and supports life in animals. It combines with all known elements except one—Fluorine.

(NOTE.—Oxygen is the most abundant and the most important of all substances in nature. It constitutes by weight nearly one-fourth of the atmosphere, eight-ninths of water, and about one-third of the earth's solid mass.)

HYDROGEN. *Symbol* H: *Equivalent* 1.

46. *What is hydrogen?*—Hydrogen is a kind of air or gas, colourless, and, when pure, without odour or taste. It does not support respiration; for an animal soon dies when confined in it. Nor does it support combustion; for a lighted candle will go out in it. Yet it is highly inflammable, for, when mixed with common air, and brought near a flame, it will explode. It is the lightest of all known substances, being fourteen and a half times lighter than common air, and is therefore the best material for inflating balloons, though coal gas, on account of its greater cheapness, is most used for that purpose.

(NOTES.—(1) Hydrogen signifies water-former—being derived from two Greek words, *hudor*, water, and *gennao*, I form or generate. United with oxygen, it forms one ninth in weight, and two-thirds in bulk or volume, of water. The chemical name of water is, *protoxide of hydrogen*. Hydrogen is held with such affinity by oxygen and other bodies, that it is not found in nature in a free state, but, in the form of water and aqueous vapour, hydrogen is diffused universally over the globe; like oxygen, is an important constituent of animal and vegetable matter; in union with carbon forms a large number of gaseous, liquid and solid compounds; and associated with carbon and oxygen, is a constituent of inflammable substances, such as ether and alcohol.

(2) But though hydrogen is inflammable, and therefore burns, it does not support combustion. Oxygen gas does not burn itself, but it aids the decomposition by fire of bodies that are combustible, and is therefore *a supporter of combustion*. But hydrogen gas, *though it burns itself* (yielding a feeble yellowish blue light), will extinguish a flame immersed in it, and is, therefore, an inflammable body, or a body that will burn, but does not *support combustion*.

(3) It may appear singular that while hydrogen is the lightest of all gases, it is also spoken of as a solid body. The reason is, that although in its aerial state it is the lightest of all known substances, yet when imbibed by living vegetables it becomes solid, and forms oil, wax, resin, &c.; and in combination with oxygen, it forms water, which has the property of becoming either solid, liquid, or aeriform.

NITROGEN. *Symbol* N: *Equivalent* 14.

47. *What is nitrogen?*—Nitrogen, like oxygen and hydrogen, is an air or gas, transparent, without

colour, taste, or smell. Like hydrogen, it does not support combustion or animal life; but unlike hydrogen, it does not take fire when brought near the flame of a candle. Nitrogen is a little lighter than the atmosphere, and constitutes four-fifths of it.

(NOTES.—From the fact that animals placed within it immediately die, it has been called *azote*—life destroyer—from two Greek words, *a*, privative, and *zoe*, life; and it is still so called by the French chemists, though that name would be equally applicable to all the other gases except oxygen. But though animals speedily die in nitrogen, it does not act as a poison; for the air we breathe is four-fifths nitrogen. It is because animals cannot live without some oxygen in the air which they breathe.

2. The name nitrogen, assigned to this element by English chemists, is based upon its property with oxygen of producing an acid which is the principle of *nitre*, made gaseous by combination with caloric.

3. Nitrogen, while found abundantly in the mineral kingdom, is one of the most important constituents of organic substances, as has been stated in a previous lesson. It exists in the tissue and muscle of the animal body to the amount of 17 per cent In an uncombined or free state, it constitutes by weight nearly four-fifths (79 parts out of 100) of the atmosphere. But while nitrogen forms a most important element in both the vegetable and animal kingdoms, it has not yet been decided by chemists whether plants derive their nitrogen through their leaves directly from the air, or dissolved in water, through their roots, or whether the animal system has the power of using or assimilating it when absorbed from the air by the lungs.

4. It has been shown in Lesson V., that nitrogen forms five compounds with oxygen. Among the native mineral substances mentioned in Lesson II. nitrogen forms 14 per cent of the nitrate of potash, and 16 per cent. of the nitrate of soda. With hydrogen, nitrogen forms ammonia—one of the most powerful medicines, as well as one of the most important elements of manure.

5. It is a curious fact, that while animals immediately die in pure nitrogen, and while the atmospere is composed four fifths of nitrogen and one-fifth of oxygen, that oxygen and nitrogen united in equal volumes, constitutes the *nitrous oxide*, which causes such pleasurable excitement, causing merriment almost to insanity, to those who inhale it, so as to be called the *laughing gas*. The reason assigned is, that it introduces into the body more oxygen than can be consumed, and therefore deranges the nervous system, and, as a powerful stimulant, gives an unnatural activity to the nervous centres of the brain.)

CARBON. *Symbol* C: *Equivalent* 6.

48. *What is carbon?*—Carbon (from the Latin *carbo*, coal) is a solid substance, usually black, without taste or smell, and more or less combustible. Its purest form is *diamond*, which is crystalized carbon, as is also plumbago, in a less pure form. The most common form of carbon is wood-charcoal. Lamb-black is a variety of carbon; and it is found as anthracite and bituminous coal in vast deposits in the earth—formed from the vegetation of an earlier period.

(NOTES.—1. *Corbon abundant and important.* This important substance is essentially an element of the organic kingdom, and its various compounds are more widely and abundantly diffused than any other substance. It is the solidifying element of all living structures, whether vegetable or animal. It constitutes nearly half the weight of the dried substance of vegetables or animals. In the vegetable kingdom it forms the skeleton of the plant or the tree—a fact witnessed in wood-charcoal, often retaining the shape of the very fibre, knots and rings of the wood, from which it is obtained by smothered combustion. Carbon performs an equally important part of the structure of animals as in that of plants. In the mineral kingdom, besides the deposits of coal, it is one of the ingredients of limestone, marbles, chalks, corals and shells; and in the atmosphere it is present everywhere united with oxygen to form carbonic acid, which contains by weight twenty-seven per cent. of carbon.

2. *Carbonic acid.* In Lesson V., p. 24, it has been shown that carbon forms two compounds with oxygen—*carbonic oxide*, and *carbonic acid.* The latter of these compounds is by far the most important; and its importance and curious phenomena will justify a few remarks upon it. Carbonic acid is a colourless gas, of slightly sour taste, and about one and a-half times heavier than air. This gas is one of the products of all ordinary combustion. The burning of fuel yields it in vast quantities. The combustion of a bushel of charcoal produces 2,500 gallons of this gas. It is formed within the bodies of all animals by the union of the oxygen of the atmosphere with the carbon of the system, and escapes, through the lungs, by respiration into the air. Sir H. Davy says—"Each adult man exhales about 140 gallons per day." It also results in great abundance from the decay and putrefaction of animal and vegetable substances, and is generated from the earth in volcanic districts, and sometimes collects in large quantities at the bottom of cellars and wells, and in mines, under the name of *choke-damp.*

3. It is essential to the growth of plants; but it extinguishes burning substances, of all kinds, and is fatal to animal life. It

destroys life, not merely because, like nitrogen, it shuts out oxygen from the blood in the lungs, but, even when diluted with ten times its bulk of air, it acts as a narcotic poison gradually producing stupor, insensibility and death. It is thus that persons sleeping in a close room are sometimes suffocated by the fumes of burning charcoal—carbonic acid gas. When breathed pure, carbonic acid gas, as it is said, produces spasms of the glottis, closes the air-passages, and thus kills suddenly by suffocation. Thus the Lake of Alverno, in Italy, evolves so large a quantity of carbonic acid gas, that birds flying over it drop with suffocation; and a dog entering the celebrated *Grotto del Cano* (cave of the dog) falls down dead, though a man may enter the cave without feeling the effects of the poison. The reason is, that the gas flows along the floor of the grotto not more than to the height of the knees, while the head of a man rises above it, and he breathes the air.

4. It is a singular fact that while carbonic acid gas is a deadly poison to the blood, when taken into the *lungs*, it is not injurious, and produces an agreeable sensation, when taken into the *stomach*—arising from the different chemistry of these organs. Thus all kinds of good spring and well water (which sparkle when poured from one vessel to another) owe their pleasant flavour to the presence of carbonic acid, as do soda waters, champagne, beer, porter, &c., their effervescence and pungency.

5. Of the compounds formed by the union of carbon with hydrogen, nitrogen, chlorine, and sulphur, I will not here speak. I may, however, remark, that with hydrogen carbon forms a gas, called *light carburetted hydrogen* (CH_2),—the *fire-damp* of the coal mines the fatal explosions of which prompted the invention of Sir H. Davy's *safety-lamp*; also the *inflammable air of marshes*, formed abundantly in stagnant pools during the spontaneous decomposition of vegetable matter. The explosion of this gas in the mines produces carbonic acid by the combustion; so that the unfortunate miners who are not burned are suffocated.)

REMARKS ON THE FOUR ELEMENTS ABOVE DESCRIBED—OXYGEN, HYDROGEN, NITROGEN AND CARBON.

The four elements—oxygen, hydrogen, nitrogen and carbon—which have become familiar by the above statements and explanations, and by references in previous lessons, are the chief elements of all vegetable and animal substances—"the four letters which compose the alphabet of organic nature, and have been termed *organogens* (generators of organization.)" It is true that in some organic structures other elements are used; as calcium and phosphorus in the bones, iron in the blood, silicon

in the stalks of grains and grasses, giving them their stiffness, and other elements to a limited extent for various purposes. But these elements occur in very small quantities. The *organogens*—the generators of organization—are the four grand elements which chiefly build up the structures of vegetable and animal life. Only one of them as has been shown, is a solid, while the other three are gases—invisible gases, whose properties are only known from their effects—all without taste or smell; and the one solid element is in its ordinary form of a dark colour; but these few materials produce the endless variety of forms, colours, odours, tastes and other qualities presented in the living substances of the animal and vegetable kingdoms. "Then of substances not living, (it has been well observed) the earth's envelope of air, fifty miles thick, is a mixture mostly of two elements, oxygen and nitrogen, and all the water is composed of oxygen and hydrogen. And to come to the solid crust of the earth, carbon is seen in the enormous quantities of coal treasured up in the bowels of the earth for the use of man; carbon and oxygen united with a metal form the lime-stone rocks and ranges of mountains; oxygen is a large constituent of the granite and other hard rocks; and of the compound mixture under our feet, which we call earth, these four grand elements form a very large proportion."

LESSON VIII.

CHLORINE, SULPHUR, AND PHOSPHORUS.

CHLORINE. *Symbol* Cl.: *Equivalent* 35.

49. *What is chlorine?*—Chlorine (from the Greek Kloros, green) is a gas of a yellowish-green colour, of a disagreeable odour, and is about two and a half times heavier than common air,

(NOTES.—1. Chlorine differs from the three colourless gases already noticed (oxygen, hydrogen and nitrogen) in this, that it has a decided colour, though the muriatic acid (when pure), which results from the union of chlorine with hydrogen, is colourless. The muriatic acid is the old name of this acid; the new name is *hydrochloric* acid—from the words hydrogen and chlorine. But the old name is most used. It is curious that the chlorine and hydrogen (H Cl) will not unite to form this acid in the dark, only in daylight.

2. Chlorine united with the metal sodium (chloride of sodium) forms common salt—being 65 per cent. of it. It is therefore called a Haloid Salt producer. The chloride of soda (in which chlorine gas is combined with the alkali *soda*) is a powerful disinfectant or destroyer of offensive smells and deleterious airs in houses, stables, and especially in a time of infectious disease, such as the cholera, &c. One of the most important properties of chlorine is its bleaching power, extensively prepared and used as chloride of lime for bleaching linen, cotton goods and paper.

Its bleaching and disinfecting properties arise from its strong affinity for hydrogen, which it takes away from colouring and putrescent substances, thus decomposing them. STÖCKARDT remarks: "All animal and vegetable substances contain hydrogen, which is taken from them by chlorine. But if a single chemical pillar falls the whole chemical structure tumbles with it. By the abstraction of the hydrogen the colouring matter becomes colourless, the odorous principles scentless, the morbific matter innoxious, the insoluble substances are frequently rendered soluble." HOOKER further explains this fact so important in manufactures. "The chlorine taking the hydrogen of the water (for an article cannot be bleached without being moistened) sets free the oxygen, and this in its nascent state (that is, the moment it is produced) has special chemical power, and attacks the colouring matter, destroying it or burning it up as we may say, for the union of oxygen with other elements is essentially a combustion. It is oxygen then that really does the bleaching here, just as in the case of the sun-bleaching. But the question arises, why does the oxygen burn up the colouring matter and not the cloth itself? This is from a principle well established in chemistry, namely, that the more ingredients there are in a compound the more easily is it decomposed. While the vegetable tissue or substance is composed of three elements, carbon, oxygen and hydrogen, the colouring matter is composed of these with nitrogen in addition, and is therefore more readily demolished by the oxygen than the cloth is. But sometimes the cloth is somewhat burned in the process; that is, some of the tissue are destroyed by the released oxygen, and the cloth is consequently weakened. This is done whenever after the chlorine has released sufficient oxygen (by abstracting the hydrogen of the water) to destroy the colouring matter, it continues to release more. The point then to be aimed at by the bleacher is, to set free only enough oxygen by means of the chlorine to oxidize

(that is, burn up) the colouring matter and not the substance. There is the same danger that the process may be carried too far in the common sun-bleaching, or grass bleaching, as it is called." On this process the same author observes: "By the influence of the sun's light the oxygen of the air is made to unite with the colouring matter of the cloth, and so this is burned up (oxidized), the product passing off in the air just as the products of ordinary combustion do. If the cloth is exposed too long, some of the substance itself is burned up, lessening the strength of the cloth and rotting it as it is commonly expressed. The reason that the coloured matter is affected before the substance, is that it is more combustible, or, in other words, more readily oxidized."

SULPHUR. *Symbol* S: *Equivalent* 16.

50. *What is sulphur?*—Sulphur, or brimstone, is a brittle inflammable crystaline solid substance, of a pale yellow colour, with little taste or smell, but emitting a peculiar odour when rubbed or heated. It is about twice as heavy as water.

(NOTES—1. This important substance occurs as a mineral in volcanic districts, as in Italy and Sicily. There are large deposits of it in Spain and Iceland; and it is found less abundantly in some gypsum beds in Europe. It is separated from other matters, and prepared for use by a process of distillation. Much of the sulphur in use is obtained from a sulphide or sulphuret of iron—the iron pyrites—which contains about 54 per cent. of sulphur, and yields it by distillation.

2. Sulphur combines with metals, as iron, silver, copper, lead, zinc, &c., forming sulphurets or sulphides of those metals. Though described as a mineral, it enters into the composition of many vegetable and animal substances: as turnips, beans, peas, horseradish in the vegetable world, and in the hair, horn, hoofs, nails, feathers &c., in the animal. It exists in eggs, and discolours the silver spoons used in eating them, forming the black sulphide or sulphuret of silver. It is extensively used in medicine, and in the arts, being employed in the manufacture of gunpowder, friction, matches, vermillion, taking impression of seals, &c., &c. Sulphur is the strongest chemical substance next to oxygen, and has a powerful affinity for most of the other elements either directly by itself, or indirectly through its combinations; as acids and sulphates. Combined with oxygen, it forms sulphurous and sulphuric acids, which are extensively used in manufactures, and form new and important compounds with other substances.

3. *Sulphurous acid* is composed of one part sulphur and two parts oxygen ($S\ O_2$), and is produced by burning sulphur in the air, when it unites with oxygen, forming a colourless gas, of a disagreeable taste and suffocating smell. Sulphurous acid is used

for bleaching or whitening silk, woollen and straw goods, as chloride of lime is used to bleach linen and cotton goods. It also extinguishes combustion. It is therefore often used to quench the burning soot of chimneys by sprinkling some sulphur on the coals. The sulphurous acid rising drives out all the air and thus stopping the supply of oxygen to the burning soot, puts out the fire.

4. *Sulphuric acid* has one-third more of oxygen in it than sulphurous acid has—being composed of one part sulphur and three parts oxygen ($S\ O_3$). STÖCKARDT says: "What iron is to the machinist, sulphuric acid is to the chemist. As the former makes out of iron not only machinery of all sorts, but also instruments, by which he can work up every other material, so sulphuric acid has for us a double interest. It not only forms the bases of important salts, but we employ it also as the most useful chemical means for producing numerous other chemical substances and changes. It stands as it were, the Hercules among the acids, and by it we are able to overpower all others, and expel them from their combinations." It occurs in commerce as a liquid only. It is about twice as heavy as water. It is commonly called the *oil of vitriol*, as it was formerly obtained from green vitriol. It is now manufactured on a large scale from sulphur. Besides innumerable chemical uses, it is extensively used in the arts; in dyeing, calico printing, refining gold and silver, purifying oil and tallow; in the manufacture of blacking and various paints, of soda water, and various acids, such as the muriatic, nitric, &c.; also in the manufacture of soda from common salt, of chlorine for bleaching, of the sulphate of magnesia (Epsom salts) of the sulphate of soda (Glauber's salts), &c., &c.

5. Sulphur combined with hydrogen ($H\ S$) forms a gas called *sulphuretted hydrogen* or *hydrosulphuric acid*—a colourless gas, of the well known smell of rotten eggs, and which is produced by the putrefaction of organic substances containing sulphur, such as flesh, blood, albumen, or white of eggs, &c.)

PHOSPHOROUS. *Symbol* P: *Equivalent* 32.

51. *What is phosphorous?*—Phosphorous is a solid substance of a pale yellow colour, appears somewhat like bees's-wax, is soft and flexible at common temperatures and very inflammable. From its singular quality of shining in the dark, it has its name, which is derived from two Greek words, *phos*, light; and *phero*, to carry or bear, *light-bearer*.

(NOTES.—1. Phosphorous has such an affinity for oxygen, and is therefore so inflammable, that it never occurs naturally in a free state, and when prepared cannot be prevented from oxidizing, or taking fire, without being immersed in water. It must therefore be kept and cut under water. On being taken out of the water, it

should be held on the point of a knife or by a pair of forceps, as it takes fire in the air on the slightest touch or even heat of the hand, and burns furiously. It is a formidable poison.

2. Phosphorous is largely employed in the manufacture of lucifer or friction matches. At an establishment in the city of Ottawa, 100,000 of these matches are manufactured per day: and it is said that upwards of 200,000 pounds of phosphorous are annually used in London in the manufacture of matches—simply to tip the ends of them. But as the phosphorous would be liable to take fire when exposed to the air, it is kneaded with water and gum, or glue, into a paste, which when dried serves as a protecting varnish. The points of the matches are first coated with sulphur, then dipped in this preparation of phosphorous, and then cautiously dried in a stove. On rubbing the match against some rough surface, the friction causes the phosphorous first to take fire (causing a white vapour), next the sulphur or brimstone, and then the wood of the match.

3. Phosphorous, though not existing naturally as an element, is widely diffused in combination with other substances. It is usually found in the form of *phosphates*—which are compounds of metals with phosphoric acid. In plants and animals it mostly exists as phosphates of lime, magnesia, potash, and soda. As the phosphate of lime, it constitutes ten per cent. of the *bones* of animals; and from them the phosphorous used in matches is chiefly obtained. The phosphate of lime is the mineral portion of bones, and constitutes about 54 per cent. of their weight.

4. Phosphoric acid, consisting of one part phosphorous and five parts oxygen ($P\ O_5$), is always produced when phosphorous is burned in dry air or oxygen, for which it has an intense affinity. When a match is burned, the white smoke that appears is the phosphoric acid. This acid is of great importance in agriculture, as will appear hereafter, and it is chiefly from its presences in bones that they are so useful as a manure.

5. *Phosphuretted hydrogen* or phosphide of hydrogen consists of one part phosphorous and two parts hydrogen, is a colourless gas of more offensive smell than sulphuretted hydrogen. The curious phenomenon of will-o'-the-wisp or jack-'o-lantern, where a flame or light is said to move over marshy places, is ascribed to the presence of this self-inflammable phosphuretted hydrogen.

6. *Phosphorous* and *sulphur*, on account of their great inflammability, are called *pyrogens*—from two Greek words, *pur*, fire, and *gennao*, to produce—fire-generators.)

LESSON IX.

METALS. POTASSIUM AND SODIUM.

(NOTE.—The seven elements described in the three preding lessons are called, as has been stated, non-metallic substances, or metalloids. The remaining eight elements now to be described are called *metals.* They are opaque; they are characterized by a peculiar brilliancy called metallic lustre; they are conductors of both heat and electricity. Their various connections with agriculture will hereafter appear. They are distinguished as follows:—1. Metals of the alkalies—potassium and sodium. 2. Metals of the alkaline earths—calcium and magnesium. 3. Metals of earths—aluminum and silicon. 4. Metals used in the arts—iron and manganese. The first two will be the subject of the following lessons.)

POTASSIUM (Latin Kalium). *Symbol* K: *Equivalent* 39.

52. *What is potassium?*—Potassium is a bluish or silver-white metal of great lustre, and so soft at common temperatures that it may be marked by the fingers like wax. It is so light that it swims on the water, and has so great an affinity for oxygen, that its cut surface immediately tarnishes on exposure to the air. It cannot be kept in the air at all, but is kept in naphtha—a liquid containing no oxygen, but consisting only of carbon and hydrogen in equal quantities. It is never found free in nature, but occurs abundantly in rocks and soils combined with oxygen as potash, and in this form it enters largely into the composition of plants and the interests of agriculture and manufactures.

(Notes—1. Potassium has so strong an affinity for oxygen, that a little piece of it thrown upon the surface of water, instantly decomposes the water, taking the oxygen to itself to form potash, and setting free the other ingredient of water, hydrogen, which takes fire from the heat produced by the sudden union of the oxygen and potassium, burning with a flame of a beautiful violet colour. The contact of potassium with ice produces the same phenomenon of instant flame.

2. But it is the compounds which this metal forms with oxygen which are so important to agriculture and manfactures. Potassium

and oxygen combined in equal equivalents (K O) form a compound well known as potash—a strong alkali, possessing powerful basic properties, as will be explained hereafter. Potash (oxide of potassium) combined with the acids forms *salts*, as was explained in Lesson VI, such as carbonate of potash, nitrate of potash (saltpetre) &c.

3. Potash, or potassa, derives its common name from having been first obtained from the ashes of vegetable substances which had been burned in iron-pots,—hence named pot-ashes. Crude potashes and pearl ashes are prepared in large quantities in the woody parts of this country. When the wood or the leaves of any tree are burned a whitish ash remains behind, which contains variable quantities of carbonate of potash. This ash washed with water, and the washings evaporated in large iron cauldrons, and calcined, furnishes the commercial potashes. From these potashes pearl ashes, a purer kind of carbonate of potash, are obtained by adding a small quantity of water, decanting the liquid from the insoluable impurities present in the crude potashes and evaporating to dryness. ("London Encyclopedia.")

4. *Caustic potash* (which derives its name from its use in medicine in the form of small sticks to cauterise or cleanse ulcers and foul sores) is a hydrate of potash, containing single equivalents of potassa and water. When not hardened as a white solid, it is a white powder. In both its powdered and solid state, it has a powerful affinity for water, possesses in the highest degree alkaline properties—completely neutralizes the acids—restores to blue the vegetable colours which the acids have reddened—changes vegetable yellows to brown—decomposes animal and vegetable substances whether living or dead—has strong cleansing powers, and is therefore used in the making of soap; and potassa salts are among the most valuable of manures as will be seen hereafter. Indeed its uses can hardly be enumerated, and its compounds are almost endless as chlorates, sulphates, carbonates, nitrates, &c. &c. The sulphate of potash is an essential ingredient of *alum*; and the nitrate of potash is saltpetre, or nitre, is of special interest as being one of the three ingredients of *gunpowder*,—which is composed of nitre, charcoal and sulphur. The philosophy of gunpowder explosion is thus explained by Fownes: "When gunpowder is fired, the oxygen of the nitrate of potassa is transferred to the carbon, forming carbonic acid; the sulphur combines with the potassium, and the nitrogen is set free. The large volume of gas thus produced and still further expanded by the very exalted temperature, sufficiently accounts for its explosive effects.")

Sodium (*Natrium*). *Symbol* Na.: *Equivalent* 23.

55. *What is sodium?*—Sodium is a bright metal somewhat like silver, and very much resembles potassium both in appearance and properties. It is

not so light as potassium, yet so light as to swim on water. Its affinity for oxygen is not so strong as potassium, yet so strong that it rapidly tarnishes on exposure to air; like potassium; it must be preserved in naphtha or petroleum; does not take fire and burn like potassium on being thrown upon the surface of *cold* water, but, on being thrown upon the surface of *hot* water, sodium bursts into a beautiful yellow flame (and is thus converted into oxide of sodium or soda), while potassium burns with a violet flame. It is a very abundant substance, but is not found pure; it constitutes two-fifths of sea-salt, and is a large ingredient in rocks and soils.

(NOTES.—1. Sodium, the natrium of the Germans, was discovered by Sir Humphrey Davey in 1807, a few days after his discovery of potassium, which it so much resembles. It is only used in its combinations. Soda is a compound of equal equivalents of sodium and oxygen—protoxide of sodium (Na O). The common washing soda (called carbonate of soda) consists of equal atoms of carbonic acid and the oxide of sodium or soda. Soda united with sulphuric acid forms glauber salts—as has been explained in the notes on sulphur. Sodium united with chlorine forms common salt—chloride of sodium, as has been explained in the notes on chlorine. It is from common salt that the other compounds mentioned are obtained. "From common salt, or chloride of sodium, sulphate of sodium is prepared, from this, sulphuret of soda; then soda; and finally sodium" (*Stockhardt.*)

2. Of the many other compounds of sodium, I will not here speak. As caustic potash has been shown to be obtained from the carbonate of potash, so from the carbonate of soda has been obtained the caustic soda, which is so extensively employed in the manufacture of soap and glass. *Hard* soaps are formed from fats by *soda*; *soft* soaps are formed from fats by *potassa*. Potassa and soda, melted with sand, yield glass.

3. As potassium and sodium are the lightest of all metallic substances—both floating upon water—and have the greatest affinity for oxygen; so their oxides form the most powerful bases and are the strongest *alkalies*, which play so important a part in agriculture and manufactures.

From this lesson on the alkali-metals, I will proceed in the next lesson to give some account of the two metals of the alkaline earths—calcium and magnesium.)

LESSON X.

CALCIUM AND MAGNESIUM (ALKALINE EARTHS).

CALCIUM. *Symbol* Ca: *Equivalent* 20.

56. *What is calcium?*—Calcium is a silvery white metal, a little harder than lead and a little heavier than water. It is the metallic basis of *lime*, as its name indicates—calcium being derived from calx, the Latin term for lime, and from which we have the English word *calcareous*.

(NOTES.—1. Calcium is but little known and is put to no use as a metal, and is only procurable by difficult chemical process, but is widely known and used in its combinations. Its compounds are numerous and of the highest importance to the agriculturist, the manufacturer, and the artist.

2. Calcium with oxygen (Ca O) forms lime, and with carbonic acid (Ca O, C O_2) forms carbonate of lime, or *limestone*, composing whole ridges of mountains and known as one of the principal constituents of our earth. The varieties of marble consist essentially of this carbonate of lime, or limestone; it forms more than half of chalk, is the base of plaster of paris and alabaster, and constitutes the greater part of the mineral portion of the bones of animals.

3 *Lime* is the protoxide of calcium, and is produced by burning limestone (carbonate of lime) in large masses in kilns. The simple object of this burning is to drive off the carbonic acid into the air by the heat, when a white substance remains, sufficiently hard to be transported without crumbling to pieces, called *quick lime*, or caustic lime. One ton of good limestone (or carbonate of lime) yields about eleven hundred weight of quicklime. When quicklime is exposed to the air, it rapidly imbibes moisture and crumbles to powder; it then gradually absorbs carbonic acid, becomes less caustic, and finally regains the neutral condition of the carbonate. The air-slaked-lime is a mixture of the hydrate and carbonate of lime.

4. *Hydrate of lime* is the chemical name for *slaked lime*, and is produced by pouring about one pound of water upon three pounds of quicklime, which then melts to thrice its original bulk, and crumbles to a fine white powder, called the HYDRATE of *lime*. During the process of slaking a large heap of good lime, the heat evolved is sufficient to scorch wood. This rise of temperature is caused by the solidification and combination of a portion of the water with the lime. But if the water is added too rapidly in slaking, it seems to chill the lime and produces gritty lumps, which impair its value for both building and agricultural purposes.

5. *Mortar.* One of the most important uses of lime is in making mortar, which consists of lime and sand (silica) made into a paste with water, and which is employed by builders to cement stones and bricks together. The excellence of the mortar depends much upon the quality of the lime (which should be perfectly caustic) and the selection of the sand, which should be sharp and rather coarse grained, and free from the least impregnation of clay. It should be spread thinly and not allowed to dry too rapidly; to prevent which the surface of the brick or stone is sometimes saturated with water before the mortar is applied. It hardens gradually by a chemical action between the lime and the sand: and as the mortar becomes dry by the evaporation of the water, carbonic acid is attracted from the air and unites with a portion of the lime; so that there is in the mortar, a mixture of the hydrate and carbonate of lime, which has more firmness than either substance separately. Hence the remarkable hardness of the mortar of old buildings.

6. *Hydraulic cement.* But ordinary mortar will not solidify, or long resist disintegration under water. Hydraulic cement possesses this property. By burning limestone containing clay (which is the silicate of alumina) a burnt lime is obtained which, when mixed with water and sand, yields a mortar that solidifies quickly and becomes as hard as a stone under water. This is called *hydraulic cement*, and is therefore used in building piers of bridges and other structures under water.

7. Of the many other compounds of calcium and their uses I will not here speak. The *chloride of lime*, so extensively used for bleaching cotton and linen goods, I have mentioned in the notes on chlorine.

8. Lime, as a constituent of good land and its importance as a manure on clay and vegetable soils, will be noticed hereafter. Some idea may be formed how largely lime enters into the system of plants and is abstracted from the soil, from facts stated by Professor *Johnston* as to the amount of lime removed from an acre of land by the following crops, including hops, straw and grain:

Wheat, 25 bushels	8¾	lbs.
Barley, 38 "	15	"
Oats, 50 "	8½	"
Turnips, 25 tons	138¾	"
Potatoes, 9 "	266	"
Red clover, 2 "	126	"

Johnston remarks that "Grain grown on well-limed land has a thinner skin, is heavier, yields more fl that richer in gluten—than if grown on unlimed land."

MAGNESIUM. *Symbol* Mg: *Equivalent* 18.

57. *What is magnesium?*—Magnesium, like calcium, is a silvery-white, ductile, malleable metal;

not found native, but chemically obtained by decomposing the chloride of magnesium.

(NOTES.— 1. Magnesium forms several useful compounds, as oxide, chloride, nitrate, carbonate, phosphate, sulphate, silicate of magnesia. Its best known and most useful compounds are *magnesia*—the oxide of magnesium—consisting of the union of equal equivalents of oxygen and magnesium ($Mg\,O$); and *Epsom salts*—sulphate of magnesia ($Mg\,O, S\,O_3 + 7\,H\,O$)—whose constituents, as the formula shows, are sulphuric acid, the base magnesia and water.

2. Magnesium was long considered of no use separately; but it is now beginning to be largely used for illuminating purposes, especially in mines, in photography, &c. where a very brilliant light is required. It is not improbable that magnesium may, at no distant day, be employed as the chief domestic illuminating agent in place of candles, gas, or coal oil.

3. *Remarks on the alkaline earths.* The two metals—calcium and magnesium—described in this lesson are called alkaline earths. The properties of the *alkalies*, as also of acids, have been described in lesson VI. The metals calcium and magnesium are midway between alkalies and earths (which will be treated in the next lesson)—identical with neither, and partaking partly of the qualities of both. The alkalies are very soluble; the earths are insoluble; the alkaline earths are partially soluble. The alkalies are caustic; the earths are not at all caustic; the alkaline earths somewhat caustic. It is from this caustic quality that the milk of lime—lime diffused in water—is used in tanning, to remove the hair from hides. The alkalies with fats form soluble soap; the alkaline earths with fats form insoluble soap.)

LESSON XI.

METALS OF EARTHS. ALUMINUM AND SILICON.*

ALUMINUM. *Symbol* Al: *Equivalent* 14.

58. *What is aluminum?*—Aluminum is a white metal like silver in colour and hardness, but only one fourth as heavy. It is never found free in

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* Silicon holds an equivocal place in systems of classification—many chemists ranking it, on account of its affinities, among the non-metallic bodies; but BRANDE ranks it among the metals. His arrangement is here adopted, and silicon associated with aluminum—these forming the bases of the two principal earths. According to SILLIMAN, silica, or oxide of silicon, is estimated to form one sixth part of the surface of the globe.

nature, but always in union with oxygen, with which it unites in proportion of two to three, forming a sesquioxide of aluminum, well known as alumina ($Al_2 O_3$).

NOTES.—1. This metal was formerly obtained only at great cost; but M. DEVILLE, who has charge of the private laboratory of the Emperor of France, has of late years discovered a process by which it can be obtained in large quantities at as small a cost as silver by weight; and being as bright and as strong as silver, and four times lighter, it may be used for various purposes at one-fourth the cost of silver. Being very sonorous it makes good bells, and the French government propose to use it for helmets and cuirasses, for which it is so well fitted by its lightness and strength. Besides oxygen, aluminum unites with chlorine, sulphur, and phosphorous, and with all of them forms *sesqui* compounds.

2. Alumina—the sesquioxide of aluminum—or *aluminous earth*, is one of the most abundant productions of nature in every region of the globe, is a constituent of the oldest primary rocks, of the secondary strata, and of the most recent alluvial deposits; it is the basis of clay and an invariable constituent of all fertile soils. The various kinds of clay of which bricks, pines, pottery, porcelain, &c., are made, consist of hydrate of alumina more or less pure, in chemical combination with silica or sand.

3. Though alumina commonly is a rude mass of earth, it is sometimes found crystallized into the most beautiful and precious gems. The *saphire*, which in some of its varieties is next in hardness and value to the diamond, is pure alumina crystallized. The oriental *ruby*, the oriental *topaz*, the oriental *amethyst*, the oriental *emerald*, are red and yellow, and violet and green varieties of the saphire.

4. That useful salt, *common alum*, is the sulphate of alumina and potassa, its chemical formula being $K O, S O_3 + Al_2 O_3, 3 S O_3 + 24 HO$. As common alum is composed of two salts—alumina and potassa—chemically united it is called a *double* salt, and one of great and various utility. The *silicates of alumina* include all the varieties of *clay*, which are silicates or hydrated silicates of alumina. The varieties of *fire-clay* used for lining furnaces and other like purposes are nearly pure silicates; that is compound of alumina and silica (sand) = $Al_2O_3, 3 Si O_3$ *Fuller's earth*—so much used for cleaning and scouring cloth, from its property of absorbing grease—is a porous silicate of alumina. Feldspar and many other crystallized minerals are chiefly composed of silicates of alumina, as are granite, prophyry and other ancient unstratified rocks.

SILICON. *Symbol* Si; *Equivalent* 22.

59. *What is silicon?*—Silicon (sometimes called silicium) is a dark brown powder, not occurring free

in nature, but produced by chemical process. The word silicon is derived from *silex*, the Latin term for *flint*. Silicon is chiefly known in its union with oxygen forming silicic acid, silica, or sand—which is estimated to form about one sixth part of the surface of the globe. While carbon is the main constitutent of the organic kingdom, silicon in the form of silicic acid, is the chief constituent of the mineral kingdom.

(NOTES.—1. The union of silicon with oxygen in proportion of one to three ($Si\ O_3$) forms silicic acid or silica, which is the chemical name for what in common language is called flint. It seems strange to one unacquainted with chemistry, that a hard tasteless solid, such as we have in flint, quartz, &c., should be called an *acid*. It is so called because it unites with oxygen to form compounds, termed silicates, just as sulphuric and nitric acids unite with oxygen to form sulphates and nitrates.

2. *Silicic acid*, is better known by the names *silica* and *siliceous earth*. When pure, it is a light whitish power, which feels rough and dry when rubbed between the fingers, and is both insipid and inodorous. This compound is an abundant natural product. In some of its forms this mineral is found everywhere. It is a constituent of every soil; and under the form of sand and sandstone it covers a great part of the earth's surface. It constitutes a large portion of many mountain ranges, the sand and gravel of soils, and the pebbles upon the sea-shore. It forms gun-flints, grindstones and the porous burr-stones, used in flouring mills for grinding grain. It is an essential constituent in the mineral part of organic matter. It forms the outer-coat of the grasses, and of the husks of grain; and from this covering the long, slender, hollow stems of grasses and grains derive their strength, as the bodies of animals do from the skeleton. According to Professor Johnston, silica forms 74 per cent. of the ash of rye-straw, and 65 per cent. of the ash of wheat straw. If there is a deficiency of silicic acid in the soil, the grain-stock will be weak and therefore liable to fall down or lodge. It is the silica which chiefly blunts the edges of scythes and other instruments used in cutting the stalks of grasses and grains.

3. The crystallized forms of silica are numerous and important. Quartz and flint are nearly pure silica, and feldspar and mica are silicates. Various precious stones: *carnelian, amethyst, agate, opal, jasper*, &c., are silica, and their different colours are caused by the presence of metallic oxides. Crystallized silica, when colourless, forms quartz or *rock crystal*; when violet coloured, it is the *amethyst*, which owes its colour to traces of iron and manganese; when green it is the *prase*, or green quartz, and is coloured with

the oxide of iron; when tinged with a delicate apple-green, it is the *chrysoprase*, coloured by the oxide of nickel; when red, it is *rose quartz*, and owes its colour to the presence of manganese; when possessing red veins or spots, caused by the per oxide of iron scattered through it, it is *blood-stone* or heliotrope; when deposited from water, it is *chalcedony*, of which the milk-white variety forms *white carnelian* and the red variety *red carnelian*. The *onyx*, the *sard*, and the *sardonyx*, are varieties of chalcedony; the first, brown and opaque white in alternate layers; the second, a deep brownish red; the third, alternate layers of red and milk-white, forming a beautiful arrangement of colours in cameos, &c. Other forms of silica constitute jasper, opal, and numerous varieties of *agates*.

4. Besides other forms and uses, silica is extensively used in the manufacture of various kinds of glass; in the form of quartz-crystal it is often used for the glasses of spectacles, under the name of *pebbles*.)

LESSON XII.

METALS EMPLOYED IN THE ARTS. IRON AND MANGANESE.

IRON (*Latin*, *Ferrum*). *Symbol* Fe: *Equivalent* 28.

60. *What is iron?*—Iron is the most useful, most common, and most tenacious of all metals. When pure it is almost white; but the best iron in common use is far from being pure. It was in early times the symbol of war; it has become the emblem and instrument of civilization.

(NOTES.—1. The uses of iron can hardly be enumerated; an American poet has tersely expressed in the following lines a few of the many uses of this metal:

"Iron vessels cross the ocean,
Iron engines give them motion;
Iron needles westward veering,
Iron tillers vessels steering;
Iron pipe our gas delivers,
Iron bridges span the rivers;
Iron pens are used for writing,
Iron ink our thoughts inditing;
Iron stoves for cooking victuals,
Iron oven, pots and kettles;
Iron horses draw our loads,
Iron rails compose our roads;
Iron anchors hold in sand,
Iron bolts, and rods and bands;
Iron houses, iron walls,
Iron cannon, iron balls;
Iron axes, knives and chains,
Iron augurs, saws and planes;
Iron globules in our blood,
Iron particles in food;
Iron lightning rods on spires,
Iron telegraphic wires;
Iron hammers, nails and screws,
Iron everything we use."

2. Iron has been found native in a few instances, and in small quantities, occurring almost entirely in meteoric stones; but it is

almost always found in combination with oxygen, carbon, sulphur and some other elementary substances. These compounds of iron are the most abundant oxides in nature, and constitute the colouring matter of rocks and soils, are contained in plants, form an essential constituent of the blood of the animal body.

3. *Ores of iron* is the name given to minerals which contain iron in such form and quantity as to be employed in the preparation of the metal. Mineralogists have described nearly fifty different species of these ores; but the essential constituents of them all are *iron* and *oxygen*; and only about five or six of them are used to any great extent in the manufacture of iron. The following are the principal ores: (1) Loadstone, or the magnetic black oxide of iron, remarkable for its magnetic properties—the ore of most of the celebrated iron mines of Sweden. It is from this ore that the Swedish bar-iron is manufactured so much for making steel. (2.) *Red iron ore*, or *specular iron ore*, or *red haematite* (*sesqui oxide of iron*) found in different countries, and producing to a limited extent a hard iron resembling polished steel. (3) *Brown iron ore* (*hydrated sesquioxide of iron*) abundant all over the world, especially in America, and the chief source of the iron of commerce. (4) *Bog iron ore*, found in low places, immediately beneath the soil, consisting of hydrated peroxide, mixed with phosphate. This ore yields phosphorous cast-iron. (5) *Pyrites*. Iron sometimes occurs combined with *sulphur* in various proportions, usually in fine crystallized minerals of brass-like lustre, called *pyrites;* which signifies *fire-stone*—so named because it was used in fire-locks before the introduction of gun flints, to produce sparks with steel. Pyrites is a sulphide or sulphuret of iron; of which there are two varieties; *magnetic iron pyrites*, a protosulphide of iron; and *common* or *yellow pyrites*, a bisulphide of iron—the latter containing twice the proportion of sulphur as the former. When yellow pyrites occurs in minute brilliant scales, it is sometimes mistaken for gold—"fools' gold." It is easily tested by heating, when it gives off a *sulphurous* smell, which of course real gold never does. Common pyrites occur plentifully, sometimes massive, crystallized in various forms, and sometimes in very fine laminæ and grains, in coal, &c., and is chiefly prized as the source of copperas, Spanish brown, sulphur, and sulphuric acid. When oxidized by exposure to the air and moisture, it yields protosulphate of iron—the green *copperas* or *green vitriol* of commerce and which is often pernicious to soils.

4. *Iron is produced from its ores* by subjecting them to intense heat in a blast-furnace with charcoal. The object of this is twofold. *First*, to separate the oxygen from the iron. This is effected by the intense heat, which causes the oxygen to leave the iron and unite with the carbon of the charcoal, forming carbonic acid, which flies off with the smoke of the furnace. *Secondly*, to remove from the iron the impurities of clay, flint (silica), &c., which most ores contain. The same heat which separates the oxygen from the iron fuses (by the aid of lime added for the purpose when the

ore does not contain it) the silicic acid, and alumina into a dark coloured glass called *slag*, which flows with the melted metal to the bottom of the furnace. The slag or glassy substance being much lighter than iron, floats upon the surface of the liquid iron, and protects it from the atmosphere which would otherwise oxydize a considerable quantity of it. The *slag* runs off by an aperture left for that purpose, while the melted iron is drawn off at intervals through a *tap-hole* at the bottom of the furnace, into moulds of sand, where it becomes cool, and constitutes the *pig* or *cast* iron of commerce. These moulds of sand consist of a *straight channel* with *furrows* running at right angles. The workmen call the channel of the moulds the *sow*, and the furrows the *pigs*. Hence the origin of the term *pig-iron*.

5. *Varieties of iron. Pig* or *cast-iron, wrought-iron*. steel; the differences in which are chiefly owing to the proportion of carbon present in each. The first product of the blasting furnace is *pig* or *cast-iron*, which contains about five per cent. of carbon, and which with some other impurities causes the brittleness and fusibility of pig-iron, and thus adapted to be run into moulds. It is therefore used in making all kinds of castings. But while its hardness and capability of being cast in moulds fit it for a great variety of uses, its brittleness renders it incapable of being worked in any other way and unfits it for the various uses to which wrought iron and steel are adapted.

Wrought iron is obtained from *pig* or cast iron by decarbonizing it, or burning the carbon out of it. This is done by taking advantage of the fact, that carbon is more combustible than iron; and exposing the pig-iron (after some refining preparation) to a current of air heated to the highest degree in an oven-shaped furnace (reverberatory furance) in which the fuel is not mingled with the metal as in the case of smelting, but heats by the flame reflected from the low roof. The result is that the oxygen of the heated air passing through the furnace unites with the carbon of the pig or cast iron, and passes off as carbonic acid; and the metal thus divested of all but a trace of about half per cent. of carbon, is taken out in the shape of balls with a long oar-shaped iron instrument, and after being subjected to a great pressure by machinery, it is passed through a succession of iron rollers, each pair having a smaller space between them than the preceding, until the soft *bar-iron* of commerce is produced. This bar or wrought iron differs in several respects from cast iron. The latter is hard and brittle, while the former is soft, flexible, malleable, ductile, and the most tenacious of all metals. When heated in a high degree, wrought iron becomes only a semi-fluid, and therefore cannot be made to run into moulds like cast-iron; but at red heat can be wrought into any shape, and at white heat can be *moulded*—which cannot be done with cast iron. There is also a difference in the *texture*. Cast from is *granulous*—composed of grains—as may be seen by examining a broken edge; but the structure of wrought from is *fibrous*—composed of threads or fibres lying alongside of

each other. In welding, the fibres of the iron intermix, which adds to the strength of the material; and therefore articles which require to be very strong, such as anchors, &c., are not made of a single piece, but of a bundle of bars of iron welded together.

Steel is a form of iron half way between wrought and cast iron as to the quantity of carbon it contains—a compound of iron and carbon. Cast iron contains five per cent. of carbon; wrought iron contains half per cent.; steel contains from one to two and a-half per cent.

Steel may be manufactured by two opposite processes. It may be made by partially *decarbonizing* very pure cast iron—that is by burning out half the carbon; or from wrought iron by restoring part of the carbon separated from it in its preparation. The latter is the usual method. It consists of a process called *cementation*—by heating to full redness bars of the purest iron surrounded by pulverized charcoal in iron or fire-clay rectangular boxes, whereby the carbon combines with the iron and converts it into steel. This process requires from 6 to 10 days, according to the thickness of the iron bars, which, when removed from the furnace, exhibit a *blistered* surface.

The steel obtained by the partial refining of cast iron is called *native*, or *forge-steel*, while that prepared by cementation is called *bar* or *blistered steel*. When the *blistered steel* is drawn down into smaller bars by the tilting hammer, or extension cylinders, it forms *tilted steel;* and when broken up, and heated again to welding heat, and again forged into bars, it forms *refined steel*, or *shear steel*—so called because it was at first prepared thus for making *shears* to dress woollen cloth.

English *cast steel* is prepared by breaking into pieces and heating blistered steel to the fusing point in fire-clay crucibles, casting it into ingots, which are afterwards hammered or rolled into bars.

Tempering steel presents some curious facts. The most remarkable property of steel is that of becoming extremely hard when quickly cooled; which is not the case with iron. When steel is heated to a cherry-redness and then plunged into cold water, it becomes so hard and brittle as to be almost unfit for any practical purpose. If again heated to redness, and cooled rather gradually, it becomes elastic; and if cooled very slowly (*annealed*) it becomes soft, ductile and malleable, like the softest bar-iron. Between these two conditions any required degree of hardness can be attained; and is thus determined by the workman from the colour of the metal in heating. Steel, while being wrought into any instrument or article, must of course be as soft as possible; but before being tempered, it must be hardened in the highest degree in the manner above described, and then *tempered* or *let down* by graduating the heat applied. The lowest degree of heat (followed by gradual cooling) reduces the steel least from its high degree of hardness; while the greatest degree of re-heating, followed by gradual cooling, makes the steel most soft and ductile. Now as the heat is applied and increased, the steel assumes a different

colour, owing to the thin film of oxide which appears on the surface, and which reflects the various colours according to its thickness. These various colours may be seen by experiment with a common knitting needle. First, heat it to redness in the flame of a common spirit lamp or candle, and quench it in cold water. Hold it now again in the flame, and observe the change of colour, first of a pale straw yellow, then dark golden yellow, then brown, purple, bright blue, indigo blue, and very deep blue. Now there is a definite degree of hardness on the one hand, and of elasticity on the other, corresponding to each one of these colours—the yellow giving the most brittleness and hardness; the blue the most softness and elasticity; and the other colours giving the intermediate results. The pale yellow indicates the temper for tools for cutting metals; golden yellow for razors and best penknives; brown and purple for scissors, axes, chisels, ordinary knives, &c.; bright and deep blue for swords, watch springs, saws and other articles requiring great elasticity.

6. Steel admits of a higher polish and is less liable to rust than iron. But iron undergoes no change by dry air; it is only in moist air that it oxidizes and becomes covered with rust. *Galvanized iron* is made by dipping iron (with a cleaned surface) into melted zinc, and then into melted tin. The coating thus given prevents rust.

Such are a few of the forms and compounds of iron, used in every day life, and the manner and *reasons* of certain processes in its manufacture and modifications.)

MANGANESE. *Symbol* Mn: *Equivalent* 28.

61. *What is manganese?*—Manganese is a hard, brittle metal, greyish-white, like cast-iron, resembling iron in several of its properties, in many of the ores of which it is found. It is never found native; but in its oxides, next to iron, it is the most diffused of all the heavy metals, though rarely met with in considerable quantities. It forms no less than seven different compounds with oxygen; and its oxides are sparsely diffused through nearly all soils, and traces of them have been detected in the ashes of most plants. The ashes of oak-bark and horse-chesnut are rich in oxide of manganese. It rapidly oxidizes when exposed to the air—its surface becoming covered with a dark-brown rust; and it is generally therefore kept in naphtha, like phosphorous and potassium.

(NOTE. This metal is extremely difficult to prepare in a state of purity, and so hard to fuse that it has not been applied to any use. It is only used in its compounds. The most important of these is the per-oxide of *manganese* ($Mn\ O_2$), which is employed as a cheap method of procuring oxygen on a large scale, and in enormous quantities, in the preparation of chlorine from sea salt, or in the decomposition of common salt for the production of chlorine, and as a chemical agent in the various arts and manufactures. *Protoxide of manganese* ($Mn\ O$) is employed for giving a violet colour to glass, and is the basis of the salts of this metal. One of these is very remarkable. On fusing hydrate, or carbonate of potassa, or nitre, with the black or peroxide of manganese, in an open vessel, a dark coloured compound is obtained, long known under the name of *chameleon mineral*, because of its yielding in cold water a solution, which changes its colours, being successively green, blue, purple, red, brown, and ultimately deposits a brown powder, and becomes colourless.

LESSON XIII.

OTHER USEFUL METALS. TIN, COPPER, ZINC, LEAD, MERCURY, GOLD PLATINUM, AND SILVER.

(NOTE.—Out of the 66 elementary bodies which chemists have discovered, I have, in the foregoing lessons, given some account of the fifteen which are most connected with the interests and pursuits of agriculture. But there are several others which enter so largely into social and commercial relatiens, that a brief notice of them will, I trust, not be deemed superfluous or uninteresting.)

TIN (Latin, *Stannum*). *Symbol* Sn: *Equivalent* 59.

62. *What is tin?*—Tin, next to silver, is the most beautiful of white metals, is softer than gold, but harder than lead, slightly ductile, very malleable—the common tin-leaf or foil not being more than one thousandth part of an inch in thickness. Tin does not easily oxidize or *rust*, but long retains its lustre in either air or water.

Where is tin obtained?—Tin is never found pure in nature; it is always found in combination with oxygen or sulphur (as an oxide or sulphuret), in rocks and alluvial deposits. It is rather a scarce metal, found in few parts of the world in any quantity. Cornwall, in England, is its most abundant

source, where it is found as tin dioxide or *tin-stone.* It has also been found in Spain, Saxony and Bohemia, and has been brought from Borneo and Malacca in India, and from Chili and Mexico. It has not been found in the United States except a small vein in the White Mountains of New Hampshire.

Has tin been long in use?—Yes, tin was in common use in the time of Moses, as was gold and silver, brass, iron and lead (Numbers xxxi. 22). The ancient Phœnicians and Romans employed it in the manufacture of bronze; and they are supposed to have obtained it from Britain and Spain.

How is tin employed in manufactures?—Tin is chiefly employed as an *alloy*—that is, as a compound with some other metal. It is extensively used to protect sheet-iron from the oxidizing or rusting influence of air and liquids. Our common tin ware is not tin alone, but consists of thin sheets of iron dipped in melted tin metal. The sheets of iron thus coated, or rather alloyed with tin, constitute the well known tin-plate, so useful for innumerable purposes; iron chains, &c., are often coated with tin to prevent their rusting. Tin is also used to line copper vessels, which may then be employed without danger to cook any kind of food. *Pins,* which are made of brass, are coated with a very thin covering of tin by a chemical process, by which they are boiled for a few minutes in a solution called tinning liquor, consisting of common salt, alum, bitartrate of potassa, with water, to which are added tin filings, or finely granulated tin. The pins soon become coated with a film of tin and are taken out, cleaned and dried. Tin combined with antimony and copper forms *Britannia metal.*

(NOTE.—Alloys which contain mercury (quick silver) are called *amalgams.* An amalgam of tin with mercury is used for silvering the backs of mirrors, or looking-glasses; and an amalgam of tin

and zinc with mercury is used to excite electrical machines. Other alloys of tin will be noticed under copper.)

COPPER (*Latin, Cuprum*). *Symbol* Cu : *Equivalent* 32.

63. *What is copper?*—Copper is a tough, malleable metal; the only metal of a red colour; next to gold, silver, and platinum, the most malleable and ductile of metals, and therefore much used in the forms of sheet and wire; more elastic than any metal except steel; and the most sonorous of all metals.

Where is copper found?—The richest copper mines are those of Cornwall, in England, which are supposed to have been worked long before the Christian era. It is an abundant metal found in various countries, as Sweden, Germany, Russia, South Australia, Chili, Cuba, &c., and there is much of it in the neighbourhood of Lake Superior, one piece of which was taken to Washington, and weighed 3,404 pounds.

In what state is copper found?—Copper is often found native (as in the region of Lake Superior); and hence it became known to the ancients long before iron, which required science and skill to reduce it to the metallic form. But copper more frequently occurs in ores, of which there are several kinds. Of these the most important are the varieties of *copper pyrites*—a double sulphuret of iron and copper ($Cu_2 S + Fe_2 S_3$); that is an ore in which the sulphur is chemically combined with both of these metals—the particles of the two sulphurets or sulphides being most intimately mingled together. There are also other ores of copper—red or cuprous oxide ($Cu_2 O$), pure cuprous sulphide (Cu_2S), carbonate or malachite ($2 (Cu O) C O_2 H O$). Large quantities of valuable ore, chiefly carbonate and red oxide, have been of late years taken to England, from South Australia and Chili.

How is copper used?—Copper is largely used in sheathing ships, as it does not tarnish or oxidize as easily as iron; it is also worked into a variety of domestic utensils, as tea-kettles, boilers, saucepans, &c., &c., and is employed for various mechanical and artistical purposes.

(NOTE.—Vegetable acids dissolve copper in a *cold state*, but not in a *hot state*. Sauces containing vinegar or anything tart, and preserved fruits and jellies, should not therefore be allowed to remain in copper vessels, as the salts produced are poisonous.)

Does copper combine with other metals?—Copper combines with several metals, as tin, zinc, lead, &c., to form many useful *alloys*. Bronze, which was especially used in ancient times for the fabrication of utensils and works of art of every kind, consists of from 85 to 97 per cent. of *copper* and from 15 to 3 per cent. of *tin*. GUN-METAL, of which cannons are cast, contains 90 per cent. of copper, with 10 per cent. of *tin*. BELL-METAL and GONG-METAL are formed of 75 to 80 parts *copper* and 25 to 20 *tin*. SPECULUM-METAL, with which mirrors of telescopes are made, consists of 2 parts of copper and 1 of tin. The speculum of Lord Rosse's celebrated telescope is composed of 126·4 of *copper* to 58·9 of *tin*. BRASS is an alloy of *copper* and *zinc*—71 per cent. of the former and 29 per cent. of the latter. RED-BRASS, termed *tombac*, *Dutch-gold*, and pinchbeck, consists of 85 per cent. of copper to 15 per cent. of zinc. GERMAN-SILVER consists of 2 parts of *copper*, 1 of *nickel*, and 1 of *zinc*. *Gold* and *silver* coin is alloyed with from one-tenth to one-twelfth of *copper*, by which its hardness and wearing are greatly improved.

(NOTE.—The several *compounds* of copper are not noticed.)

ZINC. *Symbol* Zn : *Equivalent* 33.

64. *What is zinc?*—Zinc is an abundant and useful metal of bluish-white, colour, of bright metallic

lustre, closely resembling magnesium in its chemical character. At low and high degrees of heat, it is naturally so hard and brittle as not to be workable; when heated to between 250° and 320° it becomes malleable and ductile, and may be easily hammered and rolled into leaves, and drawn into wire; and what is remarkable, it afterwards retains this malleability and ductility when cold. But if heated to a high degree, zinc again becomes brittle. It is harder and lighter than lead, cheaper than copper, and not affected by the air and water so readily as iron.

Where is zinc obtained?—Zinc is found abundantly in Great Britain and on the continent of Europe, and also in immense quantities in the State of New Jersey.

In what state is zinc found?—Zinc is found in a state of carbonate, silicite, and sulphide, associated with lead ores in many districts. The chief ores are the sulphide or *zinc-blende*, and the carbonate usually called *calamine.*

How is zinc employed?—Zinc is employed in the form of sheets for roofing, gutters, gas-pipes, gasometers, lining refrigerators, sinks, &c., &c., protecting the floor or carpet from the heat of stoves, and in various other ways. It is also used by the chemist for preparing hydrogen, and in galvanic batteries. It is likewise used as a protecting covering for iron. The sheets of iron are plunged into melted zinc covered with sal-ammonia, which keeps the surface of the zinc free from oxide and allows the two metals to unite. Iron thus coated with zinc is said to be *galvanized*, and is called *galvanized-iron.*

(NOTES.—1. Under the head of *copper*, it has been shown that zinc is a constituent of *brass* and *German silver*. Among the compounds of this metal, it may be remarked that sulphate of zinc ($Zn\ O, S\ O_3$) is the *white vitriol* of commerce.

2. Zinc sheets should be riveted with zinc nails, not as is sometimes the case with iron or copper nails, the contact of which with

zinc tends to destroy it by electric action. Indeed any of the common metals in metallic contact with zinc tend to produce its oxidation.

3. It may appear singular that while zinc itself tarnishes or oxidizes in air or moisture, it should be used as a protecting covering to iron against rust. This arises from the difference between the rusting of the two metals. When iron oxidizes on exposure to dampness, the oxidation goes into the very body of the iron, eating it, as it is commonly expressed; but when zinc oxidizes or tarnishes, a thin film is formed on its surface—hydrated oxide; and when zinc once becomes coated with this thin film of rust, it undergoes no further change; the film protects the zinc from any further action of the oxygen of the air, while iron rust eats in and in until it destroys the metal. The same thing is also true of tin. The tarnishing of tin itself is the same as that of zinc, but the rusting of *tin-ware* is different. This takes place only when the iron covered by the tin comes into contact with the air, by some defect in the covering, or wearing off of the tin, or its removal in any spot by contact with some hard body. No sooner is any portion of the tin so worn or rubbed off by friction or otherwise, as to denude the iron and thus expose it to the air than a spot of rust appears and rapidly extends, soon making a hole through the sheet. Thus from the electrical relations of the metals, the iron, if anywhere exposed, has an increased tendency to oxidation. Hence the superiority of iron plates, or sheets covered with zinc, over those covered with tin—the zinc being an electro-positive, and tin an electro-negative in regard to iron exposed to air or water.)

LEAD (*Latin*, *Plumbum*). *Symbol* Pb: *Equivalent* 104.

66. *Describe lead.*—Lead is a very soft, flexible metal of bluish-gray colour, very malleable but not very ductile; has little tenacity, and is not elastic. In the air a film of oxide is rapidly formed on lead, as on zinc, and protects it from further corrosion. Lead contracts on solidifying, which renders it unfit for castings. Next to iron, lead is the most abundant metal, is proverbially heavy, and is used for a great variety of purposes.

67. *How is lead found?*—Lead does not occur free in nature. There are many kinds of lead ores and extensive lead mines in many different countries; but the ore from which all the lead of commerce is extracted is its sulphide or sulphuret,

composed of 104 parts lead and 16 sulphur, and which is the *galena* of mineralogists.

68. *Mention some of the compounds of lead.*—There are four definite combinations of lead with oxygen—forming oxides; and the protoxide of lead forms several salts, with the acids. I will mention two or three. *Protoxide of lead* (Pb O) is made to assume different colours and is used for different purposes. When lead is heated in air a *yellow powder* is formed, which is called massicot, and which is sometimes used by painters, and in the composition of ointments and plasters of the apothecary. If massicot be melted it crystallizes on cooling into a *reddish-yellow* or brick-red coloured mass, composed of brilliant scales or flakes, and is called *litharge.* This is extensively used in the arts; in the manufacture of flint glass, conferring on it brilliancy and fusibility; in forming with linseed oil the varnish of the cabinet-maker; in making, on being boiled in oil, the sticking plaster of the surgeon; in the manufacture of red lead, white lead, &c., &c. When the *massicot* is heated to low-redness with a current of air flowing over its surface, it forms *red lead*, or *minium*, which is of a beautiful red colour, and used in painting, forming a cheap substitute for vermillion. *White lead*, so extensively used as a white paint and to give body to other paints, is a carbonate or salt of lead (Pb O, C O_2).

69. *State some of the alloys of lead.*—Lead, like copper, forms with other metals useful alloys. *Type metal* is an alloy of *lead* and *antimony.* *Tin workers' solder* consists of but equal parts of lead and tin; but the *Plumbers'* solder is composed of two parts of lead to one of tin; *common pewter* is composed of three parts of tin to one of lead. *Lead shot* are composed of an alloy of lead and *arsenic.* Shot is made by pouring melted lead through an iron cullender or strainer, perforated with holes according

to the desired size of the shot; and the drops are let fall from such a height that they solidify before reaching the water. A small quantity of arsenic is added to the lead to render the drops perfectly globular.

LESSON XIV.

THE NOBLE METALS—MERCURY, SILVER, PLATINUM, AND GOLD.

70. MERCURY OR QUICKSILVER (Latin *Hydrargyrum*). *Symbol* Hg: *Equivalent* 100.

(NOTE.—Mercury, silver, platinum and gold are called *noble metals*, because they do not *rust*—that is, combine with oxygen of the air at ordinary temperatures.)

MERCURY is a silvery-white metal of a very brilliant metallic lustre. It is distinguished from all other elements by being liquid at ordinary temperatures. From its liquid character and silver colour it was called hydrargyrum (from *hudor*, water, or liquid, and *arguron*, silver), and has received the ordinary name of *quicksilver*. It becomes solid or freezes only at forty degrees below zero. Unlike water, it contracts instead of expanding at the moment of congelation.

Mercury is sometimes found native, but it is chiefly obtained from an ore called *cinnabar*, which is a sulphide of mercury. It is found in small quantities in England and France, in Siberia, the East Indies, and in South America; but the principal mines from which it has been obtained are those of Idria, in Illyria, and Almaden, in Spain, and in China and Japan. Latterly it has been discovered in great abundance and purity in California and Australia.

Mercury is extensively used in the construction of thermometers and barometers, and for extracting

gold and silver from their ores. With tin it forms an amalgam for silvering mirrors, and with tin and zinc it forms the amalgam for electrical machines. The compounds of mercury, though poisonous, are used as medicines and for many other purposes. *Calomel* is a compound of mercury and chlorine subchloride of mercury (Hg_2Cl), as is *corrosive sublimate*—chloride of mercury. Vermillion is sulphide of mercury (Hg S). Mercury is a constituent of numerous other compounds and amalgams, and is employed for various medicinal, artistical and mechanical purposes.

71. Silver (Latin, *Argentum*). Symbol Ag: *Equivalent* 108.

Silver is the whitest of metals and second to none in lustre, which it does not lose in pure air at any temperature. It is very malleable, and so ductile that a single grain may be drawn into a wire 400 feet long. In malleability and ductility it is only inferior to gold. Silver is found in the native state, as well as combined with sulphur and chlorine, as a sulphide, and chloride. Its mines are discovered and worked in various countries.

Silver is used in every country for coin and for various articles of utility and ornament. Silver coin is always alloyed with copper to increase its hardness and to resist the wear of use. In Great Britain the standard silver coin is composed of one-eleventh copper; in France and the United States one-tenth; in Prussia twenty-five per cent.

Silver does not oxidize or rust in air or water; but it becomes *tarnished* from the action upon it of hydro-sulphuric acid, traces of which the air always contains, derived from organic bodies. The gas is also produced during the combustion of mineral coal, and escapes from the stoves, furnaces and grates into the rooms or cabinets where articles of

silver are kept. It is because they contain a small quantity of sulphur, that eggs, mustard and horse-radish tarnish silver spoons. Silver forms compounds with oxygen, sulphur, chlorine, iodine, and bromine, all of which are darkened by the action of the light—a property which contributes to the beautiful processes of photography.

PLATINUM. *Symbol* Pt: *Equivalent* 99.

72. Platinum is the heaviest of known metals (except iridium), being twice as heavy as silver; has a bright colour like that of steel; is very ductile and malleable like gold; cannot be melted by the heat of the hottest furnace; can only be melted by the oxyhydrogen blow-pipe; is about half as malleable as gold; does not tarnish by exposure to the air, or to any acid except aqua regia—a mixture of nitric and hydrochloric acids. It is harder than copper but softer than iron. Being very malleable and ductile, it can be easily wrought into vessels.

NOTES.—1. The crucibles of the chemist are often made of platinum, and it is also used in the manufacture of oil of vitriol, and in enamelling on glass and porcelain.

2. Platinum forms several alloys with iron, copper, silver, zinc, lead, &c.)

73. GOLD (Latin *Aurum*). *Symbol* Au: *Equivalent* 98.

Gold is the most precious and widely diffused of all metals—being found in most countries. It is of a bright yellow colour, and so malleable that it may be extended into leaves two hundred and eighty-two thousandths of an inch in thickness, or so thin that 1200 of them pressed together would be no thicker than a leaf of this book, and it is so ductile that a single grain may be drawn into 500 feet of wire. It does not tarnish by exposure to air or any acid except aqua regia.

(NOTES.—1. The various uses of gold are too well known to require explanation.)

2. Gold occurs in nature in the metallic state, sometimes beautifully crystallized. It is found disseminated in primitive rocks and in the sands of the beds of rivers, formed by streams from the mineral veins of rocky mountains. When these sands are washed, the gold dust being of greater specific gravity than the sand, is left behind, while the sand is washed away.

LESSON XV.

KINDS OF SOIL.

(NOTE.—I have now given some account of the two kinds of substances—organic and inorganic—which exist in nature; the proportions of these substances in soils, plants and animals; the organic constituents of plants and animals; the fifteen elementary substances with which the farmer has to do, their names, symbols, equivalent numbers; the definite proportions in which they combine to form acids, bases, salts, &c., together with definitions of various terms and terminations. To the description of the fifteen non-metallic and metallic substances with which the farmer has to do, I have added, in lessons XIII. and XIV., a brief account of other useful metals which enter into the commerce and business of every-day life. There are two more preparatory subjects of which the farmer should have some knowledge—namely, the *kinds of soils* and the *structure of plants.*)

74. *What is the soil?*—The soil is that part of the earth's surface which is tilled for agricultural purposes, and which is reached and stirred by agricultural tools.

75. *How is the soil made up?*—The soil is made up of various kinds of earth, of which the three most important are *silicious* earth, or sand; *argillaceous* earth, or clay; and *calcareous* earth, or that made of limestone, which has been shown in lesson X. to be carbonate of lime. The mixture of these three different kinds of earth with various vegetable and animal substances, forms most of the different kinds of soils.

76. *What is the origin of soil?*—As soils consist of mineral and vegetable substances (as shown in lesson II.) they originate in the decomposition of rocks and the decay of vegetables. The surface of the rocks left exposed to the action of winds, rains

and frosts, summer and winter, by degrees crumbles away. The natural crumbling of the naked rock gradually covers it with loose materials, in which seeds fall and vegetate, and thus a soil is eventually formed.

77. *How is it known that soils originate in the decomposition of rocks?*—Because the soils of a country resemble the rocks beneath them. The geologist, as he travels over and investigates the nature of the rocks beneath the earth's surface, finds, by comparison of the different kinds of rocks, "that they are all either sandstones, limestones, or clays of different degrees of hardness, or a mixture in different proportions of two or more of these kinds of matter;" and on analyzing the soils, he finds that they have a resemblance to the rocks beneath them. "The conclusion (says Professor Johnston) is therefore irresistible, that soils, generally speaking, have been formed by the decay of solid rocks"—"that the accumulation of soil has been the slow result of the natural wearing away of the solid crust of the globe." "The soil thus produced partakes necessarily of the chemical character and composition of the rock on which it rests, and to the crumbling of which it owes its origin. If the rock be a sandstone, the soil is sandy; if a claystone, the soil is more or less stiff; if a limestone, the soil is more or less calcareous; and if the rock consist of any peculiar mixture of those three substances, a similar mixture is observed in the earthy matter into which it has crumbled."

(Note.—From these remarks may be inferred the intimate and important relations between agriculture and geology. See the 6th chapter of Johnston's Agricultural Chemistry on the "*Direct relations of Geology to Agriculture.*")

78. *What is the organic part of soils?*—The organic part of soils is that which is chiefly derived from the decayed remains of vegetables or animals

which have lived or died upon the soil; or which have been spread over it by rains or rivers; or which have been added as a manure, by the hands of man.

79. *How are soils classified?*—Some have classified soils by their predominant characteristic—terming that, *rocky soil* which abounds in large boulders, and that *stoney* soil whose surface abounds with stones of smaller sizes; then clay, sandy, gravelly loamy, vegetable, peaty soil, &c. The following is an abridgment of the classification of soils by Professor Johnston, based principally upon their chemical constituents:—

1. *Pure clay* (pipe clay) consisting of about 60 per cent. of silica and 40 of alumina and oxide of iron, for the most part chemically combined. It allows no free sand to subside when diffused through water, and rarely forms any extent of soil.

(NOTE.—For the constituents of silica, alumina, oxide of iron and free sand, see lesson XI., under the articles aluminum and silicon, and lesson XII., under the article iron.)

3. *Strongest clay soil* (tile clay, unctuous clay) consists of pure clay mixed with 5 to 15 per cent. of free sand, which can be separated from it by boiling and decantation.

4. *Clay loam* differs from clay soil, in allowing from 15 to 30 per cent. of free sand to be separated from it by washing, as above described. By this admixture of sand, its parts are mechanically separated, and hence its freer and more friable nature.

4. *A loamy soil* deposits from 30 to 60 per cent. of sand by mechanical washing.

5. *A sandy loam* contains from 60 to 90 per cent. of sand; and

6. *A sandy soil* contains not more than 10 per cent. of pure clay.

But the above classification has reference only to the clay and sand, while we know that lime is an important constituent of soils, of which they are seldom entirely destitute. We have therefore,

7. *Marly soils*, in which the proportion of lime is more than 5 per cent. but does not exceed 20 per cent. of the whole weight of dry soil. The marl is a sandy, loamy, or clay marl, according to the proportion of clay it contains would place it under one or the other denomination, supposing it to be entirely free from lime, or not to contain more than 5 per cent.; and

8. *Calcareous soils*, in which the lime exceeding 20 per cent. becomes the distinguishing constituent. These are called calcareous clays, calcareous loams, or calcareous sands, according to the proportion of clay and sand which are present in them.

Lastly, vegetable matter is sometimes the characteristic of the soil, which gives rise to another division of

9. *Vegetable moulds*, which are of various kinds, from the garden mould which contains from 5 to 10 per cent., to the peaty soil, in which the organic matter may amount to 60 or 70 per cent. These soils also are clayey, loamy, or sandy, according to the predominant character of the earthy admixtures.

NOTES.—1. The mode of examining, with the view of naming the first six kinds of soil above mentioned, is very simple, and is thus stated by Professor Johnston: "It is only necessary to spread a weighed quantity of the soil in a thin layer upon writing paper, and, to dry it for an hour or two in an oven or upon a hot plate, the heat of which is not sufficient to discolour the paper—the loss of weight gives the water contained. While this is drying, a second weighed portion may be boiled, or otherwise thoroughly incorporated with water, and the whole then poured into a vessel, in which the heavy sand parts are allowed to subside until the fine clay is beginning to settle also. This point must be carefully watched, the liquid then poured off, and the sand collected, dried as before upon paper, and again weighed. This weight is the quantity of sand in the known weight of *moist* soil, which by the previous experiment has been found to contain a certain quantity of water."

2. To determine the quantity of lime in *marly* and *calcareous* soils, the following directions are given: "To 100 grains of the dry soils diffused through half a pint of cold water, add half a glassful

of muriatic acid, (the spirit of salts of the shops) stir it occasionally during the day, and let it stand over night to settle. Pour off the clear liquor in the morning and fill up the vessel with water to wash away the excess of acid. When the water is again clear, pour it off, dry the soil and weigh it—the loss will amount generally to one per cent. more than the quantity of lime present. The result will be sufficiently near, however, for the purposes of classification. If the loss exceed 5 grains from the 100 of the dry soil, it may be classed among the marls; if more than 20 grains, among the calcareous soils."

3. "The method of determining (says Johnston) the amount of *vegetable* matter for the purposes of classification, is to dry the soil well in an oven, and weigh it, then to heat it to dull redness over a lamp or a bright fire, till the combustible matter is carried away. The loss, on again weighing, is the quantity of organic matter."

LESSON XVI.

STRUCTURE OF PLANTS AND OFFICES OF THEIR ORGANS.

(NOTE.—In lesson II. I have stated the organic constituents of plants. I now propose to give some account of the parts and structure of the plants which it is the chief object of the farmer to produce. It is scarcely more important for the builder, in order to do his work, to master the plans and specifications of the architect, than for the farmer to acquaint himself with the structure, elements and habits of the plants on the right culture of which his wealth so essentially depends.)

80. *What are the principal parts of plants?*—Plants consist chiefly of three parts—the root, the stem, and the leaves.

81. *What are these parts of a plant called?*—These parts are called the *organs* of the plant—the instruments of its growth, (as the mouth, teeth, stomach, arteries and veins are the organs or instruments of life and growth in the animal economy) and are, therefore, called the *organs of vegetation.*

82. *But do not plants consist also of flowers, and fruit, and seed?*—Plants produce *flowers*, from which comes the *fruit*, and from this the *seed;* but these take no part in *nourishing* the plant. Their use is to reproduce, multiply and perpetuate the species, and they are therefore called *organs of reproduction.*

83. *What is the root?*—The root is the part which grows from the light into the earth, gives the plant foothold, and the means of nourishment. The root usually branches into smaller roots, and rootlets, and fibres, more and more slender; the cells along the sides and at the end of which are the real mouths by which most of the food of the plant enters into its circulation.

(NOTE.—The roots of plants are as infinitely diversified in size, shape and form, as the branches and tops. When the roots produce fruit and die in the same season, the plants are termed *annuals*, as wheat, oats, barley, and many others; when the plants grow two years from the same roots, they are called *biennials*; and when the plants grow for a succession of years from the same roots, they are called *perennials*).

84. *What is the stem?*—The stem is the part of the plant which grows upwards into the air and light, and bears the branches, leaves, flowers and fruit.

(NOTES.—1. The point at or near the surface of the ground, where the *root* and *stem* join, is called the *crown* or *collar* of the plant.

2. As the roots of a plant greatly vary in size, length, form, duration, &c., so the same variety prevails in the stem, which is variously named according to the appearance it presents; for instance, the stem of a tree is termed the trunk; the stems of wheat, barley, rye, and the grasses, are termed straw; the stems of Indian corn are called stalks; the stem of the strawberry is termed the runner; the stem of the grape and the melon is called the vine.)

85. *What are the parts of the stem?*—The parts of the stem are the pith, the wood, and the bark—the garment or protecting covering of the wood.

(NOTES.—1. The forms, offices, and various growth of the different parts of the stems of plants, are treated at large in works on Botany and Vegetable Physiology.

2. The stems of some plants, like the animal body, grow by the increase and formation of new material within, as Indian corn, wheat, oats, barley, rye, the onion, asparagus, all the grasses, &c. The new fibres as they continually form, grow in the inside of the stem. These plants are called *endogenous* plants—the word endogenous meaning, in plain English, *inside-growers*.

3. But those plants whose stems grow by the formation of new tissue near the outside of the stem, are called *exogenous* plants—

outside growers; such as the forest trees, the bean, the pea, the clover, potato, beet, turnip, flax, &c. In plants that live and grow many years, as trees and shrubs, a new layer is added to the wood on the outside, next the bark, every year as long as the tree or shrub lives. The new ring of fibre, always formed on the outside of the old ones, may be seen in many agricultural plants, as, for example, the potatoe and beet; but it is more obvious in plants of harder texture and larger growth. The inner or heart-wood of a tree soon dies. The sap-wood is the only active part; "and this, with the inner bark, which is renewed from its inner face every year, is all of the trunk that is concerned in the life and growth of the tree." Gray, in his *Botany for Young People*, remarks, that. "Plants with exogenous or outside-growing stems, especially those that live year after year, almost always branch freely. All common shrubs and trees of the exogenous class make a new set of branches every year, and so present an appearance very different from that of most of those of the endogenous or inside-growing class."

4. By observing the layers of wood, the age of a tree may be readily ascertained. A striking illustration of this is given by *Adamson*, who relates that in visiting Cape Verde in the year 1748, he was struck with the venerable appearance of a tree 50 feet in circumference. He recollected having read in some old voyages an account of an inscription on a tree thus situated. No traces of such an inscription remained, but the position having been accurately described, *Adamson*, was induced to search for it by cutting into the tree, when to his extreme delight, he discovered the inscription entire under no less than three hundred layers of wood—proving that each new layer is formed on the outside of the last preceding one, and that the inscription had been made three hundred years before.)

86. *What are the leaves?*—The leaves (which make the foliage) are generally flat and green bodies, variously shaped, one side upwards to the sky, and the other downwards towards the ground; they are intersected with ribs or veins, and their surface on both sides is covered with a coating (called *epidermis*) which is provided with numberless invisible (to the eye) *stomata*, mouths, or "breathing pores," by means of which the intercellular spaces in the interior of the leaf are brought into direct communication with the outer atmosphere.

(NOTES.—1. These *stomata* or *mouths* or *pores*, are wanting in the submerged leaves of aquatic or water plants; but are found on the upper surfaces of floating leaves. They are mostly absent from the upper surfaces of land plants, exposed to the heat of the

sun; while they exist in great numbers on the lower and shady side of all green leaves. About 100,000 may be counted on an averaged size apple-leaf.

2. The colour of the leaves, as long as their vegetative activity continues, is *green;* the loss of activity in autumn, on the maturing of the plant in case of cereal grains, or in case of the foliage of deciduous trees, is connected with the cessation of growth and death of the leaf.

3. There are, however, some plants whose foliage is other than a green colour during the period of active growth, such as red, brown, white, &c.; but these are mostly cultivated by florists for ornamental purposes.

4. Leaves are attached to the stem, for the most part in two ways; *alternately,* when they follow each other one by one as in the Morning Glory; or *opposite,* when they are in pairs, two on each joint of the stem, one opposite the other, as in the Maple. But in some instances three, four, or more leaves are found on the same joint of stem. The variety in the forms of leaves in different plants affords easy means for distinguishing one species from another.

87. *What are the offices or the functions of the leaves?*—The leaves are the *lungs* of the plant, and perform the same offices in the vegetable kingdom as the lungs in the animal kingdom; they are the organs through which the air, and light and heat of the sun act upon the sap which comes into them from the ground through the roots and stem.

(Notes.—1. In lesson III. I have described the *organic* constituents of plants; and in lesson VII. I have shown that these constituents are composed of *oxygen, hydrogen, carbon* and *nitrogen.* The air consists of oxygen and nitrogen, and water of oxygen and hydrogen. The nitrogen is supposed to be obtained directly from the soil by the roots of the plant; but the carbon (in the form of carbonic acid) oxygen and hydrogen and chiefly absorbed by the leaves, though in part by the roots from the soil. Through the surface of the leaves the superfluous moisture from the water imbibed by the roots is evaporated, and oxygen gas is thrown out into the air, and carbonic acid and other gases for the nourishment of the plant are absorbed. The sap changed by these actions of the elements, is carried back down into the stem, and converted, by the vital action of the plant, into wood, bark, new branches, branchlets, leaves and fruits, and whatever else is produced by the plant.

2. The leaves apart from their offices of nutriment, growth and fruitfulness, afford beautiful and refreshing shade from the heat of the sun. The removal of green leaves from a tree would destroy its growth, as well as its shade.)

88. *What is the flower?*—The flower is an organ or collection of organs, by means of which the seeds are prepared; one great object of the plant being the production of fruit containing seeds.

(NOTE.—There are peculiar attractions to the study of flowers so universally admired and cherished from their beauty and fragrance, the exquisite arrangement and forms of their parts, and the endless variety they exhibit.)

89. *What are the parts of the flower?*—By examining a rose, one will see that the flower consists of *calyx*, *corolla*, *stamens* and *pistils*.

90. *Describe each of these parts of the flowers?*—1. Outside of the leaves of the flower, is the *calyx*, (a Latin name for a *cup*) which consists of several (usually five) leaves, which form a cup, to protect all the parts of the flower before they are ready to open. These leaves are called *sepals*, and are generally green, though in the Fuchia they are white or red.

2. Inside the calyx in the *corolla* (crown), consisting of flower leaves, called *petals*, of delicate texture and beautiful colour, and these chiefly give beauty to the flower.

3. Next inside the *corolla* are the *stamens*, which grow fast to the bottom of the corolla or crown, and are slender thread-like organs of a pale yellow colour. Each stamen consist of two parts—a *filament* and *anther*. The *filament* is the stalk of the stamen, and the *anther* is a little sack, full of yellow powdery matter, called *pollen*—essential to the fertility of seeds.

4. Inside the stamens, in the middle of the flower, are the *pistils*—the organs in which the seeds are formed. The pistils are various in form and number; but each pistil has at its base a seed-vessel, called *ovary*, which contains *ovules* (little eggs) or young seeds. The ovary, or seed-vessel, tapers into

a slender body called the style, tipped with a delicate crest called the *stigma*, which is usually tender and moist when the flower is in perfection.

(NOTES.—1. These are all the parts which any flower has; but many flowers have not all these parts. Some have only one flower-cup, or one set of blossom leaves, as the lilies. Some have no corolla, as the flower of buckwheat; some have neither calyx nor corolla; some stamens have no filament, and some pistils have no style. The style and the filament are not essential parts of the flower; but the *anther*, the *ovary*, and the *stigma*, are essential. Everybody is familiar with the root, stem and leaves of plants; if the reader will commit to memory and become as familiar with the names of these parts of the flower, calyx, corolla, stamens, pistils, and the parts of these also, and learn to distinguish them in all common blossoms he may meet with, he will have mastered the germ or rudiments of floral Botany, and will have acquired the means of much entertainment and pleasure in his visits to every garden and his labours in every field and forest.

2. The grand function of the flower is *fructification*, and the parts essential to this are the stamens and pistils. The fertilizing dust, or *pollen* of the *anther*, carried by the wind, insects or other agencies, falls upon the moist *stigma* or naked tip of the *pistil*, and sends out a slender microscopic tube or root, which penetrates the interior of the pistil to the *style* or base until it enters the *ovary*, or seed-sack, and comes in contact with the *ovule* (little egg) or young seed, which it *fertilizes*, by producing within it an *embryo*, or minute future plant.

3. When the seeds are fertilized, the flower, having fulfilled its functions, begins to fade; the corolla and stamens usually fall off or wither, while the base of the pistil, the *ovary* and *included ovules* (egg seeds,) swells and rapidly increases in size until the seeds are ripe, or become *fruit*, when the *ovary* or seed-sack, falls to the ground, or opens to release its contents.

4. Whatever contains the seed is called the fruit of the plant. In case of some seeds each kernel is at the same time both a seed and fruit, as wheat, rye, barley, &c.; but for the most part, the *fruit* contains several or many *seeds*, as the bean or pea pod, apple, pear, melon, &c.

5. The fruit is the ripened *ovary*, or seed-vessel with its appendages, and may be a berry, a grain, a pod, a nut, such as the acorn, chestnut, beech-nut, hazel-nut (the cup of the acorn and the burr of the others being a sort of fleshy calyx; a stone fruit, such as the peach, cherry, plum, walnut, butter-nut, and hickory nut. Thus the ovary or seed-vessel ripened, consisting of the base of the pistil in its matured state (says Johnston), exhibits a great variety of forms and characters, which serve chiefly to define the different kinds of fruit.

6. In this summary notice of the flower—one of the most beautiful creations of divine goodness; the reader can hardly have failed to admire and even adore the display of infinite skill and benevolence, as also in the works and laws of nature referred to in preceding lessons. The reason, and principle, and even modes of many of these operations, are beyond the search and comprehension of man, but none the less real, though the more wonderful. If every page of the flower book of nature abounds in *mysteries*, the higher book of revelation could not have orginated with the Author of nature were it without mysteries.

SECOND PART.

PREPARATORY KNOWLEDGE APPLIED.

(NOTE.—Though I have made many practical remarks in the notes, in connection with the definitions and explanations of the preceding Lessons, I now proceed to the more formal and extended application of them to the business and interests of the farmer; and in doing so I will embody in the plainest and briefest manner I can the results of my own observations, and examination of the latest and most accepted works on agriculture published both in England and America, (it being always understood that I pretend to advance no further than *first lessons*,) with a view of dignifying agricultural pursuits, and of prompting farmers to improved methods of culture and a more general and thorough study of the practical science of agriculture. Having explained the nature of the elementary substances with which the farmer has to do, and organic and mineral constituents of both soils and plants, the first step in the practical application is, to ascertain the proportions of these substances in both soils and plants, and the relations of the one to the other.)

LESSON XVII.

COMPOSITION OF SOILS AND PLANTS AND THEIR RELATIONS TO EACH OTHER.

91. *What has been shown by chemical analysis to be the composition of rich and poor soils?*—The following table shows the composition of soil fertile without and with manure, and very barren:

In One Hundred Pounds.	Soil Fertile Without Manure.	Fertile with Manure.	Very Barren.
Organic matter	9.7	5.0	4.0
Silica	64.8	83.3	77.8
Alumina	5.7	5.1	9.1
Lime	5.9	1.8	.4
Magnesia	.9		.1
Oxide of Iron	6.1	3.0	8.1
Oxide of Manganese	.1	.3	.1
Potash	.2	..	..
Soda	.4	..	..
Chlorine	.2	..	..
Sulphuric Acid	.2	..	.
Phosphoric Acid	.4	..	..
Carbonic Acid	4.0	..	.
Loss during analysis	1.4	.	..

(Notes.—1. By turning to Lesson II., page 17, the reader will see that I have shown how to distinguish between the organic and inorganic parts of plants, and that the average per cent. of organic matter in good soils is from 5 to 10, the proportion of organic matter stated in the above table—the remaining 90 to 95 per cent. of the soil being inorganic or mineral matter, except in peat lands.

2. It will also be observed that the inorganic substances named in the above table, are the same which I have mentioned in lesson VI., page 27, in describing acids, and in lessons IX and X., pages 43–47, under the heads of Lime, Potash and Soda, as contained in farm productions.

3. Every farmer knows the existence of the differences of soils mentioned in the above table. In the third column one half of the inorganic bodies present in the first column are entirely wanting, and two others, lime and magnesia, are reduced to a minimum. To apply a sufficient quantity of manures to make the very barren soils fertile, would not pay, except in places where produce is high and manures cheap. The above table shows clearly the differences in soils which cause fertility and barrenness. The barren soil is barren because of an excess or deficiency of certain substances. Agricultural chemistry is competent to ascertain the defect and prescribe the remedy, the application of which becomes simply a question of expense.

92. *What has been shown to be the composition of the chief productions of the farm?*—The approximate composition of the most common cultivated crops is shown in the following table, which has been constructed chiefly by Sprengel, and

partly by *Johnston*, quoted from the *New American Book of the Farm*:

	Potash.	Soda.	Lime.	Magnesia.	Alumina.	Silica.	Sulphuric Acid.	Phosphoric Acid.	Chlorine.	Oxide of Iron.	Oxide of Manganese.	Total in every 1000 lbs.
Wheat—Grain ...	2.25	2.40	0.96	0.90	0.26	4.00	0.50	0.40	0.10	Trace	....	11.77
" Straw...	0.20	0.29	2.40	0.32	0.90	28.70	0.37	1.70	0.30	....	....	35.18
Barley—Grain ...	2.78	2.90	1.06	1.80	0.25	11.82	.59	2.10	0.19	Trace.	....	23.49
" Straw...	1.80	0.48	5.54	0.76	1.46	38.56	1.18	1.60	0.70	0.14	0.20	52.42
Oats—Grain	1.50	1.32	0.86	0.67	0.14	19.76	0.35	0.70	0.10	0.40	....	25.80
" Straw.....	8.70	0.02	1.52	0.22	0.06	45.88	0.79	0.12	0.05	0.02	0.02	57.40
Rye—Grain.....	5.32	*	1.22	0.44	0.24	1.64	0.23	0.46	0.09	0.42	0.34	10.40
" Straw.....	0.32	0.11	1.78	0.12	0.25	22.97	1.70	0.51	0.17	....	....	27.93
Field } Bean	4.15	8.16	1.65	1.58	0.34	1.26	0.89	2.92	0.41	....	....	21.36
Bean } Straw ...	16.56	0.50	6.24	2.09	0.10	2.20	0.34	2.26	0.80	0.07	0.05	31.21
Field } Pea.....	8.10	7.39	0.58	1.36	0.20	4.10	0.53	1.90	0.38	0.10	....	24.64
Pea .. } Straw ...	2.35	....	27.30	3.42	0.60	9.96	3.37	2.40	0.04	0.20	0.07	49.71
Potato—Roots...	4.028	2.334	.331	.324	.050	.084	.540	.401	.160	.032	....	8.284
" Tops....	8.19	.09	12.97	1.70	.04	4.94	.42	.97	.50	.02	....	30.84
Turnips—Roots..	2.386	1.048	.752	.254	.036	.388	.801	.367	.239	032	....	6.303
" Leaves.	3.23	2.22	6 20	.59	.03	1.28	2.52	.98	.87	.17	....	18.09
Carrots.....	3.533	.922	.657	.384	.039	.137	.270	.514	.070	.033	.060	6.619
Parsnips	2.079	.702	.468	.270	.024	1.62	.192	.100	.178	.005	....	4.180
Rye Grass	8.81	3.94	7.34	0.90	0.31	27.72	3.53	0.25	0.06	....	....	52.86
Red Clover	19.95	5.29	27.80	3.33	0.14	3.61	4.47	6.57	3.62	....	....	74.78
White Clover	31.05	5.79	23.48	3.05	1.90	14.73	3.53	5.05	2	0.63	....	91.32

(NOTES.—1. By comparing the preceding two tables, it will be seen that soils contain the same substances as the crops which grow in them.

2. But it will be noticed that the ashes of the different grains and roots vary much in composition. Phosphoric acid is the chief ingredient in the ashes of the grains, wheat, corn, rye and oats, but not so with the vegetables, potatoes and turnips; while potash exists in large proportion in all, but more largely in the vegetables than in the grains. Phosphoric acid is the largest ingredient in rye and oats; and the same is true of barley and buckwheat; but a very small per centage of it is found in the straw. In the grain, there is less than one and a half per cent. of silica, while in the straw there is a very large percentage. It is silica that gives strength and elasticity to straw. Wheat straw, on account of its having to bear a heavy head, requires more strength than that of hay; the silica in the former is nearly twice that of the latter, in addition to the straw being hollow for obvious reasons, this is one of the many indications of design and wisdom in the works and laws of nature, though more strictly speaking in the works and laws of God.

3. Without entering into further details, I may remark, that by comparing the preceding tables, it will be seen that in the ashes of grains, phosphoric acid predominates, but in those of roots, potash and soda abound; that lime is all important to the grasses, and silica to the straws; while the other ingredients, though small in quality, are, nevertheless, essential to the growth and perfection of both grains and vegetables, as will appear more fully hereafter.

4. From the analysis of soils and crops in the two tables, the intimate relation of the one to the other is manifest. The soil supplies the food of plants which can no more grow to luxuricance and perfection without an ample supply of appropriate food, than can animals become strong and fat without a sufficiency of proper provender. Hence the necessity of seeing that the soil of each field possesses the requisite supply of the substances essential to feed the crops which are growing upon it.)

LESSON XVIII.

SOILS ADAPTED TO DIFFERENT KINDS OF GRAINS AND VEGETABLES.

(NOTE.—In Lesson XVI. I have stated the classification of soils, and how they may be ascertained. In the preceding section, XVII. I have, in two tables, given an analysis of rich, common and barren soils, and of the most common grains and vegetables grown by the farmer. It will now be proper to show how the different kinds of soils are adapted to the growth of different kinds of grains and vegetables.)

93. *How will a farmer obtain good crops?*—The farmer will obtain good crops by selecting soils

adapted to the different kinds of crops, and then cultivating his crops as he would take care of his cattle—according to the laws of nature.

94. *But if his soils are not good, what is he to do?*—He is to improve his soils, by culture and manures, the best way possible for this purpose.

95. *What is said of clay soils?*—The strongest clay-soils are suitable for wheat and beans, and the less stiff clay-soils are suitable for oats and clover. They are so excellent for meadows and pasturage, that they are styled *grass lands.* They are strong and lasting soils for their special purposes.

96. *What is said of sandy soils?*—Sandy soils are peculiarly fitted for the growth of barley and Indian corn, turnips and other green crops. The lighter sandy soils are the best for growing rye and buckwheat.

97. *What is said of loamy soils?*—Loamy soils are intermediate between clay and sand, and are the richest natural soils, uniting all the materials necessary for the growth of crops.

(NOTE.—Clayey soils are often called heavy lands, and sandy soils, light lands. Loamy soils are called clayey, sandy, or calcareous loams, as they incline to clay or sand or lime in their composition.)

98. *What are alluvial soils?*—Alluvial soils are such as are formed by the washing of streams, on the low banks of which they are formed, and they vary in their characteristics from a mixed clay to almost pure sand; but in general they combine the components of loamy soils and sandy loams. When the streams on the banks of which they are situated, have their sources among mountains and hills, and bear in their current the dissolving portions of various rocks and quantities of leaf and other vegetable mould, and overflow their banks winter or spring,

the bottom lands formed and enriched by such deposits possess almost inexhaustible fertility.

99. *What is said of peaty soils?*—Peaty soils consist almost wholly of decayed plants, and are frequently called vegetable soils. They generally occupy low, swampy levels; the peat exists in various stages of decay, from the partially decayed fallen trees, stumps and leaves to a woody mass of impalpable powder.

(NOTES.—1. In this natural state, peaty land is mostly unfit for any profitable vegetation or culture; but should the Act of our Legislature for draining swamps and marshes, passed in the Session of 1869-70, be successfully carried out, hundreds of thousands of acres of most valuable land will be added to the domains of agriculture.

2. Though the soils mentioned above are thus distinguished by external characters, and therefore by peculiar qualities of different value and special productiveness, they pass into each other, like the colours of the rainbow, by such minute gradations, that it is sometimes difficult saying to what class they belong. The intermediate classes are the most numerous, as they are the most useful —another indication of the wisdom and bountifulness of Divine Providence.)

LESSON XIX.

HOW TO CONSERVE AND IMPROVE SOILS.

(*Soils—how used; contents of good soils; object, nature, classification of manures.*)

100. *How should a farmer conserve his soils?*—By using and feeding them well, as he would his horses, if he would conserve and keep them fit for labour.

101. *How should a farmer use and feed his soils well?*—By so tilling and cropping them with different grains, grasses and vegetables in succession as to exhaust his soils least, and by restoring to them, in the form of manures, what he takes from them in the form of crops.

102. *But will not the same crops grow in the same soil year after year?*—Yes, if the soil receives an annual coat of manure by the overflow of some stream like the banks of the Nile; or if the soil is annually supplied by artificial manure with the substances extracted by the crop, as gardens; but if the same kind of cropping be carried on in the same soil year after year without the addition of manures, the land will yield less and less, until it becomes poor or barren.

103. *Are there any examples of this?*—Yes; there are many examples in almost every County of Canada, where farms have become unproductive and poor by this hard usage. They have been worked to death without being fed, like hardly used cattle.

104. *Why do lands thus become impoverished?*—Because the crops draw so largely certain substances from the soil, in a shorter or longer time, that it cannot furnish a sufficient quantity of such substances to the growing crop. A cistern from which water is daily drawn for family use will, in time, become dry, unless replenished by rains or otherwise. If a man, from time to time, is taking money out of his purse, and putting none in, his purse will at length become empty. A farmer will inevitably reduce his land to poverty if he constantly takes out of it the money of his crops without paying anything into it in return.

105. *But where is the farmer's profit, if he puts as much into the land as he takes out of it?*—He takes off the land wheat, oats, potatoes, turnips, &c., which he sells for much more money than he pays for the manures which he puts into it. "He puts in the land what is cheap, he takes off what is dear."

106. *What elementary substances should the soil contain for the nourishment of plants?*—The soil

should contain the various elementary substances which are found in plants.

(NOTE.—These substances, organic and inorganic, have been stated in Lesson III., and the composition of them explained in the fourth and following lessons.)

107. *Name these substances.*—They are, 1. Oxygen; 2. Hydrogen; 3. Nitrogen, in the shape of Ammonia; 4. Carbon; 5. Sulphur; 6. Phosphorus; 7. Chlorine; 8. Silicon; 9. Sodium, in the shape of common salt; 10. Calcium; 11. Potassium; 12. Magnesium; 13. Iron; 14. Manganese; 15. Aluminum, as the basis of clay.

(NOTES.—1. In some plants there is also a minute quantity of fluorine, and certain marine plants contain iodine and bromine. But with these Canadian farmers have nothing to do.

2. The first four of the above-named substances are atmospheric elements, but are always found in *combination*—sulphates, phosphates, silicates, nitrates, carbonates and fluates of lime, soda, potash, magnesia, iron, alumina, manganese, or in other more complex combinations.

N.B.—For the meaning of these terms and terminations see the explanations given of them. Lessons V. and VI.—pages 21–32.)

108. *But does every plant contain all these elementary substances?*—They are all found in the ashes of some plants, and are therefore essential to them; but many plants contain only a part of them; very few contain them all. Some plants contain also more of certain substances than other plants, and require, of course, a larger supply of such substances in the soil.

109. *What are the substances called which the farmer thus uses to remedy the defects and improve the qualities of the soil?*—They are called *manures*, and are anything which furnishes food for plants, and thereby enriches the soil.

110. *How are manures classified?*—They are divided into two classes, *organic* and *inorganic*, but are usually treated under the heads of *vegetable* manures, *animal* manures, and *mineral* manures.

Some mention another class called *mixed* manures, consisting of mixtures of *vegetable* and *animal* manures, with the addition also, in some cases, of mineral manures.

LESSON XX.

HOW TO CONSERVE AND IMPROVE THE SOIL (*Continued*).

(VEGETABLE MANURES).

111. *What are the vegetable manures?*—They are such parts of plants as are put into the soil to make it more productive; such as different kinds of clover, buckwheat, cabbage leaves, radishes, turnip-tops, potato tops, stalks of Indian corn, rye straw, hay, hay-stuff, &c. The former of these are green manures, the latter are dry.

112. *To what kinds of soils are the green crops best suited?*—The green crops are best suited to light and sandy soils and calcareous soils, which need no lime.

113. *Why?*—Green crops are best suited to light and sandy soils, because they supply such soils with what they are deficient in—vegetable mould, retentive of moisture, and containing ammonia and nitric acid; they add to the land organic substances which it did not before possess, and are therefore a clear gain to the soil in every respect.

(NOTE.—*Johnston* says, "A green crop ploughed in is believed by some practical men to enrich the soil as much as the droppings of cattle from a quantity of green-food three times as great." (Agricultural Chemistry)

The author of the *New American Farm Book* remarks, that "Lands in many of our Eastern States which have been worn out by improvident cultivation, and unsalable at $10 an acre, have by this means (of manuring with green crops), while steadily remunerating their proprietors for all the outlay of labor and expense, by their returning crops, been brought up in value to $50." Of *clover* for green manures, the same author observes, "This is suited for all soils that will grow anything profitably, from sand if posses-

sing an adequate amount of fertility to the heaviest clay, if drained of its superfluous water" (pp. 82, 83.)

114. *What is said of dry vegetable manures?*—Straw and hay are usually fed to cattle and horses, or trodden upon by them, and afterwards put upon the land, mixed with their manure. But long straw ploughed or buried into stiff clay soils serves to loosen and mellow the clay, and let in the air, and cause the decay not only of the straw, but of other organic matter previously existing in the soil.

(NOTES.—1. NORTON, in his *Elements of Scientific Agriculture* (to which the prize was awarded by the New York State Agricultural Society), says—"It has been found good practice, in many parts of the country, to draw out straw in the autumn, and lay a thin covering of it over winter grain. This serves a protection during winter, and retains moisture when necessary during a dry spring or early summer. By the time that the stubble is ploughed, it has decayed so as to turn under easily, and forms quite a rich coating in the way of manure."

2. In the *Manual of Agriculture*, by G. B. Emerson and C. L. Flint (the latter Secretary of the Massachusetts State Board of Agriculture), it is remarked, that "Straw and leaves of particular vegetables are the best manure for those vegetables—wheat straw for wheat, potatoe tops for potatoes, and the leaves and pruning of grape vines for those vines." The leaves of different trees have different degrees of value. Poplar leaves, oak, chestnut-leaves, beech and maple leaves, are rich in nutritive matters, while thinner leaves and pine leaves contain very little nourishment for plants.

115. *What is said of hay-stuff or swamp or marsh mud as a manure?*—It is applied to light soils, or such as contain little organic or vegetable matter; and is applied with most advantage when mixed with barn-yard manure, in the proportion of about one-third of the latter.

LESSON XXI.

HOW TO CONSERVE AND IMPROVE THE SOIL—(*Continued*).

(ANIMAL MANURES.)

116. *What is said of animal manures?*—This class of manures is far more powerful than the vegetable manures.

(NOTE.—In Lesson III. I have stated the organic constituents of animals as well as of plants. Animal manures contain a great quantity of nitrogen and the important salts. The nitrogen unites with the hydrogen and forms ammonia, and this the ammoniacal salts. These dissolve other mineral substances, and are absorbed by water, which carries them down to the roots of plants, and constitute their most nourishing food. The dry flesh of dead animals—including quadrupeds, birds, fishes, &c.—contains 50 per cent. of carbon, and from 13 to 17 per cent. of nitrogen, besides salts of potash and soda, of lime and of magnesia, and is therefore one of the best manures. *Doctor Dana*, of Massachusetts, says—"The body of a dead horse can convert twenty tons of peat into a manure richer and more lasting than stable manure.")

117. *Why?*—Because, as animals live almost entirely on substances derived from the vegetable kingdom, these substances restored to the earth from which and from the air, they have originally come, must contain the most important element of the food of plants.

118. *What parts of animals constitute manures?*—All parts; the blood, flesh, bones, hoofs, hair, feathers, wools, skins, and the bodies and offals of fish.

(NOTES.—1. Hoofs, hair, feathers, wool, skins, and blood, contain more than 50 per cent. of carbon, and from 13 to 18 per cent. of nitrogen, besides sulphur, and salts of lime, of soda, and of magnesia—thus constituting first class manure. Hair (says the *Boston Manual of Agriculture*) spread upon the meadows, augments the crop *three-fold;* and the Chinese, who know its value, collect it every time they have their heads shaved—and the operation is performed once a fortnight—and sell it to the farmers. The crop of hair, from the head of each individual, amounts, in a year, to about half a pound. Every million of persons, therefore affords *two hundred and fifty tons* of hair, that is, of manure of the most valuable kind, since it represents *two thousand five hundred tons* of

ordinary barn-yard manure, and which might be collected, without trouble, but which is now invariably lost."

2. It may also be remarked, that the BLOOD, besides its carbon and nitrogen, contains soluble salts, such as common salt, phosphates, sulphates, and carbonates of potash, soda, &c., water, and some insoluble salts, namely, phosphate of lime and of magnesia—the chiefest element of fertility in soils. (Let the reader bear in mind the meaning of these chemical terms, and the substances they import, as explained in the *sixth lesson.*)

3. But BONES are one of the most important of animal manures. Bones consist of about 66 per cent. of *earthy* or inorganic matter, which remains as ashes when the bone is burnt, and about 34 per cent. of organic matter, which burns away. The organic part—called *gelatin*, or glue when boiled out by the glue-makers,—is extremely rich in nitrogen, and therefore an excellent manure. The earthy share is for the most part a phosphate of lime, that is, lime in combination with phosphoric acid—two of the most valuable substances to enrich the soil.

4. It has been justly remarked, that part of bones of animals, on being burnt, leaves an ash corresponding with that of plants in the substances which it contains with the exception of *silica*, which does not enter into the composition of the animal. Hence the table—

"The soils contains silica and alumina;
The plants contains silica, but no alumina;
The animal contains neither silica nor alumina."

LESSON XXII.

HOW TO CONSERVE AND IMPROVE THE SOIL (*Continued*).

(MIXED MANURES.)

119. *What are mixed manures?*—By mixed manures are here meant the excrements of animals mixed with the straw of cultivated plants, such as is usually found in the barn-yard.

120. *What is said of mixed manures?*—It is said as the uniform experience of farmers and gardeners, the world over, that the manure which comes from the stable, the cow-house, the sheep-fold, the pig-sty and other similar places, is, on the whole, the most valuable and the most beneficial of all known manures. Other manures are useful for particular purposes; this manure is useful for all

purposes, and is the only manure which keeps up the fertility of all kinds of land.

121. *Are these varieties of barn-yard manure of equal value?*—No, when fresh that of the horse is the most valuable, as it contains much nitrogen, but is liable to lose ammonia by fermentation. That of the hog comes next, and then that of sheep. That of the cow stands at the bottom of the list, as the enriching substances of her food go chiefly to form milk,—the manure thereby being rendered poorer. This remark, however, does not equally apply to the manure of cattle not yielding milk.

(NOTES.—1. It is said, as a general rule, that the manure from cows and oxen is more fit for very dry, light soils; and that from the horse-stable, for stiff, clayey soils. The scrapings of the sheep-fold and the contents of the pig-sty are better suited to mead w lands, as they often impart a disagreeable flavour to table vegetables.

2. The manure of all these animals is much richer than the food they eat, as it contains much more nitrogen. The manure from animals fed on rich food is much stronger than that from animals poorly fed. This is the reason why human excrements are better manure than those of the animals above mentioned, from the richer quality and variety of the food of men.

3. The contents of the stables and barn-yard must undergo *decomposition* before they are fit for use as manure. For the *fermentation* necessary to *decompose* them, moisture and warmth are requisite, as keeping them cold and dry will prevent decomposition. The decomposition takes place in consequence of the attraction which the elements have for the oxygen of air and of water, which is always ready to unite with other elements. The carbon of organic bodies combines with oxygen and forms carbonic acid. The hydrogen unites with the oxygen, and forms water, or with nitrogen and forms ammonia, and with sulphur and phosphorus forming sulphuretted and phosphuretted hydrogen. The manure of all animals is particularly rich in the phosphates and in nitrogen. Professor *Dana* says: "The urine of a cow for a year will manure one and a quarter acres of land, and is more valuable than her dung two to one."

4. All kinds of manure, as to both their liquid and solid parts, should be carefully collected, and *protected from the sun*, the *air*, and the *rain*. If it be exposed to the open air, or drenched by the rain, or parched by the sun, a great quantity of the useful products of its decomposition will be volatilized, washed away, and lost. When heaps of manure exposed to ferment, are without any covering, ammonia is always formed and given off; which may often

be perceived by the smell, especially in horse manure. Where the manure heap is not under cover, the escape of the ammonia may, for the most part, be prevented by shovelling two or three inches depth of earth over the heap; and if this does not arrest the escape of so valuable a substance, sprinkle a few handfuls of plaster upon the top of the heap; the sulphuric acid of the plaster will unite with the ammonia and form a sulphate of ammonia, and thus remain to enrich the manure.

General Remark.—From what has been said on vegetable and animal and mixed manures, it is clear that each farmer has on his own premises the most essential manures for the conservation and improvement of his land. This continuous home supply of these manures is, as a general rule, ample to answer his purposes. Yet this latent wealth of fertility is by many farmers (so called) utterly neglected and left to waste, while their farms are becoming less and less productive if not, in many places, already reduced to barrenness!)

122. *What is said of the excrements of birds as manure?*—They are distinguished for their fertilizing properties, as they possess the united virtues of both liquid and solid excretions of other animals, and are therefore particularly rich in nitrogen, and also in phosphates. The manure of turkeys, geese, ducks, hens and pigeons is valuable—three or four hundred pounds of such manure (that has not been exposed to the rain or sun) being worth at least 14 or 18 loads of ordinary manure.

123. *What can you state respecting Guano (pronounced Goo-ah-no) as a manure?*—Guano consists of the accumulated excrements and remains of sea birds in tropical rainless latitudes of both Africa and South America. But that which is best in quality and best known is found on some of the islands of the Pacific and Atlantic Oceans near the coasts of South America. It is found in the Pacific, near the coast of Peru, between the 13th and 21st degrees of south latitude, where the rain never falls; and where, in some places on the islands and islets, it is said to have accumulated to the enormous height of from 60 to 80 feet. It is the remains of the dung, feathers, eggs, food and carcases of innumerable

flocks of marine birds which have made these islands their place of resort for rearing their young through many centuries.

(NOTES.—1. The *London Cyclopedia of Practical and Scientific Agriculture* remarks—"Guano is primarily derived from the ocean, in the fish consumed by sea-fowl, whose execrements, having accumulated on islands and rocks, furnish an almost inexhaustible supply of a manure so powerful and concentrated as to baffle all artificial attempts at imitation." Many millions of tons of this manure have been imported into England since 1844, at an average value of $40 per ton. It has been taken, but in much less quantities, to other countries in both Europe and America.

2. *The New American Farm Book* (1869) remarks as follows on the use of guano as a manure: "It is applied to roots, grain and other cultivated crops, and as a top-dressing for grass; but it has thus far proved of most value to the former. Before using it as a top-dressing, it is mixed with twice its bulk of fine earth, ashes, plaster or charcoal dust. The proper quantity is from 200 to 400 pounds per acre, sown broadcast and harrowed in; or it may be supplied in two dressings—the first sown after the plants appear, but not in contact with them, the last, ten or fourteen days after, and immediately before moist or wet weather. For hot-houses and many minor purposes, is prepared by dissolving 4 pounds in 12 gallons of water, twenty-four hours before using as an occasional dressing. On account of its volatile character, it should be closely covered until wanted.")

124. *What is the relative value in nitrogen of the farmyard and animal manures?*—Professor Johnston (in his *Elements of Agricultural Chemistry and Geology*) has given the relative value of these manures in the following order—the number opposite to each representing (as he expresses it) the weight in pounds, which is equivalent to, or would produce the same sensible effect upon the the soil as 100 lbs. of farmyard manure:—

Farmyard manure	100
Solid excrements of the cow	125
" " " horse	73
Liquid excrements of the cow	91
" " " horse	16
Mixed excrements of the cow	98
" " " horse	54
" " " sheep	36

Mixed excrements of the pig	64
Dry flesh.....	3
Pigeon's dung.....	5
Liquid blood	15
Dry blood	4
Feathers	3
Cow hair.....	3
Horn shavings	3
Dry woollen rags	2½

(NOTE.—Dry substances are longer in dissolving and becoming decomposed in the soil, and do not show so immediate and sensible effect upon the crop as more fluid manures, but continue to evolve fertilizing matter much longer. It is thus seen that a few pounds of some of the manures mentioned in the above table, or two pounds and a-half of woollen rags, are equal in virtue to 100 pounds of farmyard manure. Yet most of these manures, so valuable as fertilizers, are neglected by many farmers!)

LESSON XXIII.

HOW TO CONSERVE AND IMPROVE THE SOIL—(*Continued.*)

(INORGANIC OR MINERAL MANURES.)

125. *What are inorganic or mineral manures?*—These are various substances belonging to the mineral kingdom which promote the growth of plants and contribute to the fertility of soils.

(NOTE.—Many of these manures are called *saline* manures, as they consist of *salts* of certain minerals, such as carbonate of potash (pearl or potashes), carbonate of soda (or common soda of the shops), sulphate of potash, sulphate of soda (or Glauber salts), sulphate of magnesia (or Epsom salts), sulphate of iron (or green vitriol), nitrate of potash (nitre, or saltpetre), nitrate of lime, chloride of potassium, chloride of sodium (or common salt), silicate of potash, silicate of soda, sulphate of ammonia, chloride of ammonium (or sal-ammoniac), carbonate of ammonia (or smelling salts), and several others.

N.B.—For the chemical meaning of the terms carbonate, sulphate, nitrate, chloride, and salts, and how they are formed, see Lesson VI., pages 26–33.

126. *What are the chief manures of a saline and mineral character?*—They are lime, marl, gypsum,

common salt, wood and coal ashes, peat ashes, &c., in the form, for the most part, of nitrates, sulphates, phosphates, and other chemical compounds.

128. *Give some account of lime as a manure.*—Lime has been called "the prince," and is the most abundant of all mineral manures. It is usually found in the form of common limestone, which is the carbonate of lime, being a combination of lime with carbonic acid. Every 100 pounds of pure limestone contains about 44 pounds of carbonic acid gas and 56 pounds of lime. The carbonic acid is separated from the limestone by burning it, as in lime-kilns, when the lime that remains is called caustic or quick-lime, but is slacked (or its thirst satiated by about one-fourth its weight of water being poured upon it, when it swells, cracks, heats and finally crumbles to a fine powder. The heat during slacking is caused by the chemical union of water and lime.

(NOTES.—1. Different kinds of limestone, differing in purity, such as magnesian limestones, or dolomites, &c., are found in various districts. In Lesson XI. pp. 46, 47, under the head of calcium (of which lime is the oxide), the mechanical uses of lime are mentioned, also its compounds.

2. In all cases lime is better after than before burning, because the burning reduces it to fine powder, more fitted to be dissolved in the soil and to be taken up by the plant through the roots. Quicklime, in consequence of its absorbing moisture from the atmosphere, may be slacked by exposure to the air, as well as by the application of water.

3. *Morton's English Cyclopedia of Agriculture* says—"If a plain farmer is asked why he lays lime on his fields, he will at once point to the practical results by way of answer—thicker, more luxuriant, and sweeter grass, larger and more equal and firmer turnips, bulkier and more abundant crops of barley and wheat; and above all, the almost total disappearance of couch grass and other weeds." The *New American Farm Book* remarks—"Lime, next to ashes, either as a carbonate or sulphate, has been instrumental in the improvement of our soils beyond any saline manures. Like ashes too, its application is beneficial to every soil, not already charged with it—as calcareous soils). It makes heavy land lighter, and light land heavier, it gives adhesiveness to creeping sands or barley gravel, and comparative openness and

and porosity to tenacious clay: and it has a permanently beneficial effect where generally used, in disinfecting the atmosphere of any noxious vapors in it. It is observed by JOHNSTON, that "Grain grown upon well-limed land, has a thinner skin, is heavier, yields more flour, and that richer in gluten than if grown on unlimed land. On flax alone it is said to be injurious, diminishing the strength of the fibre of the stem."

4. From the table in Lesson XVII., p. 79, it is seen how largely lime enters into the compositions of various kinds of grains and vegetables. The shells of the lower animals contain lime, combined chiefly with carbonic acid; and the mineral portions of the skeletons of the higher animals consists of lime combined with phosphoric acid.

5. It is not upon wet and swampy, but upon drained or thoroughly dry land, that the application of lime is so marked and permanently beneficial.

"Much money (says the *English Cyclopædia of Agriculture*) was at one time wasted in liming imperfectly drained land, and there is even still very considerable scope for amendment in this respect. Drain first, and (where necessary) lime afterwards, is an agricultural aximo that should form the motto of every farmer who would wish to derive the full advantage of his outlay." While lime should not be laid on wet and swampy land, it should not be mixed with fermenting farm-yard manure, as it expels ammonia, a most valuable element of fertility.

6. As to the quantity of lime per acre to be applied, the *English Cyclopædia of Agriculture* says, that "fifty years ago, the usual quantity of lime applied ranged from 100 up to 300 bushels per acre; and in the first liming especially, the larger quantity was generally employed—the maxim being to give a good dose at once, so that a second application might not be needed for some years afterwards. This practice, especially on new soils, certainly worked well in practice; but on old cultivated land, however, the older practice entirely agrees with that of the present day, namely, to apply small doses at frequent intervals. About 100 bushels of lime per acre was considered a sufficient dose, fifty years ago, for old cultivated land; and even yet the majority, of light land farmers, especially, will agree in considering this to be enough for profitable application." *The New American Farm Book* says: "In the United States, the average for a first dressing is from 50 to 120 bushels per acre; which may be renewed every four or six years, at the rate of 20 to 40 bushels.")

129. *In what cases is it best to apply quick-lime or slaked lime as a manure?*—Where the soil is cold and stiff, or is newly drained, and contains much of acid organic compounds, or if there are tough, obstinate grasses to eradicate, it is best to

apply caustic lime; in other cases and in light soils it is best to apply mild lime.

(NOTES.—1. The reason for using caustic lime in certain cases is, as stated by the *New England Manual of Agriculture*, that "caustic lime amends the soil by decomposing some of its ingredients, and by setting at liberty the potash and other alkalies which exist in combination with clay and in particles of sand. It also hastens the decay of organic substances and combines with some of the gaseous products given out during the process. It should be in a state of powder before it is scattered upon the soil." It also (whether caustic or mild) acts upon plants by diminishing the evaporation from their surface, and thus husbands the moisture in the soil, and makes it last longer than it would without lime. *The New American Farm Book* says that "Lime should be spread upon the ground immediately after taking off the last crop, so as to allow all the time possible for its action before the next planting."

2. The principal compounds of lime are the carbonate, the sulphate, and the phosphate. The carbonate of lime has been shown above to be limestone; the sulphate of lime is gypsum, as has been shown in the 11th Lesson, p. 46; the phosphate of lime is nearly the same as *bone-earth*, and has been noticed under the head of *bone-manure*, p. 88.)

LESSON XXIV.

HOW TO CONSERVE AND IMPROVE THE SOIL—(*Continued*).

(INORGANIC OR MINERAL MANURES.)

130. *What is said of marls?*—Marls consist chiefly of lime and clay, or lime and sand, or lime and loam, and frequently with sulphate and phosphate of lime, in varying proportions, and presenting a great diversity of substance, colour and property. Though less energetic, marls have all the permanent effects of lime, and are valuable as an *amendment* to soils—clayey marl for sandy soils and sandy marl for clayey soils.

(NOTES.—1. The *New American Farm Book* says—"Marls are adapted to the improvement of all soils, unless such as are already sufficiently filled with lime, and they are more generally useful to meadows than the pure lime. Their benefits will be greatly enhanced if the clay marl be used on light or sandy soils, and sandy marls on clay and heavy lands. From 20 to 400 cart loads of marl per acre have been applied according to its quality and

the character of the land to be benefited. Circumstances must alone determine the proper quantity to be used. Marl should be carried out and exposed in small heaps before spreading on the land. Exposure to the sun, and especially to the frosts of winter, is necessary to prepare it for use."

2. Marl of any sort is good in composts, but chiefly so in those in which peat and decayed vegetables are mixed with it.

3. In order to ascertain the presence of lime in what is supposed to be marl, or in any soil, it has been recommended to put some of the soil, or supposed marl, in a glass, and pour upon it vinegar, or spirit of salt (muriatic acid), when a bubbling or effervescence will take place if lime is present, caused by the escape of carbonic acid gas contained in the soil or marl.)

131. *What is Gypsum?*—Gypsum, or plaster of Paris,—the common name of the sulphate of lime, or plaster-stone—is a combination of sulphuric acid and lime. When pure, gypsum is composed of 43 per cent. sulphuric acid, 33 per cent. lime, and 24 per cent. water.

(NOTE.—The name of the plaster of Paris was given to this substance from its abounding in the neighbourhood of that capital, where it was first burnt into powder, and extensively used for making cornices of rooms, ornamental figures and designs upon the walls, called *stucco-work*, and for making casts of statues and medals, and for various other applications.)

132. *What is said of the use of Gypsum as a manure?*—Gypsum is used, both in the United States and Canada, more extensively than any other artificial manure; and many of the most experienced farmers consider it indispensable to good farming. In many instances a few bushels per acre have brought up land from poverty to a very good bearing condition; but crops require other food than that with which gypsum supplies them; and if a farmer takes by his crops from his land a variety of substances, and adds gypsum only, he will injure and exhaust his land. What has been said of lime manure alone, is equally applicable to the exclusive use of gypsum manure:

> "Lime and lime *without manure*
> Will make both land and farmer poor."

133. *On what soils is gypsum used to most advantage?*—The *New American Farm Book* says: "Like all saline, and indeed like all other manures, gypsum acts beneficially only on soils which are free from standing water, or which may be saturated with such water. It is felt most on sandy, loamy, and generally on clay soils, requiring more for the latter, and for all such soils as contain a large proportion of vegetable matter. From two pecks on sandy soil, to fifteen bushels on clay soil, have been applied per acre; but from two to four bushels is the usual quantity."

134. *On what kind of crops does gypsum produce the greatest effect?*—Those crops of which gypsum is a constituent. C. W. JOHNSTON, in his *Planter's and Farmer's Encyclopedia*, says—"Wheat, barley, oats, beans and peas do not contain a trace of this salt; and the farmer tells you that gypsum is of little or no service to these crops, however the application may be varied." But on the growth and productiveness of such plants as corn, potatoes, turnips, and on clovers, its effects are most beneficial and profitable, increasing the crop to twice, and in some instances, to thrice the quanty produced without it.

125. *When and how should gypsum be applied?*—The *New American Farm Book* says—"It should be sown broadcast as soon as the leaves have expanded in the spring. For corn, potatoes, turnips, &c., gypsum is usually put in with the seed, or sprinkled upon them after the first hoeing." "When the soil does not contain naturally any sulphate of lime, (says the New England *Manual of Agriculture*) or when it is exhausted by cropping, the addition of that substance, [sulphate of lime, that is, gypsum] may prove of great value in two ways; 1st, by furnishing food for the plants mentioned, and 2nd, by fixing the ammonia of the atmosphere and laying it

up in store for the future use of plants by decomposing the carbonate of ammonia contained in rain water, and making soluble sulphate of ammonia and carbonate of lime. Where applied, plaster should be scattered, in the shape of the finest, impalpable powder, in the spring, just as vegetation is beginning, and while the dew of the morning or evening is on the plants, that it may stick, but not in rainy weather."

LESSON XXV.

HOW TO CONSERVE AND IMPROVE THE SOIL—(*Continued*).

(ASHES AND OTHER ARTIFICIAL MANURES).

136. *What is said of ashes as a manure?*—Nearly all varieties of ashes are valuable as manures. Wood ashes are most commonly used, and form a manure of great value, while the ashes of anthracite and bituminous coal are not without value, especially upon cold, stiff soils, and are said to be an excellent top-dressing for grass, even on light soils.

NOTES.—1. It has been shown in lesson II., p. 17, that ashes are the mineral part of plants, and constitute from 1 to over 12 per cent. of the whole weight of plants. The ashes of different plants, and of different parts of the same plant vary in quantity and quality, as also the same plants in different kinds of soils. Thus plants which grow on low, wet, peaty soils, give a less proportion of ashes than those which grow in dry and rich soils, and the bark, twigs and leaves give much more ashes in proportion than the trunks of trees and stems of plants, and they yield a larger proportion of ashes when they are young and growing than after they have attained maturity. The ashes of some kinds of wood and plants are also much stronger than those of other kinds of wood and plants. JOHNSTON, in his lectures on agricultural chemistry, gives the following composition of the ashes of oak and beech trees, and these may be given as illustrating the general character of wood ashes:

Percentage of	*Oak.*	*Beech.*
Potash	8.43	15.83
Soda	5.64	2.79
Common salt	0.02	0.23

Per centage of	*Oak.*	*Beech.*
Lime	74.63	62.37
Sulphate of lime	1.98	2.31
Magnesia	4.49	11.29
Oxide of iron	0.57	0.79
Phosphoric acid	3.46	3.07
Silica	0.78	1.32
	100.00	100.00

NORTON, in his New York State Prize Essay on the *Elements of Scientific Agriculture*, after quoting the above table, remarks—"The substances composing these ashes are seen at a glance to be of a valuable character for applying to the soil. It will be noticed that the proportion of potash and soda is very considerable. Besides these, there is quite an appreciable proportion of phosphoric acid, and a very large quantity of lime: part of this was in combination with phosphoric acid. The potash, soda, lime and magnesia were doubtless for the most part combined with carbonic acid, forming carbonates."

2. Ashes, it is thus seen, are made up of salts, such as silicates, phosphates, sulphates and carbonates. The carbonates and sulphates of potash and soda, as found in ashes, are soluble or may be dissolved out by *boiling*. The silicates, phosphates and carbonates of lime, magnesia, iron and manganese are *insoluble*, and thus remains in leached ashes. A portion, also, of silicate of potash remain undissolved. Far the larger part of leached ashes is carbonate of lime. The next is phosphate of lime, or bone dust.

3. It is remarked in the *New England Manual of Agriculture*, that "*unleached* wood ashes are of great value in the cultivation of many crops, especially Indian corn, turnips, beets and potatoes, because of the great amount of carbonate and other salts of potash which they contain; and so important is potash to these plants, that they are often called potash plants. *Leached* ashes are of less general value, but still are a very valuable fertilizer, by reason of the salts which they contain, and which, though not soluble in simple water, may be rendered soluble by the influence of other salts, of air and of the vital power of plants, and may be thus taken up into the circulation, and again perform the service they had performed in the plants from the combustion of which they come. They have important effects when mixed in compost heaps."

4. It is also interesting and important to note the relative quantities of different elementary substances contained in the ashes of the more important objects of cultivation. This will be seen by referring to the table, given in Lesson xviii, p. 79. From that table the farmer will readily see the great value of ashes to his crops, and that good husbandry dictates to him not to lose a pound of them. They are esteemed the best of all saline manures, and in this country, they are the most economical, as from the free use

of fuel they are produced in every household, and more or less abundantly on every farm.

5. Some of the substances which form the constituents of the ashes of plants may seem very small in comparison with the whole weight of the vegetables; so the nails in a box, and the spikes and caulking for a vessel, may seem small in comparison with the other materials which enter into the construction of a box or a ship, but are nevertheless essential to their completion. The arteries and nerves constitute a very small part of the living human body; but without them it could not exist. The soil contains these substances in very small quantities, and the annual exhaustion of such salts from large crops of grain, roots and grass, must soon impoverish the soil, unless they are replaced by manures, of which ashes are one of the most important.)

137. *In what quantities should ashes be applied to the soil?*—The *New American Farm Book* says: "The quantity of ashes that should be applied to the acre must depend on the soil and crops cultivated. Potatoes, turnips, and all roots, clover, lucern, peas, beans, and the grasses are great exhausters of the salts, and they are consequently much benefited by ashes. They are used with decided advantage for the above crops in connection with bone dust; and for clover, pease and roots, their effects are much enhanced when mixed with gypsum. Light soils should have a smaller, and rich lands or clays, a heavier dressing. From 12 to 15 bushels per acre for the former, and 30 to the latter, is not too much; or, if they are leached, the quantity may be increased one-half, as they act with less energy. *Repeated dressings of ashes, like those of lime, and gypsum, without a corresponding addition of vegetable or barn-yard manures, will eventually exhaust tillage lands.*"

138. *How should ashes be applied as manure?*—The same author remarks, that, "They may be drilled into the soil with the roots and grain, sown broadcast on meadows or pastures, or mixed with the muck heap. They improve all soils not already saturated with the principles which they contain."

LESSON XXVI.

HOW TO CONSERVE AND IMPROVE THE SOIL—(*Continued*).

(OTHER INORGANIC OR MINERAL MANURES.)

(NOTE.—There are several other mineral compositions little, if at all, used in this country as manures (except common salt), though much used in Europe and in the United States, especially as garden manures. I must not omit a brief notice of them.)

139. *What is said of soot as a manure?*—Soot is considered a very valuable manure, as it is made up of carbon in a state of the finest powder, and contains other rich ingredients. The soot from the bituminous coal is still better than from wood. Salt enhances its effects. It produces its greatest effects in moist weather. It may be sown broadcast over the field or harrowed in, or mixed with other manures for immediate use. In England it is scattered upon the meadows, where it promotes the vegetation of grass, while it destroys moss. Three large crops of clover are said to have been got in one year by the use of it.

140. *What is said of common salt as a manure?*—Common salt has been used as a manure from ancient times. It should not be used in large quantities, nor in the neighbourhood of the sea coast, where the sea breezes carry quantities of salt spray and deposit them on the land. For some plants, as asparagus, for example, it is of the highest value as a fertilizer, and may be employed in large quantities,—both enriching the soil for asparagus, and killing nearly all the weeds. It is also a valuable addition to the farmyard and to the compost heap. Salt that has been used in curing fish or meat is cheaper and far better than pure salt. The *New American Farm Book* says, "When used at the rate of from three to sixteen bushels per acre, the crops of grains, roots, or grasses, have been increased from 20 to 50 per cent. It may be applied in

minute portions in the hill, or scattered broadcast, or mixed with the muck heap." "The compound thus formed (says NORTON) is very energetic in its action upon vegetable substances, and has been found an admirable application to many soils, particularly on those where there is much inert vegetable matter, that can only be decomposed with great difficulty."

(NOTE.—It has been shown in Lessons V. and IX., pp. 23, 39, that common salt is the chloride of sodium containing 60 per cent. of chlorine and 40 per cent. of sodium. Sodium chemically combined with oxygen forms soda, as has been shown in Lesson X., p. 43. It will be seen by referring to the table which I have given in Lesson XXV. pp. 98–9, that salt furnishes two essential constituents in every vegetable. Its composition, therefore, as well as experience, evinces its importance as a manure.

141. *What other combinations of sodium are good manures?*—Besides the combination of sodium with chlorine, its combination with sulphur and nitrogen form excellent manures.

NOTES.—1. The combination of sulphur and sodium forms sulphate of soda, the common name of which is Glauber's salts; the combination of sodium and nitrogen forms nitrate of soda, commonly called saltpetre. The reader is reminded of the explanations given in Lesson VI. of the import of the termination *ate*, signifying a *salt*, which always involves the combination of at least three elementary substances, one of which is always oxygen as explained in Lesson VI., p. 31. It will be remembered that the combination of oxygen with a metal, forms an oxide or a base (Lesson VI., p. 28), and that the union of an acid and a base forms a *salt*, which is indicated by the termination *ite* or *ate*. Thus the union of oxygen and sulphur forms sulphuric acid, and the union of sulphuric acid with the oxide of sodium (called base, see p. 31) forms the sulphate of soda, or Glauber salts. It will be observed that there is *oxygen* in both sulphuric acid and in the oxide of sodium, so that in Glauber's salts there are oxygen sulphur and sodium. Thus also in the nitrate of soda there is oxygen in the nitric acid (the union of oxygen and nitrogen), and in the oxide of sodium, or soda, forming nitrate of soda, or soda-saltpetre. The same remarks apply to carbonate and phosphate as to sulphate and nitrate, substituting carbon and carbonic acid, phosphorus and phosphoric acid, for sulphur and sulphuric acid. I repeat these remrks, and refer to the explanations given of them in the *preparatory part* of this book, in order that the reader may become perfectly familiarized with their import and the relations they

imply, as the clear understanding of them and even familiarity with them are requisite to the intelligent reading of any work on agriculture and manufactures, and to the appreciation of its explanations, recommendations and reasonings.

2. Nitrate of potash and nitrate of soda, being found in a crude state, in native beds, are sometimes sold at a price that may justify their use—both yielding not only nitrogen but potash and soda to plants, and are said to be particularly beneficial to wheat and barley. They give a dark green color to the leaves, promote more rapid growth; they increase the weight of clover grass and the straw of grain, increase the yield of grain, and produce a marked improvement in grass crops and pastures.

3. On the use of these saline manures, Mr. Norton, in his prize essay on the *Elements of Scientific Agriculture,* has the following suggestive remarks: "When the farmer intends to use any of these manures, it is in nearly every case better to make a mixture. One hundred weight of the nitrate of potash and soda, of common salt, sulphate of soda, and sulphate of magnesia, all mingled together, and applied with a few bushels of gypsum, would be much more likely to meet the wants of any soil, than a hundred weight of either one alone. Such mixtures are found remarkably effectual, and they are the basis of the artificial manures now gradually coming into vogue. These manures are very excellent, if the price is reasonable, and the farmer assured of their purity. The farmer should not buy these manures unless he has perfect confidence in the manufacturers, or unless, as was recommended with regard to guano, they furnish analysis by competent chemists, and warrant the manure sold to be equal in quality.")

142. *What is said of old lime plaster from the walls and rooms of buildings as a manure?*—This is formed mostly of sand and lime, chemically combined, and is therefore the true *silicate of lime.* This is worth twice its weight in hay for meadows, and for most other crops, especially on clayey and loamy soils; and it will produce a large growth of grass for years in succession without other manure.

143. *Are not broken brick and burnt clay also used as manures?*—Yes! being composed mostly of silicate of alumina, mixed with the silicate of potash and other substances, they are valuable as a top-dressing for meadows. It is said, that, "In addition to their furnishing in themselves a minute quantity of the food of plant, like old plaster, they serve a much more extended purpose by condensing

ammonia, nitric acid, and the gases of the atmosphere."

(NOTE.—The farmer should, however, remember, that old lime plaster, broken brick, burnt clay, as well as all other saline manures, supply but a part of the ingredients which enter into the composition of vegetables; and without the addition of the others the soil will sooner or later become exhausted. The authors of the New England *Manual of Agriculture* have well observed, that "The object of manures is to give the soil whatever is wholly or partly wanting to it, whether of a combustible or an incombustible nature. The use of organic manures is to furnish with *humus, geine* or *mould*, which shall serve as a reservoir, to hold in readiness, for the use of plants, all the kinds of food necessary to their growth. And the use of *humus* is to furnish and keep a ready supply of carbonic acid, ammonia and water, which three are the last result of the decomposition of vegetable substances.")

144. *But, is it not discouraging that after all the pains the farmer takes to fill his soil with valuable manure, it should all be washed away into the deep earth by the rains?*—To this question which has agitated the minds of so many farmers, the *Manual of Agriculture* (published under the sanction of the State Board of Agriculture for Massachusetts) returns the following satisfactory answer:

"It would be very discouraging if it were true, but fortunately it is not true; as is made very apparent by a simple experiment or two. If a funnel be filled with the soil, and a dilute solution of the silicate of potash be poured upon it, there will not be found in the water which passes through it, a trace of potash, and, only under certain circumstances, silicic acid.

"If a funnel be filled with earth, and water holding in solution ammonia, potash, phosphoric acid and silicic acid, be poured into it, none of these substances will be found in the water, escaping from the funnel. The soil will have completely with drawn them and incorporated them with itself.

"Or make another experiment. Take a portion of garden soil full of potash, silicic acid, ammonia or phosphoric acid, put it into a funnel and pour

water upon it. The water will not dissolve out a trace of it. The most continuous rain cannot remove from a field (except mechanically, that is, unless it carry off soil and all) any of the essential constituents of its fertility. It is a common fear that the nourishing substances in liquid manure and in guano, will, if not immediately taken up by the plants, be lost. But the fear is wholly unfounded. From liquid manure diluted with much water, or from a solution of guano, soil, when used in sufficient quantity removes the whole of the ammonia, potash, and phosphoric acid which they contain. Not a trace of these substances can be found in the water which flows from the soil."

LESSON XXVII.

HOW TO CONSERVE AND IMPROVE SOILS—(*Continued.*)

(AMENDMENTS — IRRIGATION — DRAINAGE.)

(NOTE.—I have spoken of the different kinds of soils—their composition, the vegetable and mineral manures adapted to improve them, and the several kinds of grains and roots for which they are suited. I now devote a Lesson to consider how defective soils may be amended by modifying their physical qualities, by irrigation, by deep ploughing, and by drainage).

145. *How may defective soils be amended?*—By lessening the tenacity of heavy soils and increasing that of light soils, by diminishing the humidity of moist soils and increasing that of dry soils, and by other changes of their texture.

146. *How can the texture of clayey or argillaceous soils be improved?*—As the defects of clayey soils are their stiffness, compactness, and consequent coldness and often wetness, these defects are remedied by the addition of anything that will render them more open, loose, and penetrable by air and water, such as sand, gravel, broken brick, chips,

corn-stalks, straw, &c,, and by deep ploughing and drainage.

(NOTES.—1. In England, clayey land is often much improved by burning over the surface, or by burning a portion of the clay and scattering it upon the land. By burning, the clay changes its properties, and it becomes more like sand, and in this state loosens the soil.

2. In the previous Lessons, I have stated how clayey soils are ameliorated by manures, both vegetable and mineral; but one of the most effectual methods of improving the clayey soils, is under-draining, which draws off, imperceptibly but rapidly, the excess of moisture, opens the soil to the free admission of atmospheric air, and this in its passage through the soil imparts heat and such of the gases it contains as are useful in sustaining vegetation. The clay is mellowed, made less retentive, dries sooner in the spring, and does not bake so hard in summer.)

147. *How are the defects of sandy soils remedied?*—As the character and defects of sandy soils are mostly the reverse of those of clayey soils, the treatment of sandy soils should be the reverse of that which has been recommended in regard to clayey soils. Sandy soils possess not the property, of adhesiveness, have little affinity for water, which escapes from them almost as soon as it falls; they are loose in their texture, and have but a slight hold of the manures diffused through them. As clayey soils are improved by a mixture of sand, so are sandy soils improved, but in a much higher degree, by the addition of clay. Clay and sand are necessary to each other, as they both contain qualities which are essential to a good soil; and that is always found to be best which has the proper proportion of each. The frequent use of a heavy roller also improves sandy soils, as any treatment which renders them more compact is advantageous to them. It is said that "sandy soils can never be profitably cultivated till they have acquired sufficient compactness and fertility to sustain a good crop of grass or clover; and when once brought to this condition they are among the most valuable."

(NOTE.—It is said that sandy soil amended by the addition of clay becomes permanently better. The clay can never be exhausted, and will always give to the soil the power of absorbing and retaining the elements of food for the sustenance of plants. In previous lessons I have sufficiently referred to the manures best suited to sandy soils. I have also sufficiently referred to the treatment proper for peaty soils.)

148. *What other means are employed to improve the texture of soils?*—There are three—irrigation, subsoil ploughing, and draining.

149. *What is meant by the irrigation of land?*—The irrigation of land is watering it by means of little streams, which overflow it at certain seasons, when in grass or growing grain. It is remarked, that "all water, except rain water, even that from the purest springs, has mineral and organic substances in solution. As it flows over the surface among living plants, and in sinking through the soil comes in contact with their roots, it yields up these substances for food. Beside such solid bodies, it contains in solution carbonic acid and oxygen, both of which the plant receives with avidity."

(NOTES.—1. Norton thus describes this method of irrigating land:—"The surface of the field to be irrigated must, of course, be somewhat sloping, and the water is brought on by a main ditch at the head of the slope. In this main ditch, at proper distances, are gates to regulate the flow of water into smaller ditches, from the sides and ends of which again run small cuts; these are so arranged that every part of the field shall be flowed over by a thin but regular sheet of water. At the foot of the slope is another ditch, for the purpose of conveying away, such of the water as may not sink into the earth. Where water is scarce, and the slope long, it is occasionally used several times in succession. When the flow has continued for ten days or a fortnight at a time, the supply gates are shut down; and the field allowed to dry. The operation is repeated once or twice in a season. Here there is no stagnation, as in swamps and wet land; the water is always running and fresh. Land that is intended to be irrigated should have a porous subsoil, or, if not, should be underdrained; in either case, the water sinks away as soon as the flow is stopped, the soil dries, and the plants get at once the full benefit of the fertilizing matter that has been deposited."

2. The productiveness of much of the low bottom lands on our Canadian streams, is largely owing to their annual overflow from

the streams on which they are situated; and this is the case with the lands on the low banks of many rivers and streams in America. Such waters as flow out of the sewers of cities and towns, or past slaughter houses and certain manufactories, and receive the rich vegetable food thereby afforded, are the most beneficial to vegetation. It is said that meadows thus irrigated in the neighbourhood of Edinburgh, have rented by the acre at the large sum of $250 per annum.

3. In the countries where rain seldom or never falls, the large demand by vegetable life for water, though partially supplied by heavy dews, has given rise to extensive irrigation, which has been practised from ancient times where husbandry has attained in any rank, as in Egypt and the Barbary States of Africa, Babylon, Syria, and in some countries of Europe; also in parts of both South and North America. It is said that when the Mormons first settled in Salt Lake Valley, the country was a barren wilderness, from perpetual drought in the growing seasons of vegetation; but by aid of irrigation, it has become one of the most productive countries in the world—the Egypt of America in productiveness, though without the Nile.)

150. *What are we to understand by subsoil ploughing?*—Subsoil ploughing is loosening the soil some distance below the ordinary furrow. The subsoil plough is an implement designed to follow the furrow after the common plough, and to loosen and break up the lower layers of the soil without bringing them to the surface. The subsoil plough, made expressly for the purpose, goes down as deep as it can be forced—in some cases to the depth of eighteen to twenty-four inches. In the first subsoiling, it is difficult to go down more than a few inches below the ordinary furrow; but the depth is increased at each subsequent subsoiling until the greatest depth possible is attained. The process is repeated once in five or six years.

(Note.—The objects proposed by subsoiling are to loosen the hard earth below the reach of the ordinary plough, and permit the ready escape of the water which falls upon the surface, the circulation of air, and a more extended range for the roots of plants, by which they procure additional nourishment and secure the crop against drought, by penetrating into the regions of perpetual moisture. The roots of some plants, as, for example, those of corn, potatoes, beets, &c., penetrate two or three feet when the soil permits. Subsoiling is said, in some cases, to add from 30 to

50 per cent. to the crop; but its greatest influence on stiff soil is only reached where the land has been thoroughly under-drained

(Drainage of Soils.)

(Note.—Many volumes have been written on the subject of drainage. In what follows on this subject, both in the text and notes, will be found a condensed abridgment or summary of what I have collected from the most recent and practical works on Agriculture.)

151. *What is drainage of the soil?*—Drainage is an operation by which we draw off the surplus water from the soil and from the sub or under-soil, where it would not otherwise escape.

152. *How is this effected?*—It is effected by means of drains, covered or open, dug from two to three feet in depth, and running in parallel lines from twenty to forty feet distance of each other, and with a descent of at least an inch per rod.

153. *What are the effects of drainage upon the soil?*—1. Drainage takes away the surplus water that exists in heavy and tenacious soils, which in wet seasons is a serious impediment to the successful growth and perfection of vegetation. 2. It allows of early cultivation in spring and autumn, by furnishing a dry, warm soil, which would not admit of cultivation except in the warm part of the season; thus enabling the farmer to grow a greater variety of products where only a few were adapted to the soil before, and to these it gives several weeks additional growth. 3. It saves all the trouble and waste of surface drains and open furrows, which require that much of the land be left almost in an unproductive state, to serve as conductors of the surplus water. 4. The dense mass of saturated soil is impervious to air and remains cold and clammy. By draining below the soil, the warm rains penetrate the entire mass, and thus diffuse their genial temperature through the roots. Immediately pressing after these, the warm air rushes in and supplies

its portion of augmented heat to the land. Porous soils thus readily imbibe heat, and they as readily part with it; every portion of them radiating it when the air in contact with them is below their own temperature. This condition is precisely what is adapted to secure the deposit of *dews*, so refreshing during a season of drought, and so indispensable to the progress of vegetation. 5. Rain water is charged with some of the most important elements of nutrition to plants, and especially contains considerable proportions of carbonic acid and ammonia. If these be permitted to percolate through the soil, the roots of the plants, or in their absence the elements of the soil itself, absorb and form permanent combinations with them. Air holds, also, vegetable food, and it is necessary that this should penetrate through every portion of the soil where the fibres of the roots exist. 6. The earth being rendered less moist at the surface, far less evaporation takes place there. Whence, as evaporation always cools the surface very considerably, a drained field keeps the heat better than one not drained; and the natural consequence is that the crops ripen earlier. The grain on a drained field is generally fit for the sickle some days, often some weeks earlier than that on other fields. 7. Lands well drained and deeply tilled, bear the drought better than others. The reason of this seems to be, that the pores are always open in deeply tilled, well-drained land, to an unusual depth. Evaporation cannot reach to a great depth, and, in season of drought, the open pores allow moisture which has been kept in the deep earth to rise by *capillary attraction.* 8. In a well-drained field, the spring rains, instead of being allowed to run away and be lost, are saved, as in a reservoir against the heats and drought of summer. 9. Another essential benefit of underdraining arises from advantage thereby conferred

in subsoil ploughing. If there be no escape for the moisture which may have settled below the surface, the subsoil plough is of little benefit; but by loosening the earth it admits a larger deposit of water, which requires a longer time for evaporation and insensible drainage to discharge. When the water escapes freely, the use of the subsoil plough is attended with the best results. The broken earth thus pulverized to a much greater depth and incorporated with the descending particles of vegetable sustenance, affords an enlarged range for the roots of plants, and in proportion to its extent furnishes them with additional means of growth. The farmer thus has a means of augmenting his soil and its capacity for production wholly independent of increasing his superficial acres; for with many crops it matters not in the quantity of their production, whether he owns and cultivates one hundred acres of soil, one foot deep, or two hundred acres of soil half a foot in depth. With the latter, however, he has to provide twice the capital in the first purchase, is at twice the cost in fencing, planting and tillage, and pays twice the taxes. The underdrained and subsoiled fields have the further advantage of security and steady development in seasons of drought, as they derive their moisture from greater depths, which are frequently unaffected by the parching heat. This secures them a large yield while all around is parched and withered.

(Note.—The effects of drainage have been illustrated by the following comparison:—"Plants which are kept in flower-pots would soon rot at the root if the water with which they are watered were left to stagnate at the bottom of the pot without any means of escape. For this reason, the bottom of the pot has a hole in it, to let the superfluous water run out. Now drainage does the same service for the field that the hole in the bottom does for the earth in the flower-pot."

Note on the Drainage of Swamps and Peat Beds.—In different parts of the Province there are extensive plots of wet, boggy lands whose only use now is to mire cattle, and bear certain kinds of

wild berries and a small quantity of inferior bog hay. Our Legislature has appropriated a large sum of money to reclaim, by drainage, these swamps and marshes to the purposes of agriculture, as has been done with great success and with large profit in similar circumstances in other countries. There is many a farmer a portion of whose land is useless, and often worse than useless, from the same causes. Swamps, peat-beds, and marshes occur frequently in a hilly region of country, forming low, level, wet lands, whose constant saturation with water prevents their cultivation with any useful plants. The first object in effecting their improvement is to find an outlet for the escape of the water from three to five feet below the surface, and then to intersect the land to be reclaimed, with drains accordingly. If the water in the swamp has its origin in numerous springs from the adjoining hills, a ditch should be dug around the entire outer edge of it, where it meets the ascending land, and the water conveyed in a drain sufficiently deep to a ravine or rivulet.)

154. *What is said as to the construction of drains for the drainage of lands?*—There are two kinds of drains—*open* and *covered*. But open drains, or ditches, occupy much ground which might otherwise be productive, leave a great deal of water in the soil, and carry off with the water that enters them many substances of fertility to the soil. They are now generally disapproved of by practical agriculturists. Covered drains are constructed of stones of brush, of logs, or of pipe tiles made for the purpose.

(Notes.—1. To lay a stone drain, it is necessary to dig a large trench, which involves much labour, and would not be done unless there were many rubble stones on the land which the farmer desires to get rid of; and even then the tile drain costs less, and is better.

2. Where neither tiles nor stones can be procured the brush drain is sometimes made by digging a trench, and filling it up to a certain depth with small brush. When this is done, the sticks are or should be laid with the larger ends down. The brush is then pressed down and covered over with sods with the grass side down. This is better than none. The same may be said of log drains, which are made by laying down two logs in a trench, within two or three inches of each other, and a third log upon the other two. The earth must be pressed down solid over the stones, brush or logs, which are, of course, always below the level of the plough.

3. "But two recent improvements," says the *New American Farm Book*," "have been introduced, which greatly enhance the benefits of draining. They consist in sinking the drain three feet in depth, and then using pipe tiles one and a half to two inches in diameter, and twelve to eighteen inches in length, connected by laying them simply end to end, or better, by short collars made of sections of a size larger tile. The trifling opening at each joint is found to be sufficient to admit all the water which the drain can carry; while the increased depth at which the drainage takes place, draws the water from a much greater distance. With the depth of three feet, it has been found that the drains, instead of being required once in sixteen to twenty-five feet, may be placed at intervals of thirty to forty feet, and accomplish the object with equal success and in less time. It has of late been ascertained, that in heavy soils, three feet is a sufficient depth and thirty feet is about the proper distance apart for the most effective drainage."

4. The best shape for the pipe tile (which is made in many of our brick-yards) is found to be a simple round tube. For the interior drains which enter into the large main drains, a tube of two inches in diameter is said to be about the right size. The fall should not be less than one inch to the rod. A drain properly laid in this way may be expected to last and answer a good purpose for half a century.)

LESSON XXIX.

ROTATION OF CROPS.

153. *What is meant by the rotation of crops?*—The word rotation signifies turning round as a wheel on its axis, until a complete revolution is made; and when the term is applied to agriculture, it denotes a succession of different crops, instead of a succession of the same crops, and the order in which different crops are made to succeed each other on the same soil, as, for example, (as in the county of Norfolk, England,) a crop of turnips is followed by a crop of barley, and this by a crop of clover, and this again, after one or two years, by a crop of wheat, when the rotation again commences with turnips.

154. *What is the object of the rotation of crops?*—The object of the rotation of crops is to economize, in the best manner, the resources of the farm, so as to make each field yield, with a certain amount of labour

and manure, the greatest possible amount of valuable crops with the least possible exhaustion to the soil.

155. *What reason is given for the rotation of crops?*—The reason for the rotation of crops is, that no two plants of different kinds require the same substances in the same proportion for their nourishment. I have shown in the table on page 115 the substances of which the different plants, and the different parts of the same plants, cultivated on the farm, are composed. It will there be seen that the grasses, and the straws of different kinds of grain, contain a large proportion of silica, and they therefore soon exhaust the soil's supply of it, and they should not, therefore, immediately succeed each other in rotation in the same soil, and they should be each followed by a crop which needs less of silica but more of potash or some other mineral salts. A field which would not yield a second good crop of wheat, may, even without manure, yield a good crop of clover, or turnips, or carrots.

NOTE.—In further illustration of this important subject, may be properly added the following remarks taken from the *New American Farm Book:* "The system of rotation is one of the first and most important principles of general husbandry, and it cannot be omitted without manifest disadvantage and loss. The place of rotation was formerly supplied by *naked fallows.* This practice consists in giving the soil an occasional *rest*, in which no crop is taken off, and the soil is allowed to produce just what it pleases, or nothing at all, for one or more years, when it is refreshed and invigorated for the production of its accustomed useful crops. This system, it will be perceived, implies the loss of the income of the soils for a certain portion of time, and it can be tolerated only where there is more land than can be cultivated. Modern agricultural science has detected, in part at least, the true theory of the necessity for rotation. It has been discovered that every crop robs the soil of a portion of its elements, fifteen or sixteen elementary substances contained in various forms and proportions,) and that no two dissimilar crops abstract these elements or their compounds from the soil in the same proportion. Thus, if we consider the amount of the salts taken out of the soil by a crop of turnips, amounting to five tons of roots per acre; of barley, thirty-eight bushels; one ton each of dry clover or rye grass, and

of wheat twenty-five bushels, we shall find the exact proportions of the various elements which the different vegetables have appropriated. As given by JOHNSON, they will be in pounds as follows:—

	Turnip Roots.	Barley.		Red Clover.	Rye Grass.	Wheat.		Total.
		Grain.	Straw			Grain.	Straw	
Potash	145.5	5.6	4.5	45.0	28.5	3.3	0.6	233.0
Soda	64.3	5.8	1.1	12.0	9.0	3.5	0.9	99.6
Lime	45.8	2.1	12.9	63.0	16.5	1.5	7.2	149.0
Magnesia	15.5	3.6	1.8	7.5	2.0	1.5	1.0	32.9
Alumina	2.2	0.5	3.4	0.3	0.8	0.4	2.7	10.3
Silica	23.6	23.6	90.0	8.0	62.0	6.0	86.0	299.2
Sulphuric acid	49.0	1.2	2.8	10.0	8.0	0.8	1.0	72.8
Phosphoric acid	22.4	4.2	3.7	15.0	0.6	0·6	5.0	51.5
Chlorine	14.5	0.4	1.5	8.0	9.1	0.2	0.9	25.6
Grand total (exclusive of turnip tops)								970.9

"Besides the elements above noted, all crops contain oxide of iron, and nearly all oxide of manganese and iodine; and of the organic elements associated in various combinations, they appropriate about ninety-seven per cent. of their entire dried weight. Now it is not only necessary that all the above materials exist in the soil, but they must also exist in a form precisely adapted to the wants of the growing plants. If a succession of any given crops are gathered and carried off the land, without the occasional addition of manures, they will be found gradually to diminish in quantity till they reach a point when they will scarcely pay the expenses of cultivation. We mean to be understood as offering this of all crops and of all soils, however naturally fertile the latter may be, unless they are such as receive an annual or occasional dressing from the overflow of enriching floods, or are artificially irrigated with water, which holds the necessary fertilizing matters in solution; and such are not exceptions, but receive their manure in another form, unaided by the hand of the husbandman."—(Pp. 296–299.)

156. *On what fact is the theory of the rotation of crops founded?*—Some of these facts are the following: 1. The soil contains only a limited supply of the mineral food necessary for a particular plant, though it may contain all the mineral substances necessary for the nourishment of every variety of plants. 2. Some plants, as the grains

for example, draw their nourishment from near the surface; while others, like carrots and parsnips, draw much of their nourishment from a greater depth. 3. Some plants, as those which have abundant foliage, draw much of their food from the atmosphere; while others, as the grains, depend more upon the materials contained in the soil. 4. Particular insects live upon certain kinds of plants, for example, certain flies live on grains and grapes, and continue to multiply as long as the same crop occupies the soil from year to year; but when a crop intervenes on which these insects cannot live, as beans or turnips after wheat or oats, then they perish for want of proper nourishment for their young.

157. *What benefits result from the rotation of crops?*—Some of the benefits resulting from the rotation of crops are the following: 1. The preservation of the soil from being impoverished by a succession of the same kind of crops. 2. The development of all the various fertile elements of the soil in the production of different kinds of agricultural plants. 3. The manuring of such crops as cannot receive it without hazard or injury if applied directly upon them. Thus wheat and the other white grains are liable to overgrowth of straw, and rust and mildew, if manured with recent dung; yet this is applied without risk to corn roots, and most of the head crops; and when tempered by one season's exhaustion, and the various changes and combinations which are effected in the soil, it safely ministers in profusion to all the wants of the smaller cereal grains. 4. By bringing the land into hoed crops at proper intervals, it clears it of any pernicious weeds which may infest it. 5. The cutting off the appropriate food of insects and worms which often become numerous and destructive under the continuance from year to year of certain kinds of crops. A

change of crops, and exposure of insects to frosts, and the change of cultivation which a rotation of crops insures, will, in all cases, greatly diminish their numbers, and, in most instances, effectually destroy them. 6. Each crop, in succession, may find in the soil valuable matters which were unnecessary to the preceding crops.

158. *What is the period assigned by agriculturists for a complete rotation of crops?*—The period depends upon the crops that constitute the rotation, upon the fancy and experience of different individuals, upon their need of certain productions, upon the different kinds and qualities of soils cultivated, and there is, therefore, no fixed period followed by all. Five, six, or seven years is the usual time, unless in case of lands that may advantageously remain a long period in grass.

159. *What is the order in which crops should succeed each other?*—It has been laid down as a principle of husbandry that the two classes of crops — culmiferous and leguminous — should uninterruptedly succeed each other. The former include wheat, oats, barley, rye, Indian corn, and most of the grasses—all of which have stems mostly joined; the latter include peas, beans, and other pulse; also, by some writers, potatoes, turnips, carrots, beets, cabbages, &c., especially in reference to rotation of crops.

(NOTES.—1. *Culm*, among botanists, signifies straw, and is the proper stem of grasses and plants which elevates the leaves, flowers and fruit. This sort of stem is hollow, and has frequently knots or joints at certain distances, as the straws of wheat, barley, &c. *Leguminous plants* (from *legumen*, seed-vessel or pod) are such as bear *pods*, as beans, peas, &c.; but the term here includes also, what are technically called, and described in another place, as *root crops*, such as potatoes, turnips, beets, carrots, cabbages, clover, &c.

2. The reason of this two-fold classification of plants is, that culmiferous plants, including wheat, oats, barley, &c., are regarded as robbers and exhausters of the soil, some much more so than others. They are particularly so *during the process of ripening*

their seeds. Hence, if cut green, or when in blossom, they are far less exhausting to the soil than when allowed to mature their seeds. "Leguminous plants (says the English and Scotch *Farmer's and Planter's Encyclopædia*), according to the strict agricultural acceptation, include beans, peas and other pulse. But the class is made to embrace a much more extensive range of plants, namely, all such as are considered as ameliorating or enriching crops, such as clover, potatoes, turnips, carrots, beets, cabbages, &c. These latter are far less exhausting than the culmiferous or grain plants, as few mature their seeds, and all, on account of their broad leaves, draw more or less nourishment from the atmosphere. They also ameliorate the condition of the soil by dividing and loosening it with their tap or bulbous roots. As they usually receive manure and hoeing or drill culture, they are peculiarly adapted to enrich and prepare the soil for culmiferous or grain crops."

3. The differences in the roots of these two classes of plants is worthy of remark, and accounts, in part, for their different effects upon the soil. The roots of culmiferous plants are generally more fibrous and more divided, spreading themselves near the surface, and they draw their nourishment chiefly from the upper stratum of the soil. Many of the so-called leguminous plants have spindle-formed or tap roots, with few radicles or little roots, and consequently draw most of their mineral nourishment from the lower stratum of the soil, and through the lower extremities of their roots.

4. Two analogous facts may be stated in further illustration in favour of a change or alteration of crops. The one is, that trees of the same species will not flourish in succession in the same place. Hence, if a worn-out peach orchard be removed, and young trees of the same species are to occupy the same ground: instead of being planted in the holes from which the old ones were taken, they must be arranged in rows intermediate to the old ones. The same remark applies to all fruit trees, unless a sufficient period is allowed for producing the decomposition of the roots of the removed trees for supplying the earth with fresh manure. A second fact is, that in forest lands, the new growth seldom resembles altogether that which has been felled. Hard wood frequently succeeds the pine and hemlock, while the pine and cedar, in numerous instances, succeed the primitive growth of hard wood. Of this latter, I observed an example in 1869, on some of the woody parts of the farm on which I was born, near Vittoria, in the County of Norfolk, where a new growth of pine and cedar is succeeding the primitive hard wood growth of fifty years ago. JOHNSTON, in his *Elements of Agricultural Chemistry and Geology*, remarks that "Plants seem to alternate with each other on the same soil. Burn down a forest of pines in Sweden, and one of birch takes its place for a while. The pines, after a time, again spring up, and alternately supersede the birch. The same takes place naturally. On the shores of the Rhine are seen ancient forests of oak from two to four centuries old, gradually giving place at present to a natural growth of beech;

and others, where the pine is succeeding to both. In the Palatinate, the ancient oak-woods are followed by natural pines; and in the Jura, the Tyrol and Bohemia, the pine alternates with the beech.")

160. *But in what order do the different crops of these two classes of plants succeed each other?*—C. W. JOHNSON, in his *English Farmer's Encyclopædia*, says: "The ordinary course of rotation of crops under which the light lands of England are commonly cultivated, is either on what is denominated the four-course or shift system, or the five-course or shift. The *four-shift* system, commonly consists of fallow, manured: 1, turnips, fed off; 2, oats or barley; 3, grass seed; 4, wheat. The *five-shift* system, which is, in many situations, a much more advantageous course of husbandry, is commonly fallow: 1, turnips; 2, oats or barley; 3, clover; 4, peas; 5, wheat.

"On the *clays* the course varies. On some kinds of *heavy* clays, it is usually fallow, with manure; wheat; beans; wheat, manured; clover; oats or wheat. On *other clays*, the system pursued is fallow, with manure; wheat, or oats; clover; beans; wheat. The variations, however, are of necessity exceedingly various."

In the United States, the rotations of crops vary considerably in different sections. In Massachusetts and the New England States, it appears, according to Mr. Coleman, that "Little of what may be called systematic husbandry prevails, the succession of crops being dictated rather by accident or convenience, than by any well considered principles." The following is a fair specimen of rotation, as given in his *Fourth Report on Agriculture:* "The first year the land is broken up, corn is planted and manured: the second year, oats are sowed without manure, and the land laid down to grass. It is continued in grass five years, and then broken up, and the same course repeated."

It is said that in the oldest cultivated sections of Pennsylvania, the rotations have been conducted with much sound judgment. The system most highly approved is set forth in the following example, first published in the *Farmers' Cabinet*: "The example is that of an old, practical, hard-working farmer, who commenced in the world as a day-labourer, and who is now worth at least $100,000, not taking into account many heavy pecuniary losses he has, at various times, sustained. This man, when 30 years of age, by the avails of his industry, added to a small legacy, was enabled to purchase and pay, in part, for a farm of 130 acres of land, 100 of which was under cultivation, but in a very low state. This farm is altogether upland, with a soil composed of lime, clay and sand, in the chief of which the latter preponderates, the former being least considerable. When he commenced farming, he adopted a particular system of rotation, to which he has implicitly adhered from that time to the present, which is 40 years, and his success is the best comment on the worth of his experiment. His mode was as follows: having divided his farm into *eight* fields of equal size [12½ acres each], as nearly as possible, three of these fields are sown with wheat each year; one with rye; one planted with corn; two in clover; and one an open fallow, on which corn had been raised the year previous. One of the two clover fields is kept for mowing, the other for pasture; both of which are ploughed as soon after harvest as possible, and prepared for wheat in the fall, till the manure, which is made on the farm for one year, is hauled, in the spring, on the field intended for open fallow, which is then ploughed, and after one or two cross-ploughings through the summer, is also sown with wheat in the fall. The field on which rye is sown, is that from which a crop of wheat had been taken the same year, and which had yielded

three crops of wheat, alternating with crops of clover. Corn is planted on the field from which rye had been gathered the year previous, the stubbles of which are ploughed down in the fall. Clover seed is sown early in the spring on two of the wheat fields, those which have been most recently manured. By this method, each field yields three crops of wheat, two of clover, one of rye, and one of corn, every eight years. Each field, in the meantime, has lain an open fallow, and received a heavy dressing of manure, perhaps at an average 15 four-horse loads per acre. His crop of wheat is seldom less than 1,500 bushels, but often much more. His average rye-crop is about 450 bushels; and his corn-crop, annually about 500 bushels—all which grain, at the present low prices, would amount to more than $2,000 annually, and at former prices to double that amount; and his farm is with all very highly improved."

NOTES.—1. The author of the *New American Farm Book* gives "for the purpose of illustration, and the guidance of such as may have little experience in rotation," the following Five Systems which, he says, have been pursued with advantage in this country:"

"1*st Course*—On grass sod, broken up, with a heavy dressing of barn-yard manure, and muck, ashes, and lime, if necessary. *First*, year corn, with gypsum scattered over the plants after first hoeing, which (hoeing) should be immediately after its first appearance; *second* year, roots with manure; *third* year, wheat, if adapted to the soil, if not, then barley, rye, or oats, with grass or clover seed, or both; *fourth* year, meadow, which may be continued at pleasure, or till the grass or clover gives way. The meadow may be followed by pasturing if desired. Clover alone should not remain over two years as meadow; but for pasture, it may be continued longer.

"2*nd Course*—*First* year, corn or roots on grass or clover hay, with manure; *second* year, oats and clover with a top dressing of ten to twenty bushels of crushed bones per acre; *third* year, clover pastured to the last of June, then grown until fully matured in August: when it is turned over, and a light dressing of compost of 40 to 80 bushels of leach ashes spread over it, and wheat and timothy seed sown about the fifteenth of September. If desired, the following spring, clover is sown and lightly harrowed. This gives for the *fourth* year, wheat; *fifth* and *sixth*, and if the grass continues good, the *seventh* year also, meadow.

"*3rd Course—First*, corn on grass sod heavily manured, and a half gill of ashes and gypsum, mixed at the rate of two of the former to one of the latter, put in the hill, and an equal quantity of pure gypsum added, after the corn is first hoed; *second* year, oats or barley, with lime at the rate of twenty to thirty bushels per acre, sown broadcast after the oats, and harrowed in; *third* year, peas or beans removed early, and afterwards sown with wheat; *fourth* year, wheat with light top dressing of compost, and saline manures in the spring, and clover, or grass and clover seed; *fifth*, two or three years in meadow and pasture.

"*4th Course—First*, wheat on grass sod; *second*, clover; *third*, Indian corn, heavily manured; *fourth*, barley or oats, with grass or clover seed; *fifth* and following, grass or clover.

"*5th Course*—A good rotation for light, sandy lands, is *first*, corn, well manured, and cut off early and removed from the ground, which is immediately sown with rye, or the rye hoed in between the hills; *second*, rye with clover sown in the spring, and gypsum added when fairly up; *third*, clover cut for hay or pastured, the latter being much more advantageous for the land."

2. MORTON'S *English Cyclopædia of Agriculture* remarks, that "it is impossible to specify any course of crops which can be recommended as best under all circumstances. The principle laid down is, what succession is best suited, in a given locality, to draw from the soil the largest net return, while the capabilities of the soil are, at the same time, maintained and increased.

3. The rotation of crops as a settled part of the system of agriculture originated with the Flemings, who insisted that where it was practised, the land did not need rest; and it was this system which gave their husbandry a pre-eminence over that of every other country at that period. They relied so much upon it, that in some instances they were able to obtain two crops the same year. In Scotland, it has been scrupulously pursued with the best results,—the improvements in Scottish agriculture being almost incredible. It has been introduced with equal advantage in England, where it has become general; and it is now being widely introduced in America.

LESSON XXX.

SOWING, CARE, AND HARVESTING OF GRAIN CROPS.

(NOTE.—In the preceding (29th) Lesson, page 113, it has been shown that farmers cultivate two classes of crops—*culmiferous*, straw and stalk bearing crops—grains and grasses; *leguminous*, pod-bearing and root crops—*vegetables*. The former are called *cereals* (the term cereal being derived from *Ceres*, the fabled goddess of corn), and include wheat, rye, oats, barley, Indian corn, rice and millet, though the two latter are not cultivated in Canada. In a practical classification, *buck-wheat*, though not included among

the cereals, may be added to this class, as its seeds are similar in quality and use to the cereals properly so called. The following lesson will be devoted to brief suggestions on the culture of this class of crops.)

161. *What is said of wheat as a farm production?* — Wheat is the most important and most generally cultivated of the cereal grains: it is found in every latitude except those approaching the poles and the equator, but is profitably cultivated only in what are termed temperate climates. There are from many varieties of wheat, resulting differences of climate, soil and culture; but those commonly cultivated may be distinguished by the general terms of *winter* and *spring* wheat.

162. *What are the differences between winter and spring wheat?*—Winter wheat requires the action of frost to bring it to full maturity, and is sown in autumn; its roots are peculiarly fitted to endure the severe colds of winter; the main seminal root is pushed out at the same time with the germ, and nourishes the plant in its early growth. Winter wheat is more productive than spring wheat; the straw is harder and more erect; the grain is plumper and heavier; and the price from ten to twenty per cent. higher than that of spring wheat.

(NOTE.—The difference in the price of winter and spring wheat depends upon the appearance and greater whiteness of the flour of winter wheat, rather than on any deficiency in nuritive properties of the flour of spring wheat. Sir HUMPHREY DAVY gave the analysis of 100 parts of winter and spring wheat as follows: "Good English winter wheat, gluten, 19; starch, 77; insoluble matter, 4, Spring wheat, gluten, 24; starch 70; insoluble matter, 6." This analysis gives the greater nutritive value to spring wheat, as gluten constitutes the most important element of flour, resembling so nearly the fibrin or muscle-giving property of animal food. See Lesson III., pp. 18, 19.)

163. *What is the preparation of the land needful for sowing winter wheat?*—Thorough cultivation is requisite, that the land should be as clean as possible from weeds and noxious plants at the time of sowing.

Wheat is partial to a well prepared clay or heavy loam, if it contains, naturally or artificially, a considerable proportion of lime. Many light and all marly or calcerous soils, if in proper condition, will give a good yield of wheat; but no soil, however good in other respects, however well prepared, and however favorable the climate, will produce a good crop of wheat, without a due proportion of lime—so important an aid is it to the full growth of the wheat, checking its exuberance of straw and its liability to rust, and steadily aiding to fill out the grain. Depth of soil is also requisite to large crops. The wheat plant has two sets of roots; the first springing from seed and penetrating downwards (though not so deep as those of Indian corn), while the second push themselves laterally near the surface of the ground from the first joint. They are thus enabled to extract their food from every part of the soil, and the product will be found to be in the ratio of the extent and fertility of the soil; but if water be found in excess, the tissues of the plant become soft and watery, and it runs to stalk, producing little grain. It is essential, therefore, that any surface water be entirely removed; and underdraining and subsoil ploughing contribute greatly to this, as also to the increase of the crops. Wheat on heavy clay lands is peculiarly liable to winter-kill, unless they are well drained. This is owing to successive freezing and thawing, by which the roots are broken or thrown out.

(NOTES.—1. Fresh barn-yard manure applied directly to the wheat crop is objectionable, not only from its containing many foreign seeds, but from its tendency to excite a rapid growth of weak straw, thus causing the grain to lodge and rust. The same objection lies against sowing it in rich alluvial or vegetable soils; but in each, the addition of lime or ashes, or both, will correct these evils.

2. But in the 19th Lesson, on "soils adapted to different kinds of grains and vegetables," and in the subsequent lessons on manures, draining, and rotation of crops, I have said all that is requisite on

the kinds of soils and the modes of preparing them for different kinds of crops.)

164. *How should seed be prepared for sowing?*—Pure wheat, and of the kind required should be selected, the utmost care being taken to remove from it all foreign seeds. Before sowing, it is recommended to put the seed into strong pickle, some say for twenty-four hours, and skim off any light grains; then dry the seed with pulverized quick-lime. This is said to kill all smut, clean out weeds from the grain, and ensure early, rapid growth.

165. *What quantity of seed should be sown per acre, and at what time?*—The quantity of wheat which should be sown per acre, depends upon the kind of wheat sown; but the usual quantity on ordinary, well pulverized wheat soils is about five pecks per acre, while the quantity may be increased to six or eight pecks on rough land, clay soils, and such as are very fertile. The most common, and perhaps the best time for sowing, is from the 5th to the 20th of September, in order to escape the attacks of the Hessian fly, to which earlier sown grain is liable, and to have time to root, so as not to be thrown out by the frost or be winter-killed. Late sowed wheat is also more subject to rust the following season from its later ripening.

166. *How is the seed sown and covered?*—The seed is sown either broadcast by hand (and sometimes by machine), or in drills by a machine. In newly cleared lands, and in fields where stumps are suffered to remain, the former is the only practicable method. But the drill-sowing is the most economical, where practicable, as it saves seed by its more uniform distribution; and wheat, properly drilled in is less liable to be thrown out by frost and killed; and the yield per acre is said to be larger, especially if care be taken to stir the ground and keep out the

weeds between the drills during the growth of the plant. Sowing in drills and hoeing between them is much practised in Europe. The best drills now in use, sufficiently cover the seeds for protection, but the sown grain must be thoroughly harrowed in, or (which is better) lightly ploughed in.

167. *What is said of the sowing and culture of spring wheat?*—Spring wheat requires a soil similar to that for winter wheat, but of a quick and kindly character, as the spring wheat has a much shorter time to mature. The ground should be fertile and well pulverized. It is said that the best crops are raised on land which has been ploughed in the autumn, and sown without additional ploughing in the spring—care being taken to harrow in thoroughly. Spring wheat should be sown as early as the condition of the land will allow, though, under favorable circumstances, good crops have been obtained from later sown spring wheat.

(NOTE.—I omit all reference to the insect and other enemies of both winter and spring wheat (especially the former), and the many methods which have been tried to destroy them, as also the application, in some instances, of the raker and harrow to the growing crops.)

168. *What is said of the harvesting of wheat?*—Wheat should be harvested before it gets dead ripe. The grain should be cut immediately after the lower part of the stalk becomes yellow, just after the grain has begun to harden, but while it is still so soft as to be easily crushed between the thumb and finger. Repeated experiments have shown that wheat cut then will yield more in measure and weight, and a larger quantity of sweet, white flour, If the wheat is not gathered at this time, it changes rapidly, especially in favorable weather: the grain and straw grow less valuable—a part of the starch of which the grain is composed becoming bran. Exposure to rains after cutting is also very injurious to wheat.

It makes both grain and straw darker in colour, and is apt to cause partial decay on the surface. The parts thus affected mix with the rest in grinding, and give the flour a darker hue. Early cut grain requires a longer time for drying or airing before being threshed or stored; but it should be stacked or housed as soon as possibly fit, after reaping, for the sake of both the straw and grain.

(NOTES.—1. Threshing, as well as reaping machines, are now extensively used by good farmers; a great improvement on the old methods of cutting and threshing grain—a great saving of manual labour, securing the earliest markets, when the price of grain is high, saving much expense and trouble of moving, storing, loss from shelling, vermin, &c. But the threshing machine should be a good one and properly manned; otherwise there will be great loss of grain and enormous waste of straw.

2. No farmer can afford to throw away his straw, or leave it to be trodden down by cattle running over it in the field, or blown and wasted by storms. In the winter season, the straw, if bright and clean, is valuable as a coarse fodder for young, or store stock, and as a bedding for any stock in stables, or sheds, where it may be conveniently worked into manure. No matter how rich the land, manure on some part of it will be wanted.

8. When the grain is stored in the straw, care should be taken to prevent it from heating or moulding. It should, therefore, be very dry before being carried into the barn or barrack. If stacked, it should be elevated above the ground; and if the stack is large, a sort of chimney should be left from the bottom, running through the centre to the top; which may be made by keeping a large bundle perpendicular at the surface in the centre, and drawn upwards as the stack rises, thus leaving an opening from the bottom to the roof. Sometimes additional security against heating and moulding is provided by similar openings horizontally at intervals. Mice and rats may be avoided by laying the foundation of the stack on posts or stones, covered at the top with projecting caps. Much may be said in favour of storing grain in the straw in barns or barracks, and threshing it out at leisure when the hurry of harvest is over.)

RYE.

169. *What is said respecting the sowing and harvesting of rye?*—1. The preparation of the soil for rye is similar to that for wheat; and rye occupies the same place in the rotation of crops on light soils that wheat does on heavy ones. Neither

strong clay nor calcareous lands are well suited to rye. A rich sandy loam is the natural soil for it, though it grows freely on light sands and gravels which refuse to produce either wheat, barley or oats. In point of fact, rye is usually sown upon the poorest soils of the farm, though loamy soils which are too rich for wheat, and on which it lodges, will frequently produce an excellent crop of rye, its stronger stem enabling it to sustain itself under its luxuriant growth. 2. The time for sowing rye is from the 20th of August to the 20th of September —the earliest sown requiring less seed, as it has a longer time to tiller or spread its roots, and fill up the ground. The quantity sown, varies from one to two bushels per acre, according to the quality of the soil, the richest soil demanding most seed. 3. The early cutting of rye, as of wheat, produces more weight, larger measure, and whiter flour; but what is intended for seed, must be allowed to ripen fully on the ground.

(NOTE.—Rye straw is solid, the internal part being filled with a pith; it is therefore so tough and coarse, that it is not relished by cattle unless artificially prepared. It is sometimes cut short and steamed, mixed with Indian or linseed meals, shorts or other fine feed, and contains in reality more nutriment than the straw of wheat, than which it is more valuable as litter, and still more so for *thatching* barracks, stacks of wheat, barley, oats, hay, &c.)

BARLEY.

170. *For what peculiarity is barley remarkable?* —As barley grows and ripens with wonderful rapidity, it is cultivated and comes to perfection in a greater variety of climates than any other of the cereal grains, and is therefore found over the widest extent of the habitable world. It bears the heat and drought of the tropical regions, and ripens in the short summers of those which verge on the frigid zone.

171. *How many kinds of barley are there?*— Barley, like wheat and rye, is both a winter and

spring grain, though in this country it is universally sown in the spring.

(NOTE.—There are several varieties of barley, as of wheat; but they are not noticed in these First Lessons.)

172. *What is said of the nature and preparation of the soil for barley and the time of sowing it?*—Barley requires a lighter soil than will grow good wheat, and a heavier soil than will grow tolerable rye; but a soil which, in all cases, should be well drained, well pulverized, and free from weeds, which are more injurious to it than to any other grain. Barley should follow a hoed crop, if possible, though it may be sown on a grass or clover field, turned over the preceding autumn. But barley should not follow other white grains; and it is more likely to be hurt by the trampling and feeding of sheep and other stock, than either wheat or rye, though rolling may be of service, when the plants are four or five inches high, if the ground is dry and loose. Barley should be sown as soon as the ground is sufficiently dry in the spring, at the rate of from two to three bushels per acre—poor and mellow soils, early sown, requiring the least. The seed may be simply harrowed in on stiff soils, or harrowed and rolled on light ones.

(NOTE.—The difference in the structure of the roots of the wheat and the barley plants, and the consequent difference required in the soil, or rather its condition, for each plant, is thus forcibly stated by R. O. PRINGLE (editor of the *Scottish Farmer*) and Professor MURRAY, of Edinburgh, in a recently published book on *The Culture of Farm Crops*: "The roots of the wheat have a remarkable tendency to push themselves deep into the soil as well as to ramify in all directions; those of the barley plants have the power given them of spreading laterally, and a development remarkable for its quickness. We see, then, the wheat plant distinguished by what we may call a verticality of root development and a slowness of growth, and the barley by a horizontality and quickness of growth. The roots of the wheat plant draw their assimilable food from the soil slowly, and from a great depth; those of the barley have to draw it quickly, and from the surface, and much more in a given time than the wheat roots. This quick abstraction of the

food from the soil by the barley plant is also aided by a peculiarity which distinguishes it, namely, the number of root fibres or 'hair-like processes,' by which the roots are supplied, and which Professor Lindlay calls, 'the mouths of the roots.' A quick drawer and a greedy drawer of the manurial matters contained in the soil, and that soil confined by the habits of growth of the plant, the inference is readily drawn, that the crop which precedes the barley crop should be that which leaves the soil in the condition best fitted for these habits, and rich in manurial constituents. These conditions indicate, therefore, a root crop as that which should precede the barley.")

173. *When should the barley be harvested?*—If barley is cut too soon, the grain will shrivel; but if cut late, the grain is injured, and there is a great waste of it by shelling. It should be harvested before the grain is fully ripe, as the early harvested grain is brighter than when left to full ripeness, and is of better quality.

(NOTE.—The author of the *New American Farm Book* says,—"We have seen the maltster make ten to twenty cents difference in the price of the same description of grain, solely from the time of cutting." The Rev. W. L. Rham, in his English *Dictionary of the Farm*, says,—"As soon as the ears of the barley begin to drop and lose their purple hue, acquiring a light straw colour, before the grain is quite hard, it should be reaped." Barley may be stacked like wheat.)

OATS.

174. *What is said of the climate and soils for the cultivation of oats?*—Oats are cultivated throughout a wide range of latitude and on a great variety of soils. Oats will grow on rich or poor, on dry or moist soils, on the heaviest clays or the lighest sands; but they do best in a damp climate (as in Scotland) and a moist soil, with a moderate summer temperature.

175. *How should the soil be prepared for oats?*—The authors of the *Culture of Farm Crops*, say,—"The oat plant, resembling in its habits of growth the wheat more than the barley plant, a good, deep, well stirred soil is necessary for it; the roots having more of the descending vertical development of the

wheat, than the lateral development of the barley plant. Further, although loving a moist climate and soil, a thoroughly wet one is prejudicial in a high degree to the oat; well drained, in addition to deeply stirred soil, is therefore essential, if indeed the one can be separated from the other."

176. *At what time should oats be sown, and in what quantity per acre?*—The *New American Farm Book* says:—"In this country oats are sown at the rate of two to four bushels per acre [according to the richness of the soil and the purpose of the sowing], during all the spring months, and sometimes, though rarely, in June. The earliest sown are usually the heaviest and most productive. The seed should be well harrowed in and rolled, and no other attention is required except to destroy the prominent weeds." The roller is especially useful on light lands, as the compression of the soil affected by it hastens the germination of the seed and causes it to spring up uniformly.

177. *When should oats be harvested?*—Oats should be cut before the straw has turned completely yellow. Oats sometimes ripen unevenly, and if a large proportion of such are backward, the proper time for cutting will be as soon as the latest may be rubbed out of the straw by hand. The oat is sufficiently matured for harvesting after it has passed the milk state, and is easily compressed between the thumb and finger. The lower part of the stalk will then have assumed a yellow colour, and it ceases to draw nutriment from the soil. If cut at this time, the straw is better for fodder and for other uses; the grain is fuller; the husk is lighter; and the loss from shelling, which is often a great item when left too late, is avoided.

(NOTE.—Oats may be stacked like wheat, but are far better housed in the barn.)

Indian Corn, or Maize.

178. *What is said of Indian corn as a cereal?*—Indian corn is an annual cereal plant of great importance to agriculture on the American continent. It does not ripen in Great Britain, on account of the dampness of the atmosphere and the want of the sun's heat. It seems to have been specially created for the Western Hemisphere; is grown in great luxuriance from the northern regions of Canada to the Straits of Magellan; it attains its highest perfection under the fierce blaze of a cloudless sun, and its most prolific area is between the 40th and 38th degrees of north and south latitude, excepting a limited portion of the equatorial regions. Much care is necessary in the colder regions of its growth, on account of the shortness of the seasons and the deficiency of sun for ripening it. In such localities the smaller and earlier kinds of corn should be planted on a warm soil, so as to mature before the frosts.

(Note.—Of the varieties and uses of table and field corn, it is not my purpose to speak, any more than of the varieties and uses of wheat, rye, barley and oats.)

179. *What kinds of soils are best suited for the growth of Indian corn?*—The soils adapted to the culture of Indian corn are such as are permeable to heat and the roots of the plant, and embrace those denominated sandy, gravelly, and loamy. Corn will not succeed on strong clay, wet, or poor lands. The roots grow to as great length as the stalks, and the soil must be loose to permit their free extension. Though corn adapts itself to a variety of soils, light and porous loams, a little sandy, are most likely, if well tilled, to yield large crops. Land can scarcely be too rich for corn, and the fresher and less fermented the manure applied to it is, unless on light, sandy soils, the better it will be for the crop. Corn is a very hearty feeder; it has a large amount of

stalk, leaves and grain to provide for in a few weeks, and its increase will be commensurate with the supply of food.

180. *How is the soil prepared for corn?*—It is said that the best preparation for a corn crop (except newly cleared land) is a clover or other grass lay, or sod, well covered with long manure, recently spread, neatly ploughed, and harrowed lengthwise of the furrow. A roller may precede the harrow with advantage. The time of performing these operations depends upon the texture of the soil and the quality of the sod. Stiff lands are ameliorated and broken down by fall ploughing: but where sand or gravel predominates, or the sod is light and tender, it is best performed in the spring, and as near to the time of planting as convenient. The harrow, at least, should immediately precede planting. All seeds do best when put into the fresh stirred mould.

(NOTE.—It may be remarked, that land should be prepared for corn much in the same way as for other crops, and the preparation must vary according to the crops for which the land has been used, and the state in which it is left; but in all cases, to raise corn profitably, the land must be in good condition—well manured at the time of planting, or by continued and judicious manuring previously. It is not worth while to raise poor crops of corn, or indeed poor crops of any kind. It requires almost as much labour of ploughing, hoeing and harvesting a crop of thirty as of sixty bushels or more per acre. In the culture of corn, as of many other crops, the one thing specially important is thorough and careful ploughing in the first place. There can be no successful cultivation of corn without it. The land having been fully prepared by ploughing, manuring and harrowing, the next step is, to plant the seed, which may be done by hand or by machine.)

181. *How should the seed corn be selected and prepared for planting?*—The best seed of the kind or variety desired should be selected; and this may, perhaps, be best done by the farmer before the corn is gathered in the field, where there is an opportunity for comparison, and the best formed ears may be marked, so that they may be distinguished at harvesting, and saved for seed the next year. To

steep the corn for twenty-four or forty-eight hours in a solution of saltpetre, is said to be of great utility, accelerating the growth of the plant, and protecting it against birds, squirrels and mice, and for a while against worms. But the most effectual protection of the seed against all these enemies, as also the best means of promoting its vigorous germination and growth, is said to be soaking it for twelve hours in *tar water*, with a few ounces of saltpetre dissolved in it, then rolling it, for a coating, in ground plaster, ashes or lime.

182. *At what time should the corn be planted?*—The old Indian rule was, "When the oak leaves grew to the size of a squirrel's foot, it was time to plant corn." The time for planting corn is usually within the first three weeks of May; but much depends on the season. It is best to defer planting until all apprehension of frost is removed.

183. *In what manner should corn be planted?*—Corn should be planted in hills (not in drills) from three to five feet apart, with from three to five stalks in each hill, according to the variety of corn, the quality of the soil, and the fancy of the farmer. The corn, whether planted by hand, or a corn planter, should be covered about an inch and a-half or two inches deep; but on moist or heavy soil, an inch is enough.

184. *What after-culture is recommended for the growth and maturity of the corn?*—The following directions are given by the most experienced and successful corn-producers:—1. Hilling or heaping the earth around the plants should always be avoided, except with very heavy soil, or such as is liable to an excess of moisture: in all other cases it should remain flat. 2. The first stirring of the ground, or hoeing, or dressing, should be done as soon as the plants show themselves, or are about two inches

high. This is most economically done by a light plough, or cultivator, or corn-harrow, adapted to the width of the rows, and which a farmer can make for himself, if necessary; and if the operation be frequent and thorough, there will be little use for the hoe: otherwise the work must be done with the hoe. 3. The second hoeing should be performed before, or as soon as the tassels appear, and may be preceded by the corn-harrow, a shallow furrow of the plough, or, what is better than either, by the cultivator. It may be found beneficial to run the harrow or cultivator a third, or even a fourth time, between the rows, to destroy the weeds and loosen the soil, particularly in a dry season.

(NOTES.—1. Weeds, besides choking the growth of grain, absorb much of the substance of the soil which should contribute to nourish and mature the plants. Great care should, therefore, be taken to keep the field entirely free from weeds.

2. Stirring the ground in dry weather is peculiarly beneficial to corn and all hoed crops. Some omit it from fear of the escape of moisture, but the effect is precisely the reverse, as has been shown in the Lesson on sub-soiling and draining, pp. 108, 109. The loosening of the soil, and its consequent unevenness and porosity, facilitates the admission and escape of heat, and secures the deposit of large quantities of moisture, even in the driest and most sultry weather. Corn and other crops, which were withering from excessive drought, are said to have been at once rescued from its effects by a thorough use of the plough and the cultivator.

3. But care should be taken not to break or injure the roots of the corn; the plough should not therefore be introduced between the rows after the first hoeing. The horse-hoe will stir the ground as deeply as it is safe to go. Three hoeings are thought by some to be requisite for corn; but, in general, the oftener it is hoed the better.)

HARVESTING OF CORN.

(NOTE.—Perhaps more mistakes are made, and more loss sustained in harvesting corn, than even in harvesting wheat or any other grain. I hope that what follows may prevent the recurrence of some of these mistakes and losses.)

185. *What is said of the harvesting of corn?*—There are three methods of harvesting corn: [1] Cutting the stalks at the surface of the ground when the grain has become glazed or hard at the

outside, putting them immediately into stacks; and when sufficiently dried, separating and securing both stalks and corn. (This, as will be shown, is by far the best method.) (2) Cutting and stacking the tops of the stalks when the corn has become glazed, and leaving the ears on the butts of the stalks until October or November. (3) Leaving both corn and stalks standing until the grain has fully ripened, and the stalks become dry, and then securing both.

(NOTE.—The wasteful and slovenly mode of leaving the butts or entire stalks in the field after the grain is gathered, does not merit notice, except to be reprobated.)

186. *What objection is there to the third of these methods?*—It is attended with as much labour as the first method; it greatly deteriorates the quality of the stalks as fodder, and often injures the grain by exposure.

187. *What objection is there to the second method?*—Cutting off the tops of the stalks and leaving the butts, and then afterwards gathering the corn, increases the labour, impairs the value of the forage, and diminishes the quantity of the grain. The late JUDGE BUEL, of Rochester—one of the most distinguished farmers in the state of New York—states, in his book entitled *The Farmers' Instructor*, that he "tried the experiment in harvesting several rows of corn, each consisting of 92 hills, cutting the tops of the stalks in every other hill, and leaving those of the other hill uncut. The result was that the number of ears were equal, but the size of the grains and *weight* of corn were different. The forty-six hills from which the tops of the stalks had been cut, gave forty-eight and a half pounds of ears; and the forty-six hills on which the stalks had not been cut, gave sixty-two pounds of ears; making a difference of 12 bushels 5½ pounds per acre. A serious loss of grain, therefore, results from the

not unfrequent practice of cutting the tops of the stalks before harvesting the corn. The *New American Farm Book* thus gives the scientific reason of this loss, and the superiority of the *first* of the above mentioned methods of harvesting corn: "The stalks of corn should never be cut above the ear, but always near the ground, and for this obvious reason: The sap which nourishes the grain is drawn from the earth, and passing through the stem, enters the leaf, where a change is effected analogous to what takes place in the blood when brought to the lungs of the animal system; with this peculiar difference, however, that while the blood gives out carbon and absorbs oxygen, plants, under the influence of light and heat, give out oxygen and absorb carbon. This change prepares the sap for condensation and conversion into the grain. But the leaves which thus digest the food for the grain are above it, and it is while *passing downward* that the change of the sap into grain principally takes place. If the stalk be cut above the ear, nourishment is at an end. It may then become firm and dry, but it is not increased in quantity while, *if cut near the root, it not only appropriates the sap already in the plant, but it also absorbs additional matter from the atmosphere, which contributes to its weight and perfection.* It must be perfectly dried in the field, and after this husked and carried into an airy loft or stored in latticed or open barracks [or cribs]. The stalks may be housed or carefully stacked for fodder. When fodder is high, the stalks and leaves will repay the expense of cultivation."

(NOTE.—The experienced authors of the same book remark, that "If there be no danger of early frost, the corn may be suffered to stand until fully ripe; though if the stalks are designed for fodder, they are better to be cut when the grain is well glazed, and this should be done in all cases when frost is expected. *Scarcely any injury occurs either to leaf or grain if the corn is stacked, when both would be seriously damaged from the same exposure if standing.*")

188. *What other reasons are given for adopting the first of the three methods mentioned above for harvesting corn?*—In addition to the reasons just stated, Judge Buel, in his *Farmer's Instructor*, remarks, that "by this method the crop may be secured before the autumnal rains; the value of the fodder is increased; and the ground is cleared for a winter crop of wheat or rye."

(Notes.—1. The authors of the New England *Manual of Agriculture* observe, on this subject, that "The best and most enlightened practice appears to be to cut the whole plant from the ground after the stalk has slightly turned and begun to ripen, and stook it or set it in a cluster of bundles bound together at the top, so as to shed the rain, where it will soon ripen up, when the ears may be taken off as it stands on the field or the whole may be removed to the barn to be husked."

2.—Although in Europe the word *corn* signifies breadstuffs generally, and is therefore synonymous with wheat, barley, and other small grains; yet in America the term used alone applies exclusively to Indian corn or maize. The word *corn* has been held by courts in the United States to be the established name for Indian corn. It is thus used in Canada; and I have thus used it in this Lesson.)

Buckwheat.

189. *What soils are best for buckwheat?*—Buckwheat succeeds best on light soils, but will do well on almost any soil, except heavy clay. But it yields a remunerating crop only on fertile soils. Fresh manure is injurious to it. Sandy loams are its favourite soils, especially those which have been long in pasture; and these should be well ploughed and harrowed. The usual and only necessary preparation for sowing buckwheat is to plough the land once and harrow it lightly.

(Note.—Buckwheat is frequently sown to plough in green as a manure, in preparing for some other crop. For this purpose it is said to be less valuable than clover, or a suitable mixture of plants; but if ploughed in when in blossom, it is beneficial in all soils which contain but little organic or vegetable matter.)

190. *When is buckwheat sown, and what quantity of seed per acre?*—It is sown in June or July; if

sown late, it may be injured by the early frosts, which are fatal to it. But good crops of buckwheat have sometimes been obtained from seed sown after a crop of barley has been taken from the land; and some have sown it in August, with winter wheat. About three pecks of seed per acre, sown broadcast, are enough, though some farmers sow a bushel.

191. *What is said of cutting and harvesting buckwheat?*—It is cut when the earliest seed is fully ripe. It is then raked and gathered into small bundles, which are fastened by twisting the tops, and allowed to stand and dry on the field; and as soon as dry, it should be taken and threshed out.

(NOTE.—If not perfectly dry, the straw may be stacked with layers of other straw, and when well cured it is good fodder for cattle. It is said that sheep and young horses will feed and thrive as well on this straw as on ordinary hay.)

LESSON XXXI.

LEGUMINOUS CROPS—BEANS AND PEAS.

(NOTE.—Having treated of the crops yielding breadstuffs—wheat, rye, barley, oats, corn and buckwheat—I now propose to notice briefly leguminous crops. It has been shown in Lesson xxix., p. 117, that *legumen* or *legume* signifies *pod*, and that leguminous plants are strictly plants whose seeds grow in pods, though the term is sometimes used to include root plants. This lesson will be confined to beans and peas.)

192. *What soils are proper for beans?*—The authors of the Edinburgh work on the *Culture of Farm Crops* say, "The soil best suited for the bean crop, is a strong rather than a moist one, firm in texture, yet so as to enable the plants to send their roots deep into the soil. Lime is an essential element of it." The American *Farmer's Dictionary* says, "All the varieties of bean thrive best on strong clay soils, heavy marls, and deep loams of a moist description." The *New American Farm Book* says, "The bean is partial to a quick, dry

soil; too great strength or fresh manuring giving a large quantity of vine without a corresponding quantity of fruit." The New England *Manual of Agriculture* says: "Beans grow well on a variety of soils, from very light sand to a strong loam; but sandy and gravelly soils are better for them than strong and tenacious clays. On light soils the plant not only ripens early, but is cleaner and freer from earth, which frequently adheres to the plant in large quantities during rains, especially at the period of ripening."

193. *How should the soil be prepared for beans?*—The soil should be well ploughed and harrowed, or dug, so as to be well mellowed or finely pulverized; if at all inclined to be wet, it should be ridged.

194. *How should beans be planted?*—They are usually planted in hills about two feet apart, and also in drills covered two inches deep with fine earth. When planted in hills, from four to six plants should be left in each hill, according to their proximity; or if in drills, about six beans may be planted to the foot. Low or bush beans are the only beans adapted to the field, while pole beans are more frequently planted in the garden.

195. *When should beans be planted?*—The time for planting beans varies a little, according to the nature of the soil and the forwardness of the season. Beans are tender plants, and will not bear the slightest frost; and, as they grow rapidly, they will be sure to ripen when frost is no longer apprehended. The seed is liable to rot if put into the ground in a cold, wet time; and the land should, therefore, be previously well warmed with the sun. Beans are planted from the middle of May to the middle of June; generally the best time is about the first of June. The early ripening of field beans is important, when other crops are to succeed during the same season.

196. *What is said of the culture of beans after planting?*—Beans, as well as other plants, should be kept free from weeds, and should be hoed the first time as soon as the plants have formed their full sized leaves, the space between the hills having been previously cleared of weeds if necessary.

197. *When and how should beans be harvested?*—Beans should be harvested when the leaves shrivel and the pods turn yellow. If the ground is not wanted for other purposes, they may stand until the latest pods assume a yellow colour. The crop should be harvested by pulling up the plants (by hand or with an iron hand-rake), or mowed, if the stalks are partially green. The vines, if not dry, should remain for a while in small heaps, and afterwards be collected in larger piles around stakes at convenient distances, with the roots in the centre, and secured at the top with a wisp of straw; and when well dried, they should be taken to the barn and threshed out.

(NOTE.—The straw is good fodder for sheep, and should be stacked for their use. Beans are said to be one of the best kinds of winter food for sheep, when fed in small quantities. Beans are used either green or dry for the table, and are a palatable and highly condensed food, In proportion to their weight, beans give more nutriment than any of the ordinary vegetables, yielding 84 per cent., while wheat yields 74, and potatoes only 25 per cent. of nutriment.)

PEAS.

198. *What soil is best adapted to peas?*—The soil best adapted to peas is a stiff loam, though heavy clays will bear good peas; but a calcareous or wheat soil is better. In general the pea may be successfully cultivated on any soil which can be deeply tilled and richly manured, except the stiffest clays and light sands.

199. *How is the soil prepared for peas, and when are they to be sown?*—Peas should have a clean fal-

low, or fresh rich soil, well harrowed. They are not affected by frosts, and may be sown as soon as the ground is dry. This will enable them to ripen in season to plough for wheat. Peas are sometimes sown in drills, but usually broadcast, at the rate of two or three bushels per acre. Some recommend their being covered about an inch and a-half deep; others say it is best to plough them in to the depth of three inches, and afterwards roll the ground smooth to facilitate gathering.

200. *How are peas harvested?*—Peas are harvested by being pulled up by hand, or by cutting with a scythe, or, what is more expeditious, (when fully ripe, so that the roots are easily pulled out) pulled with a horse rake. When thus gathered into heaps and well dried, they may be threshed out, and the straw carefully stacked for sheep fodder. If the straw is secured in good condition, cattle and sheep will do well upon it.

(NOTES.—1. Peas may follow any farm crop in rotation, but should never be raised year after year on the same land. Many sow peas broadcast with oats, and harrow them in, and in this way often obtain good crops, which, when thus grown, are fed unground to sheep and sometimes to horses, or made into meal for swine.

2. Peas must have abundant moisture while in blossom, or their yield will be small. It has been said that strong lands produce the best crops of peas, but the manures should be previously applied, as fresh manures increase the growth of straw, and sometimes diminish the quantity and quality of the peas.

3. I do not notice the varieties of garden and field peas. Many varieties are found in the garden and the market, each of which is marked by some peculiarity, as time of ripening, size, taste, &c.)

LESSON XXXII.

ROOTS AND ESCULENT PLANTS—POTATOES, TURNIPS, CARROTS, PARSNIPS, BEETS.

201. *What soils are best for potatoes?*—Potatoes do best on a loose, mellow, virgin soil, or one newly cleared, and the liability to rot is less in such soils than in a heavy, retentive one, or on peat land which, before the rot appeared, often produced large crops. A strong, deep, warm loam with a porous subsoil is especially fitted for this crop. A calcareous soil yields a good potatoe, and generally a sure crop, and when there is little lime in the soil it should be added. Salt, ashes and gypsum are excellent manures, but fresh manures will often unpleasantly affect the taste of the potatoe, and when of necessity applied, it should be scattered broadcast and ploughed in. Very few plants require so little preparation of the land as the potatoe.

(NOTE.—I do not speak of the many varieties of potatoes; but the chief practical distinction is known by the terms *early* and *late*.)

202. *What is said of cutting potatoes for planting?*—The potatoe may be cut into pieces before planting, each piece containing one or more eyes or germs, and a certain proportion of the body of the potatoe, in order to furnish nourishment to the germ in the first stages of its growth. The largest potatoes are said to grow from eyes taken from that part of the tuber nearest the stalk.

203. *How should potatoes be planted?*—Hills are the most convenient for tillage, as they admit of more thorough stirring of the ground with a cultivator or plough. Six or seven eyes should be placed in each hill; or if in drills, the pieces should be planted ten inches apart. The distance both of hills and drills must depend on the strength of the soil and the size of the tops, some varieties growing

much larger tops than others. Cover with light mould to the depth of four inches; and if the soil be light, leave the ground perfectly level; if cold or moist, let the hill or drill be raised when finished. Sub-soil ploughing is a great help to potatoes.

204. *What after-culture is necessary?*—There should be two careful hoeings, besides frequent weeding. Where the land is free from stumps and roots, a plough may be run through them when the plants first appear above the ground, and the earth may be thrown over them to the depth of two or three inches without injury to the tops. In such case the hoe is scarcely required, except to destroy such weeds as may have escaped the plough. The ground should be stirred several times before the tops interfere with the operation, but never after they come into blossom.

205. *When and how should the potatoe crop be harvested?*—Harvesting should not be commenced until the tops are mostly dead, as the tuber or potatoe has not arrived at full maturity before this time. They may then be thrown out of the hills by a plough, horse potatoe-digger, or some hand implement. They ought not to be exposed to the sun for any length of time, but may dry on the surface on a cloudy day, or be gathered into small heaps with tops spread over them, until freed from the surface moisture, when they may be stored by being buried in the field, or put in the cellar. In either case, they must be kept perfectly dry, and effectually protected from the frost and rain until wanted in the spring.

The Turnip.

206. *What are the best soils for turnips?*—Any soil adapted to Indian corn will produce good turnips; such as a fertile sand or light loam, loose and open, thoroughly ploughed and pulverized. Few

crops require so much preparation of the land as turnips. But it is only on new land or freshly turned sod, that they are most succsesful. An untilled virgin earth, with a rich dressing of ashes after the recent burning of brush and other vegetable matter, and free from weeds and insects, is the surest and most productive soil for a turnip crop. Such land needs no manure For a sward or grass land, there should be a heavy dressing of unfermented manure, before ploughing.

(NOTES.—1. The varieties of turnip are numerous. The common flat English turnip, and the Ruta-Baga or Swedes Turnip are most cultivated. The land designed for the Swede or Ruta-Baga should be deeply ploughed the preceding autumn—the deeper the better. Two thorough ploughings should also be given in the spring, followed by a careful harrowing, so as to mellow and completely break up and pulverize the soil. The flat turnip requires less depth of cultivation.

2. Experience has shown that it is very advantageous to raise alternately a deep or tap-rooted crop like the turnip, carrot or parsnip, and a surface rooted one like wheat, rye, barley or oats.)

207. *What is the time and manner of sowing or planting turnips?*—The common round or flat turnips are sown from the middle of June to the first of August; the earliest sowing giving a greater yield, the later sown generally a rounder root and capable of longer preservation. The seed may be sown broadcast at the rate of one or two pounds per acre, slightly harrowed and rolled; or, which is better, sown in drills, when a less quantity of seed will suffice. A *turnip-drill* will speedily accomplish the furrowing, sowing, covering, and rolling, at a single operation. The ruta-baga is generally sown in drills, about two feet apart, and on heavy lands, which should be slightly ridged. The plants should be necessarily thinned to prevent interfering with such as are intended to mature; and a deficiency may be supplied by transplanting during showery weather. They should be left eight to twelve inchess apart in drills, according to the rich-

ness of the soil. The ruta-baga or Swedes turnip is a gross feeder, and requires either a rich soil or heavy manuring. Bones ground and drilled in with the seed, or a dressing of lime, ashes, gypsum or salt, is the best application that can be made. The Swedes turnip should be sown from the middle of May to the middle of June, earlier than the English turnip, as it takes longer to mature; and two or three weeks more of growth frequently adds largely to the product. An early sowing also gives time to raise another crop in case of failure of the first.

208. *What is the after-culture?*—The horse-hoe may be used between the drills when the first rough leaves appear. This should be followed by the hand-hoe to clear out the weeds, and stir the soil around the plants. Subsequent hoeings will be necessary to prevent the growth of weeds.

209. *When and how should turnips be harvested?*—Turnips may remain in the ground without injury until hard frosts begin, when they may be taken up most expeditiously with a root-hook, which is made with two iron prongs attached to a hoe-handle. The use of a bill-hook or sharp knife will enable the operator to lop off the leaves with a single blow, when they are thrown into convenient piles, and afterwards collected for storage. The storing of turnips may be in cellars or in heaps, similar to potatoes, but in a cooler temperature, as slight heat injures them, while frost does not. If stored in heaps, one or more holes should be left at the top, which may be partially stopped by a wisp of straw or hay, to allow the escape of the gases which are generated.

NOTE.—Though turnips have been cultivated from the earliest times in both the garden and field as a culinary root, and highly prized for the table, their true value is as food for store and fattening cattle, milk cows, and sheep, as they furnish a salutary change from dry hay, being nearly equivalent as a fodder to

green summer food. With an abundance of turnips, and a small supply of straw, hay may be entirely dispensed with for cattle and sheep.)

Carrots.

210. *What is said of carrots and their uses?*—The carrot is one of our most noticeable roots. No root is more relished by domestic animals. Horses are especially fond of it, and when not kept at hard work, should have it as part of their food. It keeps up their condition, and gives them a fine, glossy coat; but weight for weight carrots are somewhat less nutritive than the potatoe. They are good for working cattle and unsurpassed for milch cows, producing a great flow of milk and a rich yellow cream. Sheep and swine greedily devour them, and soon fatten if plentifully supplied with them.

211. *What is said of the soils best for carrots, and their planting?*—The soil which best suits carrots is a fertile sand or light loam, but they will grow on soils that are more tenacious, if well drained and deeply worked. Deep ploughing and subsoiling are especially important in the cultivation of this crop. The size and weight of the root depend very much on deep tillage. The seed should be new and fresh, and should be sown (about two or three pounds to the acre) in drills, sixteen to twenty inches apart, as soon as the ground becomes warm in the spring. The plant is said to do better if planted while the ground is quite moist, since it is very slow in its early growth. The covering of the seed should be slight, not more than half an inch in depth; any deficiency of plants may be supplied by transplanting in moist weather.

212. *What after-culture is required?*—Entire cleanliness from weeds is the chief culture necessary to insure a crop. For this purpose, as soon as the plants are well up so as to be distinctly seen, they should be hoed and weeded. It is much easier to

keep the weeds down at the outset than to get them out after they have overrun the crop. The number of hoeings will depend much upon the character of the soil and the previous culture.

213. *When and how should carrots be harvested?*—Carrots may be allowed to stand till the end of October or the early part of November without injury from frost. The harvesting of them may be facilitated by running a plough on one side of the rows, when the roots are easily removed by hand. The tops are then cut off, and the surface moisture from the roots dried, when they may be stored like turnips and potatoes—the tops being fed to stock. Carrots ought to be kept at as low a temperature as possible above the freezing point. On the approach of warm weather, they will sprout early if left in heaps; and if it be desired to preserve them longer for use, the crown should be cut off and the roots spread in a cool, dry place.

The Parsnip.

214. *What soils are suited to parsnips?*—The soil may be heavier for parsnips than for carrots, and they will even thrive on a strong clay, if rich, dry and well pulverized. Large crops can only be obtained on deep, rich ground, well pulverized. Parsnips will grow well wherever carrots will, and in some parts of France carrots and parsnips are cultivated together.

215. *When and how should parsnips be sown?*—Parsnips should be sown early in the spring, as frosts do not affect them, and they require a long time to come to maturity. Drilling at a distance of twenty inches apart, is a proper mode of planting, and they should be thinned to a space of six or eight inches between the plants in the drill. The seed should be of the previous year's growth, as

older seed does not vegetate. It requires about four or five pounds of seed per acre.

216. *What is said of the after-cultivation?*—The subsequent cultivation is similar to that of carrots; but parsnips will yield more than carrots under similar circumstances of soil and tillage, are rather more nutritious, and less liable to be injured by diseases or insects.

217. *When and how are parsnips harvested?*—They may be allowed to remain in the ground all winter and dug up in the spring, unless wanted for winter's use, as they keep best in the ground, where they are uninjured by the severest frost. But particular care should be taken to allow no standing water on them, or they will rot. If taken up in the autumn, the roots should be neither trimmed nor broken, nor should the tops be cut too near the root. They should be stored out of doors, in a dry place, and covered carefully with earth, so that they can thoroughly freeze, as exposure to air, or even moderate heat, wilts them.

(NOTES.—1. There are two varieties of the parsnip, the one round or garden parsnip, the other the long field or Jersey parsnip. The best variety for field culture is the large Jersey.

2. The parsnip is one of our most delicious table vegetables; it is an excellent food also, either raw or cooked, for cattle, milk cows, and sheep, and for swine. QUALEY says, "it is not so valuable for horses, for though it produces fat and a fine appearance, it causes them to sweat profusely, and if eaten when the shoot starts in the spring, it produces inflammation of the eyes, and epiphora, or weeping." The leaves of both carrots and parsnips, green or dried, are good for cattle.)

THE BEET.

218. *What is said of the Beet?*—There are many varieties of the beet, but only two varieties in general use for the field; the sugar beet and the mangel-wurzel, both of which have several sub-varieties. They are of various colors, red, pink, yellow, white, or mottled; but color does not seem

to affect their quality, and they all grow under similar conditions.

219. *What soils are best, and how are they prepared for beets?*—Beets do well in any soil of sufficient depth and fertility, though they are perhaps most partial to strong loam; but large crops have been produced on a tenacious clay when well tilled. It is said that a crop at the rate of eight hundred bushels to the acre has been raised on a stiff clay which had been well supplied with unfermented manure. The soil cannot be made too rich. To prepare the land for the beet, it should be deeply ploughed, manured with fresh and unfermented manures, and harrowed.

220. *How is the seed sown?*—The seed should be early planted, or as soon as vegetation will proceed rapidly, but should first be soaked by pouring soft scalding water on it, allowing it to cool to blood heat, and remain for three or four days, then be rolled in plaster and drilled in. The husk, or outer covering of the seed, is thick and impervious to moisture, and without a thorough previous saturation, the seed will not readily germinate. The planting should be in drills, twenty inches to two feet apart, at the rate of four to six pounds of seed per acre, buried not over one inch deep. The distance between the plants in the drill should be from eight to twelve inches. The mangel-wurzel attains a larger size than the sugar beet, and the spaces between the plants should not be less than a foot.

221. *What is said of the after-culture?*—The after-culture, as well as the preparation of the soil, is similar to that of carrots and parsnips.

222. *When and how should beets be harvested?*—The harvesting of the beets should be commenced soon after the first leaves turn yellow, and before

the frosts have injured them. The tops must not be too closely trimmed, nor the crown of the roots or its fibrous prongs cut from such as are intended for late keeping. If the root (especially the mangel-wurzel) is bruised or injured, it is liable to decay, and care should be taken to guard against the possibility of this. When well stored in a cool cellar, or, like other roots, in pits dug for the purpose, it will keep through the winter.

(NOTE.—The beet is a universal favorite for the table, and of great value for stock. Domestic animals never tire of it, and swine prefer the beet to any other root, except the parsnip. It is said that swine have often been kept in the best condition through the winter, on no other food than the raw sugar beet, which possesses the additional merit of resisting decay longer than the turnip, and frequently beyond the carrot and parsnip. When fed to fattening animals, the beet should *follow*, never precede, the turnip. It has been found that such animals continue steadily to advance in flesh after having been carried to a certain point with turnips, if shifted to the beet; but in repeated instances they have fallen back if changed from beets to turnips.

REMARKS ON THE CULTURE OF CABBAGES AND ARTICHOKES.—The *Cabbage* is sometimes cultivated as field crop, but is mostly confined to the home or market garden. It requires high cultivation, and succeeds best in a rich clayey soil. The seed is usually sown in beds, to be transplanted into hills, where it is hoed and cultivated like other garden vegetables. The *Jerusalem Artichoke* is nearly as nutritious as the potatoe, is used for common food, and its stalks are nearly as valuable as its tubers; but it is not much, if at all, cultivated as a field crop in this country. It is said to grow well on light sands and tenacious clays, where no other crop would succeed. Its cultivation is much like that of the potatoe, the land being prepared and manured in the same way. It is very productive, and easily cultivated in drills, three or four feet apart. In countries where this plant is cultivated as a field crop, the stalks are either cut and fed out green, or left to be cut with the sickle, and stooked and dried for winter fodder. After the stalks are cut and removed, the tubers or bulbs are taken up as they are wanted to feed out, or dug late in the autumn and stored, like potatoes, for winter use. Most kinds of farm stock are fond both of the stalks and the roots.)

LESSON XXXIII.

GRASSES—MEADOWS—PASTURES—MOWINGS.

223. *How are grasses classified?*—Grasses, for convenience, are classed under two general divisions, the *natural* and the *artificial.*

224. *What are the natural grasses?*—The natural grasses include all true grasses or plants with cylindrical, hollow stems, solid joints, and alternate leaves originating at each joint, surrounding the stem at their base, and forming a sheath upwards of greater or less extent, and the flowers and seeds protected with a firm straw-like covering—the chaff of grain and grass seeds. *Timothy* is the most valued and the most cultivated of the natural grasses, which abound in marshes, woods, and prairie lands, and on which innumerable wild animals and many domestic animals subsist and fatten.

225. *What are artificial grasses?*—The artificial grasses are most leguminous plants, which are cultivated and used like grasses. The clovers, lucerne, &c., are included among the artificial grasses.

(NOTES.—1. Among the grasses said to be most profitable for mowing, are timothy, red-top, white bent, orchard grass, perennial rye grass, June grass, rough stalked meadow grass, fowl meadow grass, meadow fescue, and tall fescue. The artificial grasses comprise red, white, and other clovers, and some others not cultivated in this country. It is said that the grasses cultivated in England for the use of animals comprehend not less than two hundred varieties; but in America, there are not more than twenty.

2. The subject of grasses, pastures, grass and pasture lands, is too extensive to be treated in these First Lessons. A few practical remarks only will be made.

3. Lands laid down with natural grasses are designed as more permanent mowings than those sown with artificial ones alone. They are sown with a number of the true grasses, most of which are perennial, and are to be used as mowing lands or for pasturage. The artificial grasses are more frequently intended to occupy the ground for one or two years only, in rotation with other crops, and are usually composed of only one or two species, and those annuals or biennials. It is not uncommon to sow with the natural grasses one or more species of clover, which occupies the ground almost

exclusively one or two years, and then gives place to the perennial grasses which form a permanent turf; and this, when left uncut and fed off by animals, makes what is called pasture or pasturage.

4. Certain situations and lands, if improved at all, must be occupied as permanent meadows or pasturage; such as steep hill sides, where the rains would wash the soil into the valleys below, if broken by the spade or plough; bottom lands on the margins of streams liable to periodical overflows, endangering crops; low marshy lands, which cannot be drained; and some heavy, tenacious clay lands, requiring too much labour to be cultivated with profit; but, next to self-sustaining bottom lands, are profitable for various grasses.

5. There are great differences between the different kinds and species of grasses, some requiring different kinds of soil, abstracting different substances from the soil, and some exhausting it more than others—some longer lived, maturing earlier, and containing more nutriment, than others.)

227. *When should grass seed be sown?*—The best time for sowing the natural grasses is in the early autumn, so that they become aided by the fall rains, strongly rooted before the approach of winter. If clover is to be sown on land laid down to grass in September, the seed may be strewn on the last light snows of the March following, and they will vegetate without any covering.

(Notes.—1. The practice of sowing the natural grasses in the spring with oats or other grain, does not prevail now as formerly, though some still think that grass seeds do best when sown early in the spring on a fine mellow soil.

2. In the Lesson on the *Rotation of Crops*, I have stated the manner of preparing the soil for grasses as well as for grains, root and other plants.)

228. *What is said of mixing different species of grasses together?*—A greater weight of grass and hay can be obtained from an acre by using several judiciously selected species, than if one or two are used; since different species require different kinds of nutriment and the number of one species which will grow to vigorous maturity on a square foot of soil, will not be diminished by the growth on the same soil of plants of different species requiring different substances to support them. But in selecting the mixture for *mowing* or for *pasturage*, regard

should be had to the modes of growth and other peculiarities of each kind. Some grasses are well adapted to cut for hay, but are not so suitable to form pasture-turf. Timothy is not so good to sow for pasturage, as it cannot bear the close cropping of cattle, though one of the best of our grasses for mowing.

229. *What are some of the best grasses for mowing?*—Among the grasses most profitably cultivated for mowing, are Timothy, red top, white bent, orchard grass, perennial, rye grass, June grass, rough stalked meadow grass, fowl meadow grass, meadow fescue, tall fescue and some others adapted to certain localities and to particular purposes.

230. *What grasses are best adapted for pasturage?*—Among the species best suited to form pasturage, are meadow foxtail, orchard grass, sweet scented vernal, June grass, red top, meadow fescue and yellow oat grass.

(NOTES.—When seeds of different grasses are mixed for *mowing land*, such kinds should be selected as will come into flower about the same time; otherwise, one species will have begun to spoil before another is ready for cutting. But in laying down *pasture land*, we wish a constant succession of green and succulent herbage from early spring to late autumn, and therefore mix seeds that will come into flower at different times during the season.

2. What Timothy is among the natural, *red clover* is among the artificial grasses—the most valuable and economical of forage plants. The long tap-roots of clover loosen the soil and let in the air, while by their chemical action they fix grasses which greatly enrich the earth. The decay of them in the ground fertilizes it, and the plant shades and protects the surface, and helps to destroy many annual weeds. Clover is what is called a lime plant, and the soils best adapted to it are clayey or tenacious loams. It generally does well on good wheat lands. White or Dutch clover is as common as the red, and often forms the turf of pastures of a moist and tenacious soil. It is commonly cultivated for pasturage, and many think it is as valuable for that purpose as is red clover for hay; but cattle are not so fond of it.)

HAY HARVEST.

231. *When should hay* (that is, Timothy and the other natural grasses) *be cut?*—The time for mowing

depends upon the purpose the farmer has in view in cutting his hay; whether it is to feed milch cows, or horses, or working oxen, or young stock. If the hay is to be fed to cows in milk, and the farmer wishes to get the largest *quantity* of milk, the grass should be cut just before coming into blossom. If the object is to secure the best *quality* of milk, it must be cut in blossom, when it should also be cut for feeding store cattle. For horses at work, and for fattening cattle, it is better to cut the grass just after it has passed out of blossom, or when the seed is said to be in the milk.

232. *Why should grasses be cut before the seed is fully ripe?*—Because grasses attain their full development at the time of flowering, and then contain the largest quantity of soluble materials, such as starch, gum and sugar; these, with the nitrogenus compounds, which are also most abundant at this time, are of the highest value in supplying nutriment to animals. After flowering, and as the seed forms and ripens, the starch, sugar, &c., are gradually changed into woody fibre, which is nearly insoluble and innutritious. There is, indeed, a good deal of nourishment in the seed; but not enough to make up the loss in the stalk and leaves, if the mowing is put off till the seed is ripe. Grass fully ripe is needful for seed, but will make hay little better than straw.

233. *How should grass be cured after cutting?*—Grass should be cured as rapidly as possible, and with the least exposure, as it loses in nutriment when cured more slowly and with longer exposure to the sun. If dried too much, it contains more useless fibre and less nutriment. The more succulent and juicy the hay, the more it is relished by cattle. After being cut, the grass should be frequently spread and turned, so as to dry as soon and as uniformly as possible. This may be done by hand

with a common fork, or much more speedily and effectually by a machine called a hay-tedder or spreader. When the grass is partially or wholly cured, it may be raked by hand, or by a horse-rake, one man and a horse doing as much with a horse-rake as ten men can do without it.

(NOTE.—After the grass has been cut *at the proper time*, the true art of hay-making consists in curing it just enough, and no more, to make it fit for storing away. It is as great a mistake to dry grass too much, as to let it stand too long before cutting. When shook or stirred out, it should not remain in this condition beyond the first day, as it will lose much of its nutritive juices; nor should the dew or rain be permitted to fall upon it unless in cocks. It is better, after partially drying, to expose it two or three days in the cock. Hay should go into the barn or stack, not crisp and dry, but slightly soft and moist in its own juices. But if unfortunately rained upon, it must be thoroughly dried before going into the barn or stack. If there is reason to fear its heating in the mow or stack, four quarts of salt to the ton may be sprinkled upon it.)

CLOVER.

234. *When should clover be cut, and how cured?*—Clover should be cut after having fully blossomed and assumed a brownish hue, but before the seed is formed. It should be cured in such a manner as to lose as little as possible of its foliage, and therefore it cannot be treated exactly as are the natural grasses. The swath, unless very heavy, ought never to be stirred open, but ought to be allowed to wilt on the top. It may then be carefully turned over, and when thus partially cured, put in high slender cocks and allowed to remain till sufficiently dry to remove into the barn—perhaps three or four days; and if the weather is fair and warm, it may be opened and aired an hour or two before being carted into the barn. The clover may be housed in a much greener state by spreading evenly over it in the mow from ten to twenty quarts of salt per ton. Clover cured in this way, without loss of its foliage, is better for milch cows, calves and sheep, than any other hay. For other farm stock it is worth about two-thirds or

three-fourths as much as the best hay; but it is more productive and is grown at less expense per acre.

LESSON XXXIV.

FRUITS.

235. *What is said of the culture of fruit?*—There are no articles of cultivation on the farm so refining in their influence upon the household as fruits. They are profitable for market purposes, and often useful for stock; they afford some of the choicest and most economical luxuries for domestic use; they are sources of health as food, of luxury in their flavour and variety, of economy in household consumption, of pleasure in their production, and of boundless interest in their study and propagation. The first care of of a farmer, in founding a farm for a home, after providing for his household necessities, should be the planting of various fruits, according to the nature of his soils and the necessities of his family. Aside from their important domestic uses and profit as market crops, they adorn and beautify the farmer's home with an expression ot comfort, often of wealth, abundance and hospitality, to say nothing of the good taste they indicate in the proprietor, while they add largely to the actual value of the premises, either for occupation or for sale, if by any train of circumstances a sale becomes necessary.

236. *What are the principal fruits which the farmer should or may cultivate in this country?*—Among the many fruits which may be, and are cultivated in all or in some parts of this country, are the apple, the plum, the pear, the quince, the peach, the cherry, the currant, the gooseberry, the raspberry, the blackberry, the strawberry, the grape,

not to mention various other essential productions of the garden.

(NOTE.—To notice the varieties of each of these kinds of fruit, the soils adapted to their growth, and the modes of their culture, appertains to the accomplishments, rather than first lessons of agriculture, and would exceed the limits and purposes of this little book. I mention the subject, and enumerate the principal fruits proper for cultivation, in order to direct the attention of farmers to a branch of agriculture too much neglected; and I recommend those who wish to give practical effect to these hints, to almost any of the numerous publications on the Culture of Fruit.)

LESSON XXXV.

PLANTS USED IN ARTS AND MANUFACTURES.

237. *What plants are used in arts and manufactures?*—Plants used in arts and manufactures are commonly divided into three classes:—1. Oleaginous plants, or those cultivated for their oils; 2. Textile plants, or those raised chiefly for their fibre; 3. Plants used in the process of tanning, dyeing, and various manufactures.

238. *What plants are cultivated in this country for oil?*—The only plant cultivated to any extent in this country for oil, is flax, which is also cultivated, and chiefly cultivated for its fibre.

NOTE.—The seed is ground and the oil pressed out, leaving what is called *linseed cake*, which when ground, is broken up fine, is known as *linseed meal*, and is excellent food for stock. The oil obtained from it is known as *linseed oil*, and is used in mixing paints and for other purposes.)

239. *What is said of the soil for flax and of its culture?*—The soil best for flax is a light loam inclining to sand, which may be deeply tilled and kept clean of weeds—which must be pulled up by hand, and of which the flax must be kept as free as possible. A good wheat, is generally a good flax soil.

(NOTE.—But the choice of the soil, as well as the quantity of seed sown, should depend on the object of the farmer. If the flax

is raised chiefly for the *seed*, the soil can hardly be too rich or too well manured. But if the plant be grown chiefly for the *fibre*, a very rich soil makes the fibre rank and coarse. The *qaantity of seed* to be sown also depends upon the object in view. When the flax is thin it branches very much, and every sucker or branch is terminated by a boll well loaded with seed; but when the seed is thickly sown, the stem grows single and without branches, and gives a long, fine fibre. When sown for *fibre*, two bushels of seed per acre may be sown; when sown for the *seed*, from a half bushel to a bushel per acre is sufficient. The seed is sown broadcast, and should be lightly harrowed or brushed in and rolled. When three or four inches high it should be carefully weeded by hand by children or adults barefooted, so as to trample down the plants as little and as slightly as possible.)

240. *What is said of the harvesting of flax?*—If designed for cambrics and the finest linen, flax is pulled when flowering; if designed for coarse linen fabrics, it is not pulled till the seed is entirely formed and the bolls have turned yellow; if required for seed, the flax should be left standing till the first seeds are well ripened.

(NOTE.—When the flax plant is cultivated for the fibre of all linens made in this country, from ten to twenty-five bushels of seed per acre may also be expected, according to the character of the land and the thoroughness of the culture.)

241. *What is said of the after management of flax?*—The first thing is to remove the seed by threshing or drawing the heads through a comb or rake of finely set teeth, called rippling; and then the common method has been, dew-rotting the flax, or spreading it thinly on a clean sward, and turning it occasionally till properly rotted, after which it was put into bundles and stored till a convenient time for breaking, swingling, &c. This is said to be a wasteful practice, and to give an inferior quality of fibre. The improved method of preparing the flax is by water-rotting, which is done in vats or small ponds of soft water, similar to those used for hemp. This is said to give a strong, even, silky fibre, and without waste, and worth much more either for sale or for manufacturing than the dew-

rotted. The fibre is generally got out on the *break* by hand, when the farmer is most at leisure.

(NOTE.—Flax seed is always valuable for the oil it yields, with the residuum or oil cakes so highly valued as a feed for all animals; and the entire seed when boiled is among the most fattening substances which a farmer can use for animal food. But Flax, like most other plants grown for seed, is an exhausting crop, though not so when pulled and harvested before the seed matures. The Flemings think that flax ought not to be raised on the same soil oftener than once in eight years; but it may be oftener repeated in this country.)

HEMP.

242. *What is said of hemp, and the soil best for its growth?*—Hemp, like flax, is a textile plant, and is cultivated for its fibre, which is used in the manufacture of ropes and coarse cloths. The soil for hemp is similar to that for flax, but with a wider range from a uniform standard, as it will thrive in alluvial soils and reclaimed marsh-beds when properly treated, and in moderately tenacious clays, if rich, drained, and well pulvurized. But the soil best adapted to hemp is a deep rich mould of loam and vegetable matter, with fine sand and clay intermixed.

243. *When and how should hemp be sown and harvested?*—Sowing early in the spring produces the best crop; and the seed is usually sown broadcast at the rate of one-and-a-half to two-and-a-half bushels per acre, according to the fineness of the fibre desired. Thick sowing, as in the case of flax, produces a finer fibre. No after cultivation is necessary, and as soon as the blossoms turn a little yellow, and begin to drop their leaves, as they do in July or August, it is time to cut the hemp. When it is cut and sufficiently dried (by spreading it on the ground for some three days, according to the weather,) it is sorted in different lengths, and bound in bundles, and put into cisterns or pools of water for rotting. After being sufficiently rotted, the

bundles are taken out, dried and stacked, till ready for the mechanical processes for breaking and manufacture which follow.

Broom Corn.

244. *What is said of the soil best for broom corn, and its culture?*—The best soil for raising broom corn is similar to that for Indian corn, as is its culture.

(Note.—The use of broom corn is limited to the manufacture of corn brooms, which are superseding every other kind of broom in general use.)

Remarks on other productions used in arts and manufactures.—There are cultivated to a limited extent several other plants used in arts and manufactures, on the culture of which I need not remark, though I may just mention them. One of these is the *Hop*, which is grown in some parts of the country, and the culture of which is increasing, on strong loam or well drained clays with a light subsoil, also on light loams richly manured, and on new strong soils. *Willows*, which are cultivated for the purpose of making baskets, and which grow on a great variety of moist soils, especially in low alluvial lands on the margin of streams. *Mustard* also is cultivated in some places, sometimes for the seed, but more as a valuable crop for green food for cattle, and for ploughing in as a fertilizer. *Sumach* grows spontaneously on some rich soils, and is considerably used by dyers and the tanners of light leather. *Maple Sugar* and *Molasses* are still produced on some farms in different parts of the country; and the *Castor Bean* (from which we get our *castor oil*), though a native of the West India Islands, where it grows in great luxuriance, is cultivated in some of the neighbouring States, and might be cultivated in some parts of this country.

(Note.—I have, from design, not mentioned *tobacco*, because I have not only never used it in any form, but hope that no reader

of this little book will ever use or cultivate it. I have lived nearly seventy years, and after revolving my recollections on the subject again and again, I am unable to call to mind a single instance, within my own varied observation, of a youth who habitually either chewed or smoked tobacco having, in subsequent years, attained to any respectable, much less distinguished, position in any profession or pursuit of life. I have known many estimable and able men use tobacco, though seldom, if ever, advance in intellectural or moral power, or professional or social position, after resorting to the habitual use of this pernicious weed —the general precursor, if not parent, of intemperance and many other vices. Whenever I see a youth, or young man, with a quid of tobacco, a pipe, or a cigar, in his mouth, a feeling of sadness comes over me, and I set him down, from my past experience and observation, as destined, at best, to mediocrity in whatever profession or employment he pursues, if not to intemperance, failure and ruin. I believe the demoralization of great numbers of otherwise promising young men in our land, is largely attributable to the use of tobacco.)

LESSON XXXVI.

ECONOMY OF THE FARM.

(NOTE.—It is, of course, for the farmer to select land, as far as in his power, of the best quality and with the best facilities of market; but having made the selection, the success of the farmer will depend more on the general management of the farm, than on knowledge or skill in any particular department. From the preceding pages it is plain that farming is very far from being a mere mechanical employment; that it requires a great variety of knowledge, sound judgment, much thought in planning and directing, as well as promptness and industry in executing plans devised and in improving times and seasons. Untiring industry is, indeed, essential to success in any pursuit or profession, and not less so in that of agriculture. But sound discretion is requisite to turn that industry to the greatest profit, and in this is involved the economy both of the *farm* and the *household*. Of some essential points in reference to farms, I will briefly treat in the following lesson—offering a few hints on each of them.)

245. *What is included in the economy of the farm, apart from that of the household?*—The economy of the farm includes proper buildings with their appendages, good fences, suitable tools, proper care and management of stock, besides the culture of land and crops, treated of in previous lessons.

Farm Buildings.

(1) The FARM HOUSE can, of course, be of any form and size the means and taste of a farmer may dictate; but as the design of a house is the protection and comfort of its inmates, its location ought not to be one of either naked scorching exposure or of bleakness and dreariness. It should occupy a position easily accessible to the other buildings and to the fields, and be within convenient distance of the highway, and be screened by trees—their foliage affording a natural protection and ornament not to be equalled by any skill of the architect. Every farm house should have the essential appendage of a *cellar*—dry, ventilated, cool in summer and warm in winter, for the double purpose of a dairy and the storing of roots. Other obvious appendages of a farm-house need not be mentioned.

(2) The next important appendage of the farm, THE BARN, must depend as to its size and form, like that of the house, upon the particular wants of the farmer, or whether there should be more than one barn on the premises. The *location* of the barn and other out-buildings, in relation to both the house and fields, requires careful consideration, as there is dependent upon it much of time, and strength, and expense of teaming to and from the field, and steps going to and from the house,: all of which points have a direct bearing on the profit to be derived from the farm. The *New American Farm Book* well remarks, that the barn accommodations "should be large enough to hold all the fodder and animals on the farm. *Not a hoof about the premises should be required to brave our northern winters, unsheltered by a tight roof and a dry bed.* They will thrive so much faster and consume so much less food when thus protected, that the owner will be tenfold remunerated." "The barn and

shed ought to be well raised on good underpinnings, to prevent the rotting of the sills, and to allow the free escape of moisture, as low, damp premises are injurious to the health of animals. Every consideration ought to be given to the saving of manure. The stables should have drains that will carry off the liquid evacuations to a muck heap or reservoir; and whatever manure is thrown out, ought to be carefully protected. A low roof projecting several feet over the manure which is thrown from the stables, will do much to prevent waste from sun and rains. The mangers ought to be so constructed as to economize the fodder. Box feeding for cattle we prefer, as, in addition to hay, roots and meal may be fed in them without loss."

(3) Sheds may be regarded as extensions of the barn, and when arranged on the east and west sides of the yard, the barn forming the north side, a good protection is provided for the cattle against the prevailing and coldest winds of winter. In the space over head, if properly floored, fodder can be stored. The racks or boxes are placed on the boarded side of the shed, which forms the outside of the yard. If the ground under the shed is not quite dry, it is better to plank it; and it can then be cleansed with the same facility as the stables. A portion of the shed may be partitioned off for close or open stalls, for colts, calves, and cows and ewes that are heavy with young. The surplus straw and the like can be used for bedding.

(Note.—The supply of a barnyard with water, by bringing a running stream into it, if possible, or by a well or cisterns, is a great saving of time and labour, and sometimes of life, in driving cattle to a distance to water; and all animals require water, except such as have a full supply of roots.)

(4) Where the farmer's means permit, a distinct building is wisely provided for the *carriage or waggon house*, *stable*, *granary*, *bins*, &c.; and every

good farmer should have a *work shop* and *tool house*, where his tools should be arranged (the minor tools on shelves or in appropriate niches), that they can be readily found. Here the farming tools can be repaired during rainy weather or leisure intervals. The *New American Farm Book* well says, "*Ample shed room for every vehicle and implement about the farm should not be wanting.* Their preservation will amply repay the cost of such slight structures as may be required to house them. A *waggon*, a *plough*, or any wooden implement, will wear out sooner by exposure to all weathers without use, than by careful usage with proper protection."

(5). Fences are indispensable; but the kind of fences, whether of stone or of wood, whether zig-zag or straight, whether post and rail or post and boards, must depend on circumstances, of which each farmer can best judge for himself. The *cheapest* fences (of whatever kind) are *good* fences, kept at all times in perfect repair. Most of the unruly animals are taught their bad habits by their owners. Animals will seldom become jumpers except through their owner's fault, or from some bad example set them by unruly associates. Fences which are half down, or which will fall by the rubbing of cattle, will soon teach them to jump, and to throw down such as they are unable to jump over. An unruly animal should be disposed of as soon as possible. The farmer will find that no animal will repay him the trouble and cost of expensive fences and ruined crops.

(6). Farming Tools demand the former's special attention, as on their proper construction and condition the economy and success of his operations so much depend. If amazing improvements have been made in the tools and machinery for mechanical and manufacturing operations, equal improvements have been made in the construction of tools and machines to diminish the labour and expense, and improve

the mechanical operations of agriculture. Much enterprise and keen competition are shown in the manufacture of the best agricultural implements, which can now be obtained in almost every part of the country. Experience teaches that to have the best implements, kept in the best state for use, and the best protected from the weather when not in use is the best economy.

(7). SHADE TREES are both ornamental and profitable; and their social and moral influence exceeds the gratification they afford to the eye, and outweighs the consideration of dollars and cents. The sweet impressions made by their beauty and grateful shade on infancy and childhood, are often echoed back by the soothing reminiscences of decrepitude and age. "Trees planted for ornamental purposes around the house, and along the road-sides, add not only to the beauty of the homestead and the landscape, but to the real and permanent value of the estate, and thus pay well for the labour and care bestowed upon them. In the *selection of trees* (not for the garden or around the house) regard should be had to their ultimate value as timber and fuel, as also to their beauty and fitness for shade. The isolated *elm* is graceful and imposing, growing to an immense size, with its goodly projecting limbs and long pendant branches; and as fuel and timber it is good for most purposes. Very beautiful is the *rock* or *sugar maple*, with its straight trunk and regular upward branching limbs, forming a top of great symmetry and elegance, affording a thick and ornamental shade, giving an annual return in its sap, making excellent fuel and valuable timber, and yielding the lovely *bird's-eye maple* so much esteemed for furniture. The *black walnut* is a stately graceful tree, of much value for wood and durable timber, of extensive use for plain, substantial furniture, its knots and crotches making the rich

dark veneering, which rivals the mahogany or rosewood in brilliancy and lasting beauty. In fertile soil the walnut tree bears a highly flavored nut. The *butternut* is also a fine tree for shade, as well as for its rich flavored fruit. The same may also be said of the *chestnut*, which yields a refreshing shade, highly prized nuts, and fuel and timber of considerable value. So too with the *shell or shagbark hickory*, whose fruit is much valued, and whose timber makes the best of fuel, and is much used for mechanical purposes. The *white ash*, though having a more slender and stiffer top than any of the preceding trees, is light and graceful, good for fuel, and its timber unequalled in value for the carriage maker. The *black* and *white oak*, in soil adapted to them are trees of commanding beauty and stalwart growth, and valuable for fuel and timber. "Their foliage appears late, but is unsurpassed for depth and richness of color, and highly polished surface, and retains its summer green long after the early frosts have mottled the ash and steaked the maple with their rainbow hues."

(8) Wood Lands may seem to be a needless care for the farmer who is felling the forest; but already, in many parts of the country, wood lands have become extremely scarce and highly valuable; and many a farmer who has been prodigal of his best timbered land while clearing his farm, would now gladly, were it possible, repeople many of his fields with the oaks, and maples, and beeches, and hickories, and pines, which were once his dread. In the clearing of a new farm, therefore, as well as in the culture of an old one, the farmer should be careful to reserve, or conserve, as much wood land as may be to him and his successors a source of supply and profit. In clearing lands, when it is desirable to reserve sufficient trees for a park or shade, a selection should be made of such as are *young* and

healthy, which have grown in the most open places, with a short stem and thick top. Their continued and vigorous growth will be promoted by shortenings their tops and leading branches. Large trees will seldom thrive after the removal of the shade and moisture by which they have been surrounded. They will generally remain stationary or soon decay, or will not unfrequently be blown down by violent winds on account of the slight foothold they have upon the earth by their roots, though it was sufficient for their protected situations when surrounded by other trees.

(9) The Proper Care of Stock is vital to the success and interests of the farmer. The stock of the farm consists of horned cattle, horses, sheep, swine, and poultry; but of the purposes and uses of each of these, and of their various kinds, and of the peculiarities and merits of each kind, I cannot here speak. I confine myself to the following remarks and suggestions:

(*a*) Only good stock should be kept on the farm, as it costs no more to keep a good animal than an inferior one.

(*b*) Success in raising Stock depends greatly on its management when young. If it be not then well fed and cared for, the grown animal well be of poor quality, whatever may be its breed. Though all animals require nutriment in some proportion to their live weight, young animals—like youth of the human race—require not only food to supply the daily waste of the system, but also for the additional demand of nutriment arising from continued increase in size and weight. Hence young animals should have better shelter and more generous feed than they commonly have.

(*c*) The natural heat of the animal system is kept up by food. When animals are exposed un-

sheltered to the cold of winter, the greater part of the food they eat is required to keep them warm, instead of affording them nourishment. Hence they become poor, even when well fed. The less, therefore, cattle are exposed to the cold of winter, the better, as they eat less and thrive more. Cows give more milk, as well as keep in better condition on less food, when housed all the time during cold weather. In stormy weather, it is recommended as good economy to water them in their stalls, rather than to turn them out to seek water in the yard, or at some neighbouring brook. In the care of cattle, regularity in the times and system of feeding, milking, and cleansing the stables, should be strictly adhered to.

(*d*) Well lighted barns and stables do much for the general health and vigour of the animal system, and a full supply of pure fresh air is as essential as food. Especially is this the case for horses. But animals should not be exposed to currents of air, any more than human beings. The temperature of stables should be moderate—neither very warm nor very cold. Great warmth in a stable, as in a dwelling house, is unhealthy, and too great a degree of cold makes a larger quantity of food necessary to keep up the natural animal heat.

(*e*) Humanity dictates kindness to all animals, and prudence suggests it as the most likely means to overcome viciousness, especially in the horse, which is very sensitive, but if always handled gently, can be more easily managed, and be much more useful.

(*f*) In the keeping of sheep, one of the most important matters to be attended to is their shelter in winter, as they require less food and do better when well protected than when exposed. Good ventilation is also important to prevent disease and promote thrift, and hence it is best to give them sheds open to the south.

(NOTE.—The following experiment was tried to ascertain the difference in the cost and gain of proper shelter, and exposure to the weather, for sheep, in the milder climate of England: "Twenty sheep were kept in the open field and twenty others of nearly equal weights were kept under a comfortable shed. They were fed alike for the three winter months, each having one-half pound of linseed cake, one-half pint of barley, and a little hay and salt per day, and as many turnips as they would eat. The sheep in the field ate all the barley and oil cake, and about nineteen pounds of turnips each per day, as long as the trial lasted, and increased in all five hundred and twelve pounds. Those under the shed consumed at first as much food as the others; but after the third week they each ate two pounds less of turnips per day, and in the ninth week two pounds less again, or only fifteen pounds per day. Of the linseed cake they also ate about one-third less than the other lot, and yet increased in weight seven hundred and ninety pounds, or two hundred and seventy-eight pounds more than the others.")

(*g*) Poultry may be profitably kept to a limited extent about the farm-house, if judiciously managed; but the attempts to keep large numbers of fowls with an idea that if a few are profitable, a large number must be proportionably profitable, have generally failed. To be of any profit in winter, fowls require animal food, which they obtain abundantly in summer in the form of insects and worms. If closely confined, they must also be supplied with mineral food, such as shells or crushed bones with gravel and sand.

(*h*) *Accurate accounts*, in detail, are essential to complete success in farming. Without such accounts the farmer cannot know just where he stands, or in what part of his culture he is making or losing money. A separate account should be kept of each kind of grain and vegetables, each kind of stock, and of household and personal expenses. It is also well to keep a separate debit and credit account of each field, charging it with the time, labour, manure and seed expended upon it, and crediting it with the crops produced. The balance will show at the end of each year the gain or loss for the season. This habit of keeping accounts of all outlays and receipts in each department, tends to promote system and

order in the whole culture of the farm. The little time required to keep these accounts will be a profitable and almost daily review of each kind of labour and each kind of expenditure and receipts, and the posting of them, will afford useful employment from time to time in rainy weather.

LESSON XXXVII.

ECONOMY OF THE HOUSEHOLD.

246. *What is said of the economy of the household?*—1. For successful farming, economy of the household is not less important than that of the farm; for if there is no thrifty and judicious management of matters within the house, it will avail little for the success and profit of any farming enterprise to build suitable barns and sheds, select good cows and stock and properly feed them, or cultivate the farm with judgment and industry. The farmer's wife is not less essential to successful farming than her husband. How much is to be saved and made by the proper care of milk, cleanliness and skill in making butter and cheese, even in cooking different kinds of meat, as well as in the domestic preparation and use of the various productions of the garden and the farm, and the general order and neatness of the household!

2. It would exceed the scope of these *First Lessons in Agriculture*, to enter into the minute details of household economy; my object is to impress upon the parties concerned, the importance of economy in this whole procedure. As one man will grow twice the quantity of crops on ten acres of land that another man will on the same quantity of land, and of the same quality, simply by better management; so one woman will make a household comfortable and respectable on half the quantity of

material and means as another woman, simply by better management and economy. The judicious, thrifty and economical management of even the smallest household is worthy of the highest earthly ambition of the housekeeper, and of the highest praise that man can bestow. Intelligence, economy and industry on a small scale, lead almost invariably to enlargement of the sphere of both activity and enjoyment. It has been justly remarked, that "the wealth of a farming community is always to arise from the products of the farm. Whatever withdraws attention from assiduous cultivation, or plants the hope of gain in other sources than in the herds, the dairy, the grains and the grass-field, will eventually insure disappointment and poverty, as many farmers can testify." So, what the farmer's attention and skill are to the productions of the farm, the attention and skill of the farmer's wife are to the best use and highest value of most of those productions. Carelessness, and waste, and incompetency in the household—the attention diverted there from domestic duties by gossipping, novel reading, fashion, &c.—will paralyze the wisest exertions of out-door industry, and dry up the springs of domestic prosperity and happiness.

3. As it is as cheap to keep good cattle as poor ones; so it is as easy to make good butter and cheese as poor; to make good bread as bad bread; to cook potatoes, peas, beans, asparagus, &c., well as badly. The butter and cheese made by one farmer's wife, will often sell for much more than the butter and cheese made by another farmer's wife; and there is as great an inequality in the value and economical preparations and use of all the other articles of sale and consumption. And much of the bad health and disease in families, is attributable to bad bread and bad cookery. For example, how different is sweet and clean butter from rancid and dirty butter;

and the same remark applies to cheese! How different light and sweet bread, from heavy and sour bread, made from the same flour! How different sweet, dry and mealy potatoes, properly cooked, and the same potatoes soft and watery when improperly cooked. "How different meat properly boiled or roasted, or baked, and the same meat improperly boiled, or roasted or baked! And so with other articles of food—so different in nourishment as well as in taste. How different the clothes of the farmer and his family when properly washed, and mended, and done up, and their clothes dirty and ragged! How different unwashed, disorderly and disobedient children, from children clean, orderly and obedient! The wife and the mother is most responsible for all these.*

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* In my dedicatory address to the Commissioner, President and Members of the Board of Agriculture, as well as in the first Lesson, I have remarked on the importance of educating farmers' *sons*. I beg to subjoin the following admirable remarks by the Rev. E. H. Winslow of the United States, on the education not only of farmers' daughters, but of females generally, especially of their *domestic* education:

"The greatest danger to females, at the present time, is the neglect of *domestic* education. Not only to themselves, but to husbands, families, and the community at large, does this danger impend. By far the greatest amount of happiness in civilized life is found in the domestic relations; and most of this depends on the domestic culture and habits of the wife and mother. Let her be intellectually educated as highly as possible; let her moral and social nature receive the highest graces of vigour and refinement; but along with these, let the domestic virtues find ample place.

"We cannot say much to our daughters about their hereafter being wives and mothers; but we ought to *think* much of it, and to give the thought prominence in our plans for their education. Good wives they cannot be, at least for men of intelligence, without mental culture; without it, good mothers they certainly cannot be; more than this, they cannot be such wives as men need, unless they are *good housekeepers*; and they cannot be good housekeepers without a thorough practical teaching to that end. Our daughters should be practically taught to bake, wash, sweep, cook, set table, make up beds, sew, knit, darn stockings, take care of children, nurse, and do everything pertaining to the order, neatness, economy and happiness of the household.

4. In the life of the farmer, as in that of every other man, it is of the utmost importance to make home attractive to all the family; and it is hardly needful to repeat that the strictest neatness and good order in all the domestic arrangements is most conducive to this end. Without them no dwelling can have the air of cheerfulness and comfort. But it must be added, all this avails little without corresponding dispositions and virtues on the part of the husband and father. Nothing on earth is more to be pitied than a virtuous, industrious and intelligent woman with a shiftless and lazy husband; and worse still, as is commonly the case, if he adds to the degradation of sloth the debasement of intemperance, paralyzing the energies and breaking the heart of his wife, and rendering his children worse than fatherless.

5. The cultivation of flowers in the house and the garden not only affords a pleasant and intelligent occupation for leisure hours, but is well calculated to aid the skilful housekeeper in adorning and beautifying home. Who does not feel the genial and refining influence of flowers blooming in the win-

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"A mother, or daughter; should know *how* every thing *ought to be done* in the household, whether she does it or not; and the most favoured are sometimes placed in circumstances, in which comfort, and even life, will depend upon their practical knowledge and skill in more than one branch of domestic economy.

"All this they can learn as well as not, and better than not. It need not interfere in the least with their intellectual education, nor with the highest style of refinement. On the contrary, it shall greatly contribute thereto. Only let the time, or even a portion of it, which is more than wasted in idleness, sauntering, gossip, frivolous reading, and the various modern female dissipations which kill time and health, be devoted to domestic duties and domestic education, and our daughters would soon be all that can be desired. A benign and regenerating influence would go forth through all the families of the land. Health and joy would sparkle in many a now lustreless eye; the bloom would return to grace many a faded cheek; and doctors' bills would fast give way to bills of wholesome fare."

dow, and in the neat beds of the garden or the front yard? Graceful vines trailing over the doorway give a charm to the poorest dwelling, and make the humblest cottage attractive.

6. But the flower that blooms in the household with most exquisite beauty, which is redolent of the most delicious odour, and fraught with highest value, is PIETY—pure, unaffected, cheerful, benevolent piety. In the *wife* and *mother* it imparts an atmosphere of kindness, patience, pleasantness—the reverse of severity or moroseness—attentiveness to every duty, and sympathy with every suffering, sorrow, or joy; in the *husband* and *father* it is the fatherhood of God in humanity—an *eye* to see every want, and a *hand* to provide the needful supply, a *head* to counsel and direct the little domestic kingdom and church, and a *heart* to relieve and sustain every member; in the *children*, piety to God, to parents, to each other, presents the combination of all that is beautiful and odoriferous in the flower-garden, all that is precious in the golden mine, and all that is satisfying in the waving corn-field. In a household thus tenanted, there is no absence of cheerful and refining amusement, no presence of pharasaic austerity, no slothful inactivity, no wrangling disputes, but hearty industry all, mutual kindness all, acquisition of knowledge all, humble devotion all. On such a household God himself will ever deign to smile, bestowing upon each of its members, in the best sense, the life that now is, and an heirship of God, and a joint-heirship with Christ, in the life which is to come.

REMARKS ON HOUSEHOLD ECONOMY.

It may be instructive to some, and interesting to many, if I add a summary of what I have collected and condensed on certain parts of household economy.

1. *Milk—its properties, care, and uses.*—The care of milk forms an important part of the duties of every housekeeper, and it enters largely into many processes of cooking in every household. Milk, as is known, is an opaque fluid of a whitish color, with a sweet agreeable taste. Milk is composed chiefly of *casein* or *curd*, which gives it its strength, and from which *cheese* is made; also an oily substance, which gives it richness, and which is separated from it in the form of *cream* and *butter;* and a sugar of milk, which gives it sweetness, and a watery substance, which makes it refreshing as a beverage, and which is separated from the other constituents in cheese-making, and known as *whey.* The oily or fatty matter in pure milk varies from two-and-a half to six-and-a-half per cent.; the *cheesy* matter, or casein, varies from three to ten per cent.; and the *whey*, or watery matter, from eighty to ninety per cent. The proportions of these several substances vary according to the kind of animal, the food used, and other circumstances. Milk will generally yield from ten to fifteen per cent. of its own volume of cream—the average being about twelve-and-a-half per cent., or one quart of cream for every eight quarts of milk on an average. But the milk of some cows, fed on rich food, far exceeds this—sometimes furnishing twenty per cent. of cream, and in rare instances twenty-five or even twenty-six per cent. The quantity of cream obtained is, however, much more uniform than the quantity of butter from cream.

2. Milk weighs about four per cent. more than water; but rich milk is lighter than poor. Cold condenses milk, while heat liquifies it.

3. The elements of which milk is composed being different in character and specific gravity, undergo rapid changes when at rest. The oily or butter particles being lighter than the rest, soon begin to

rise to the surface in the form of a yellowish, semi-liquid cream, while the greater specific gravity of the whey or watery part carries it down. The butter particles in rising to the surface, bring up with them many cheesy particles, which mechanically adhere to their external surface, thus giving the cream more or less of a white colour instead of pure yellow. Some watery particles also adhere to the buttery particles of the cream, and thus make it thinner than it would otherwise be. If the buttery particles rose up free from the adhesion of the cheesy and watery particles, they would appear in the form of pure butter, and thus the process of churning would be unnecessary. But Divine wisdom has seen fit to require man's agency to prepare nearly all the bestowments of Providence for man's use.

4. From great heat and sudden changes in the atmosphere (often indicated by thunder, the collection, or coagulation of the cheesy particles sometimes takes place so rapidly, that there is not time for the butter particles to rise to the surface, and they remain mixed with the curd in what is called thick milk. When, on exposure to a warm atmosphere, milk becomes rapidly sour, its sugar of milk becomes what is called *lactic acid*. It is this sugar and the chemical changes to which it gives rise, that render milk susceptible of undergoing all degrees of fermentation, and of being made into a palatable but intoxicating liquor, which, on distillation, produces pure alcohol.

5. The temperature of milk as it comes from the cow is about blood heat, or ninety-eight degrees of Fahrenheit; and it should be allowed to cool as little as possible before coming to rest in the pan. The depth of milk in the pans should be shallow, not more than two or three inches. A moderate warmth and shallow depth promote the rising of cream. The temperature of the dairy room or

milk cellar should not vary much from fifty-eight degrees—two degrees colder than temperate heat.

6. The largest butter particles, or globules, are comparatively the lightest, and therefore begin to rise first after the milk comes to rest in the pan, and form the first layer of cream—which is the best, as it is less filled with cheesy particles. The next largest butter particles rise a little more slowly, are more entangled with other substances, and bring more of them to the surface. The smallest butter particles rise the most slowly of all, are loaded with caseous or cheesy matter, and produce inferior cream and butter. The most delicate cream and the sweetest and most fragrant butter, are therefore obtained by skimming only a few hours after the milk is set; but from eighteen to twenty-four hours after the milk is set, is the usual time for skimming the cream.

7. As milk is extremely sensitive to external influences, the utmost cleanliness is necessary to preserve it for any length of time. The pails, strainers, and pans, the milk room, and all the surroundings, should, therefore, be kept neat and clean to an extent which only the best dairy women can fully appreciate.

8. On large dairy farms, a building is usually erected as a dairy-house, which should be distant from low damp places, from which disagreeable exhalations arise, and which should be well ventilated and kept clean and sweet by the free use of pure water. But in smaller dairies, economy dictates the use of a room in the house. This room should, if possible, be one on the *north* side, and be used exclusively for this one purpose. Most cellars are not suitable for setting milk; but where an airy room can be partitioned off from the rest of the cellar, and be thoroughly ventilated by windows, a greater uniformity of temperature can be secured there than on the floor above. Such a room may be used to advan-

tage; but its floor should be dry and porous, not of cement, but of gravel or loam. Carbonic acid—a heavy and noxious gas—is apt to infect the atmosphere near the bottom of the cellar, and a porous floor acts as an absorbant. It is evident the cream will not rise so quickly or so well when the milk pans are set on the cellar bottom. The air is less pure, and the cream is liable to become acrid or bitter. When the object is to obtain the most cream in the shortest time, the milk should stand on shelves from three to five or six feet from the floor, where a free circulation of air can be had from the windows.

9. It is always best to churn as often as possible —in large dairies every day, in smaller ones less frequently. After the milk has stood from eighteen to twenty-four hours in a favorable place, and in suitable pans (tin pans are said to be the best upon the whole), the cream may be removed and placed in stone jars, to be kept until the churning. When the churnings cannot be as frequent as every other day, the cream, on being put into a stone jar, should be sprinkled over with a little pure fine salt. When more cream is added, stir up the whole together and sprinkle over it a little more salt, and so on until there is enough cream to churn.

10. Though butter may be got from cream at a temperature ranging from forty-five to seventy-five degrees Fahrenheit, it is a matter of the utmost nicety to regulate the temperature so as to get the best quality of butter from it. Careful experiments seem to show that when the cream is at about fifty-one degrees at the beginning of the churning, the *best quality* of butter may be obtained from it. The temperature rises four or five degrees during the operation, much depending on the time it takes. But if the object be to obtain the *greatest quantity* of butter from cream, irrespective of *quality*, the

churning may be commenced with the cream at fifty-six degrees, and the temperature will gradually rise to sixty. The *greatest quantity* of butter of the *best quality* is said to be got from cream standing at about fifty-three degrees, at the commencement of churning, and rising in the operation to fifty-seven or fifty-eight degrees.

11. The operation of churning should not be hurried. The butter from cream churned from half to three-quarters of an hour, is of far better quality and consistency, than butter churned in five or ten minutes, which it is possible to do by the application of warm water and violent churning, but producing butter inferior in quality and quantity.

(NOTE.—I cannot here speak of the different kinds of churns which have been invented to make butter; nor of the different instruments which have been devised for working butter after it has been churned. The common churn-dasher has been hardly improved in the principle of its operation. In one work that I have read, it is said, "A simple square box, turning on an axle, is one of the best forms of the churn. It is the *concussion*, rather than *motion*, which brings the butter, and this form of churn gives it as well as the dasher. The cream takes a compound motion, and the concussion against the sides and right-angled corners is very great.")

12. I must add a few words on the *working of butter*, after the process of churning has been completed. After the butter has come, it must be thoroughly worked, till *all* the buttermilk is removed. This is done by a roller or "butter-worker." A large sponge, covered with a clean cloth, is a very useful article for removing milk from the surface of the butter, where it will be found to stand in little round globules after the butter has been pressed or worked. With a sponge, nearly every particle of milk may be taken off. Butter made in this careful way will keep better than any other, as the buttermilk, often imperfectly worked out, does more to destroy the sweetness and solidity of the butter than anything else. The hands should never come in direct contract with the

butter. After completely removing the buttermilk, the butter may be formed into lumps of one or more pounds each, and put down into firkins made of white oak, which should first be well cleansed. When thus made, butter will keep a long time with little salting. Over-salted butter is not only less agreeable to the taste, but less healthy, than that which is fresh and sweet. In general, much salt is needed only when butter is badly worked over, and to prevent the ill effects of neglect.

(NOTE.—The importance of having a thermometer is obvious, in order to ascertain the temperature of the milk and cream, in the process of making butter.)

CHEESE—*from what and how made.*—1. Cheese is made from the casein or curd of milk. If allowed to become sour, every one knows that the milk will curdle, when the whey may be separated from it. But in making cheese, the curd is produced by an *acid* in the form of *rennet*, which is the stomach of a young calf, prepared by washing, salting, drying and preservation.

2. Cheese may be made from different parts of milk, and is named and valued accordingly. It may be made entirely of cream, or from unskimmed milk with the cream of other milk added, or from milk from which part of the cream is taken, or from ordinary skim milk, or from milk which has been skimmed two or three times, or even from buttermilk. The acid or rennet used to curdle the milk, acts on the *casein* alone, and *not* on the particles of butter, which may remain embedded in the curd as it hardens, increasing the richness and flavour of the cheese, but not adding to its firmness, which is due to the casein alone.

3. The process of cheese-making is both chemical and mechanical. The milk is heated to almost ninety-five degrees, when the rennet is added—the chemical action being thus commenced, and the

separation of the whey facilitated. Strong and good rennet will curd the milk in about half-an-hour. It is then allowed to stand from half-an-hour to an hour, when it is cut across in different directions, to allow the whey to work out more freely.

4. Great care is required in the proper preparation of the rennet; and indeed every process in cheese-making calls for the exercise of much judgment and experience. It is said that many fail in consequence of hurry in the pressing of cheese, which is better if allowed to stand more than one day in the press.

The Practice and Philosophy of Breadmaking.

1. A most, if not *the* most important branch of domestic economy is that which relates to the great staples of human food, especially the articles employed in making bread. A large part of the ill-health and unhappiness of families arises from bad and defective cooking. The really good and healthy bread commonly used bears no large proportion to that of decidedly poor quality. Much may be, and is doubtless owing to the flour which the housekeeper is obliged to use, but much more is undoubtedly owing to the bad process of making it into bread.

2. Every hundred pounds of wheat contain from fifty-five to sixty-eight pounds of starch, from ten to twenty pounds of gluten, and from one to five pounds of fatty matter. The relative quantities of these substances vary considerably in different climates and soils. Gluten, as well as starch, exists in most plants, though the proportion in some is far greater than in others. Gluten in plants is nearly identical with *fibrin*, or the muscle-forming constituent of meat. Gluten and starch of wheat flour may be easily separated. The gluten may be washed out of the dough by placing it upon a sieve or a porous cloth tied over a deep dish, and pouring on water

as long as it continues to run through of a milky colour, and until it runs clear. The starch is carried through the sieve or cloth with the water, and the gluten is left on the sieve or cloth. The starch will soon settle to the bottom of the dish.

3. On mixing water enough to moisten the whole mass of flour, the particles stick to each other and from a smooth elastic dough, which consists, not only of starch, but of gluten, so called from its sticky or glutinous character. If we add a little yeast to the flour while mixing with water to form dough, and let it stand some hours in a moderately warm place, the dough begins to ferment and rise, increasing considerably in bulk. In rising, little bubbles of carbonic acid gas are set free throughout the mass of dough; and this it is which makes bread porous and light, by the stretching or expansion of the tenacous gluten. Put the dough in a hot oven, and the fermentation and rising are at first hastened by the increased heat, but when the whole is heated to the point of boiling water, the process of rising is suddenly stopped, and the mass is fixed at this point by the baking. The reason why the rising is so suddenly checked in the oven, is that the *yeast* added to the dough is in reality a *living plant*, which grows and increases with great activity when it comes in contact with the moisture of the dough, producing fermentation or rising. During the process a part of the starch in the flour is changed into sugar, and this sugar into alcohol and carbonic acid gas. This gas cannot escape from the dough, since the elastic gluten expands, but it remains in the shape of bubbles. At last the heat becomes great enough to destroy the yeast plant, and the process of rising ceases. The alcohol mostly escapes in baking.

4. Newly baked bread is spongy, full of little cavities, made by the gas bubbles during the rising.

It is then soft and agreeable. But in the course of a day or two the peculiar softness disappears, and this bread seems to be drier, and crumbles readily. This apparent dryness is not, however, caused by a loss of water. Stale bread contains very nearly the same amount of water as that newly baked. Both contain, on an average, from thirty-five to forty-five pounds of water in every hundred pounds of bread. Stale bread, though not generally so agreeable to the taste, is considered more wholesome than new.

5. Flour in its natural state contains from twelve to sixteen per cent. of water; but it will, in addition, take up about half its own weight of water; so that a hundred pounds of good flour make about a hundred and fifty pounds of bread.

6. It is a fact demonstrated by analysis and experiment, that the bran which is so carefully sifted out of the flour, is rather more nutritious than the fine flour itself. The oily parts of the grain are mostly on the surface; and the grinding of the wheat does not wholly crush the outside covering of the grain, which is harder than the rest. This is usually sifted out from the finer portions in the form of shorts and bran. The less finely bolted flour is undoubtedly more nutritious and wholesome than the finest and whitest samples of the flour itself.

7. Rye flour has nearly the same nutritive value as wheat flour, though unlike it in several respects. Its colour is not white, but greyish-brown; the bread from it is not so porous as that made from wheat flour, nor the dough so tough. Its starch cannot be washed out like that of wheat flour. Rye bread may be kept fresh and moist much longer than wheat bread. Barley contains about the same proportions of nutritive matter.

8. The general principles of bread-making apply to all kinds of flour or meal; but Indian meal,

though in composition and nutritive properties not differing much from wheat flour, does not make equally spongy bread.

Properties and Cooking of Meat.

Beef as an example.—1. Fresh lean beef contains about seventy-eight per cent. of water, including the blood. Wheat flour bread, as stated above, contains only forty-five per cent. of water. But the *gluten* of wheat has its corresponding element in beef in the *fibren*, of which beef contains nineteen per cent., while wheat flour bread has only sixteen per cent. of gluten. Again, beef contains more or less fat—generally over three per cent. in even lean beef, while there is but one per cent. of fat in flour. The chief difference, then, is in the *starch*, which is not found in beef, while in bread it forms more than forty-eight per cent., or about one half of the whole. The *fibrin* may be ascertained by taking a thin piece of lean beef, and washing it in clean water until its colour is entirely lost, the blood being washed out and only a white mass of fibres being left, which constitutes the muscle of the living animal. This is called fibrin, and takes its name from its fibrous nature. It contains in mixture part of the fat of the animal, and with it constitutes the main substance of the meat. Meat is therefore composed of water, coloured by blood, fibrin and fat. In highly fed animals, the fat is often collected by itself in various parts of the body, as in the suet and around the bones, or is deposited in large masses under the skin, as in fat mutton and pork, instead of being evenly distributed through the fibrous mass of muscular tissue, so as to produce, in the case of beef, what is called well marbled beef. (What is said of beef applies to other kinds of meat, with certain variations.)

2. The most common modes of cooking the meats set on the table, are simple boiling, roasting and baking. Out of every four pounds, beef loses one pound in boiling, one pound three ounces in roasting, and one pound five ounces in baking. The same weight of mutton loses in boiling fourteen ounces, in roasting one pound four ounces, and in baking one pound six ounces.

3. The loss in cooking meat is mainly in the evaporation of water, and in the fat which melts out in roasting and baking. But this water, mixed as it is with the blood, and holding more or less of various saline substances in solution, constitutes what is called the juice of the meat; and if this were all extracted, the meat would become a mere tasteless mass. It is very important, therefore, in cooking meats, to preserve their rich and nourishing juices as much as possible. This is done in boiling, roasting, and some other modes of cooking meat, by subjecting it to great heat when first put over the fire. By this means the fibres near the surface are contracted, the escape of the juice is prevented, and the piece of meat is, to a great extent, cooked in its own moisture.

4. Thus, if meats are to be boiled, they should be put at once into boiling water; if they are to be roasted, they should be exposed at once to a quick fire, and thus retain the liquid contents within them, as above explained. If exposed to a slow fire, or to cold or only warm water, very much of the richness of meat, as well as of its nutritive qualities, is lost, and the piece will become hard and dry.

5. But if the object is to extract the juices of the meat for soups, broths, beef tea, &c., the opposite process should be adopted, and the meat should be put into cold water, and either simmered over a slow fire, or gradually brought to a boil. For these

purposes soft water is best, because it has a greater solvent power than hard water, which holds in solution more or less mineral matters, especially lime. In ordinary boiling, however, where we only wish to cook the meat, and not extract its juices, in which its flavour and richness consist, hard water is better.

(NOTE ON BOILING POTATOES.—Many housekeepers know not how to cook potatoes They peel the potatoes and put them into cold water to soak; both of which modes of cooking them is wrong. Potatoes, to retain their best qualities, should be boiled with their skins on, and put into boiling water at first. The true Irish method of boiling potatoes is as follows: "Cleanly wash the potatoes, and leave the skins on; then bring the water to a boil and throw them in. As soon as boiled soft enough for a fork to be easily thrust through them, dash some cold water into the pot, let the potatoes remain two minutes, and then pour off the water. This done, half remove the pot-lid, and let the potatoes remain over a slow fire till the steam is evaporated; then set them (peeled or not) on the table in an *open* dish. Potatoes of a good kind thus cooked, will always be sweet, dry and mealy. A covered dish is bad for potatoes, as it keeps the steam in, and makes them soft and watery.")

THE MANUFACTURE AND USE OF SOAP form an important part of domestic economy. When oily or fatty substances come in contact with an alkali in solution at an elevated temperature, they undergo an entire change; and on this change the whole process of soap-making depends.

2. The soap usually made in the farm-house is that known as soft soap, and is formed by the union of potash with more or less fatty matter. Hard soaps are made by the use of *soda*, with which potash is sometimes mixed. Potash will not harden when water is present, as it always is in considerable quantities in soft soap. But soap made with soda will absorb more than its own weight of water without losing its hardness.

3. In making Castile soap, olive oil and soda are used, and its peculiar marbled appearance is produced by the mixture of iron rust, which, of

course, does not improve the quality of the soap. Rosin is often added in the manufacture of common or yellow soaps. Though rosin soaps form a lather readily, and are thus thought by many to be very effective, their cleansing properties are inferior to the soda soaps, and they are less economical.

4. The cleansing properties of soap depend mainly on its alkaline ingredients. When brought into contact with impurities of clothing, or of the skin, which are made up of a greater or less quantity of oily matter derived from the exhalations of the body, together with dust and other foreign substances, the alkali of the soap readily seizes hold of the oily matters and dissolves or removes them. But if water is used without soap, it often fails to cleanse thoroughly, as it has no affinity for oily substances, and therefore leaves them, and whatever adheres to them, in the cloth or on the skin. An alkali might be used alone, but it would be so powerful as to injure or destroy whatever it came in contact with. Washing fluids are simple solutions of caustic alkali.

LESSON XXXVIII.

MISCELLANEOUS QUESTIONS AND ANSWERS, RESPECTING WATER, PLANTS, BIRDS, ANIMALS, MAN;

Compiled chiefly from a book of general Science, entitled "*The Reason Why*," but derived in part from Paley's *Natural Theology*.

247. *Why does water, in freezing, expand?*—Because, when water freezes, its particles become arranged in crystalline forms. These crystals cross and intersect each other, and cause numerous interstices. Therefore, though the water, in becoming ice, parts with much of its caloric, the arrangement of its atoms into crystals causes it to become of greater bulk. It also contains numerous bubbles.

248. *Why does ice float upon water?*—Because, as it expands in freezing, it becomes specifically lighter than water.

249. *Why does the surface of the water being frozen prevent the frost extending to the depths of the water?*—Because ice, like snow, is a bad conductor of heat; the covering or coating of ice, therefore, tends to keep the subjacent water warm.

250. *Is ice the only instance of water existing in a state of solidity?*—No; water becomes still more solid in combination with lime and other earths; and the reason is, that it parts with more of its caloric than in the process of freezing, and is therefore further removed from its natural state of fluidity.

251. *Why does frost benefit fallow soils?*—Because it expands the clods, and causes them to break and crumble into fine dust, exposing their matter to the air, enriching them by the absorption of gaseous matters.

252. *Why are clayey soils unfavourable to vegetation?*—Because the soil is *too close and adhesive* to allow of the free passage of air or water to the roots of plants; it also obstructs the expansion of the fibres of the roots.

253. *Why are sandy soils unfavourable to vegetation?*—Because they consist of particles that have *too little adhesion to each other;* they do not retain sufficient moisture for the nourishment of the plants, and they allow too much solar heat to pass to the roots.

254. *Why are chalk soils unfavourable to vegetation?*—Because they do not absorb the solar rays, and are therefore *cold to the roots of plants.*

255. *Why are mixed soils favourable to vegetation?*—Because they contain the *elements of nutri-*

tion essential to the development of the vegetables, and the plants absorb from them those constituents which are necessary to their growth.

(NOTE.—See the subjects of these questions explained more fully in Lessons 17 and 18, on the "Composition of Soils and Plants, and their Relations to each other," and "Soils adapted to different kinds of Grain and Vegetables.")

256. *What is the difference between an animal, a plant, and a mineral?*—*Animals* grow, live, feel and move; *plants* grow and live; *minerals* do not live, and they grow merely by *addition* of particles of inorganic matter.

257. *Why do some plants droop and turn to the earth after sunset?*—Because, when the warmth of the sun's rays is withdrawn, they turn downwards, and *receive warmth from the earth by radiation.*

258. *Why does the young ear of corn or wheat first appear enfolded in two or more green leaves?*—Because the light and the air would *act too powerfully for the young ear;* two or more leaves therefore join and embrace the ear, and protect it until it has acquired strength, when they divide, and leave the ear to swell and ripen.

259. *Why do the ears of wheat stand up by day, and turn down by night?*—Because, when the ear is becoming ripe, the cold dew, falling into the ear, might *induce blight;* the ears therefore turn down to the earth at night, and *receive warmth by radiation.*

260. *Why does the pea put forth tendrils, and the bean not?*—Because the bean has in its stalk *sufficient woody fibre to support itself*, but the pea has not. We do not know a single tree or shrub, having a firm, strong stem, sufficient for its support, which is *also* supplied with tendrils.

261. *Why have climbing plants tough, spiral tendrils?*—Because, *having no woody stalks of their*

own to support them, they require to take hold of surrounding objects, and raise themselves from the ground by climbing. Their spiral tendrils are, therefore, so many hands, assisting them to rise from the earth.

262. *Why have grasses, corn, straw, &c., joints or knots in their stalks?*—Because a long, hollow stem would be liable to bend and break. But the joints are so many points where the fibres are bound together, and the structure is thereby greatly strengthened.

263. *Why do ripe fruits taste sweet, and unripe fruits taste sower?*—Because the juices of the ripe fruit contain a large proportion of *sugar*, which in the unripe fruit has not been formed.

264. *Why have trees with large trunks a great number of leafy branches?*—Because it is *by the leaves* that the secretion is formed which supplies the *woody fibre.* The number of leaves on a tree, therefore, generally bears a relation to the size of its trunk, the *denseness* of its wood, and the number of its branches. Oak trees have an abundance of leaves, because their *wood is so dense* that they require a larger amount of wood-forming secretion, which is supplied by the leaves. The mammoth-tree (*Wellingtonea gigantes*) has few leaves in comparison to the immense size of its trunk; but the woody texture of this tree is exceedingly light and porous—lighter than cork—and therefore requires less leaf-produce in its formation.

265. *Why are the leaves of plants green?*—Because they secrete a carbonaceous matter, named *Chlorophyl*, from which they derive their green colour.

266. *Why do leaves turn brown in autumn?*—Because, when their vital power declines, the *oxygen*

absorbed in the carbonic acid, lodges in the leaf, imparting to it a red or brown colour.

267. *Why do some leaves turn yellow?*—Because they retain an excess of *nitrogen.* Leaves undergoing decay turn either yellow, red, crimson or violet. Yellow is due to the excess of *nitrogen;* red and crimson to various portions of *oxygen;* violet to a mixture of *carbon;* and green to *chlorophyl.*

268. *Why do leaves fall off in autumn?*—Because they have supplied for a season the natural wants of the tree. Every part has received nutrition through the spring and summer months; and the wants of the tree being supplied, the chief use of the leaf ceases, and it falls to the ground to decay, and enrich the soil.

269. *Why are grasses and vegetable productions so widely diffused throughout nature?*—Because they everywhere form the *food* of a very large portion of the animal kingdom. Without them, neither man nor beast could exist. Even the flesh-eating animals are sustained by them, since they live by preying upon the bodies of vegetable-eaters. They also enrich and beautify the earth. They present the most charming diversities of proportion and features, from the creeping ivy to the majestic oak; they spread a carpet over the surface of the earth, and afford fragrant and refreshing shade; they supply our dwellings with furniture of every kind, from the plain deal table to the handsome cabinet of satin or rosewood; they furnish rich perfumes to the toilette, and various fruits and beverages to the dessert; they charm the eye of childhood and age in the daisied field; they adorn the brow of the bride; they are laid in the coffin of the dead; and, as the cypress or the willow bend

over our graves, they become the emblems of our grief.

(NOTE.—See Lesson 16, "*On the Structure of Plants and the Offices of their Organs.*"

270. *Why do fishes float in streams (when they are not swimming) with their heads towards the stream?*—Because they breathe by the transmission of water over the surface of the gills, the water entering in at the mouth and passing over the gills behind. When, therefore, they lie motionless with their heads to the stream, they are in *that position which naturally assists their breathing process.*

271. *Why have fishes no eye-lids?*—Because the water in which they swim keeps their eyes moist. Eye-lids would therefore be useless to them.

272. *Why are the tails of fishes so much larger than their fins?*—Because their tails are their chief instruments of motion, while their fins are employed simply to direct their progress, and steady their movements.

273. *Why are birds covered with feathers?*—Because they require a high degree of warmth on account of the activity of their muscles; but in providing that warmth, it was necessary that their coats should be of the *lightest material*, so as not to impair their powers of flight; and feathers combine the highest warmth-conserving power with the least amount of weight.

274. *Why have water-birds feathers of a close and smooth texture?*—Because such feathers keep the body warm and dry, by repelling the water from their surface.

275 *Why does a black down grow under the feathers of birds as winter approaches?*—Because the down is a non-conductor of heat, and black is the warmest colour. It is therefore best adapted to

keep in their bodily warmth during the cold of winter.

276. *Why have birds gizzards?*—Because, having no teeth, the tough and fibrous gizzards are employed to grind the food preparatory to digestion.

277. *Why are small particles of sand, stone, &c., found in the gizzards of birds?*—Because, by the presence of those rough particles, which become embedded in the substance of the gizzard, the food of the bird is more effectually ground.

278. *Why have* BIRDS OF PREY *no gizzards?*—Because *their* food *does not require to be ground* prior to digestion, as does the food of grain and seed-eating birds.

279. *Why do woodpeckers tap or peck at old trees?*—Because, by boring through the decayed wood, with the sharp and hard bills with which they are provided, they get at the haunts of the insects upon which they feed.

280. *Why are woodpeckers' tongues about three times longer than their bills?*—Because, if their bills were long, they would not bore the trees so efficiently; and when the trees are bored, and the alarmed insects endeavour to retreat into the hollows of the wood, the long thin tongue of the woodpecker transfixes them on its sharp, thorny point, and draws them into the mouth of the bird.

281. *Why are the bones of birds hollow?*—Because they are thereby rendered *lighter*, and do not interfere with the flight of the bird, as they would do if they were solid. Greater strength is also obtained by the cylindrical form of the bone, and a larger surface afforded for the attachment of powerful muscles.

282. *Why, if birds of passage arrive early on their way to the North, may severe weather be ex-*

pected?—Because it shows that the indications of unfavourable weather have set in in the latitudes from which the birds come, and that they have taken early flight to escape it.

283. *Why have* BATS *hooked claws in their wings?*—Because bats are almost destitute of legs and feet; at least those organs are included in their wings. If they alight upon the ground, they have great difficulty in again taking to the wing, as they cannot run or spring to bring their wings into action upon the air. At the angle of each wing there is placed, therefore, a bony hook, by which the bat attaches itself to the sides of rocks, caves and buildings, laying hold of crevices, joinings, chinks, &c.; and when it takes its flight, it unhooks itself, and its wings are at once set free to strike the air.

284. *Why does the bat fly by night?*—Because it lives upon moths, which are night-flying insects.

285. *Why does the bat sleep during the winter?*—Because, as the winter approaches, the moths and flying insects upon which it feeds disappear. If, therefore, it should not sleep during the winter, it would starve.

286. *Why has the* SPIDER *the power of spinning a web?*—Because, as it lives upon flies, but is deficient in the power of flying in pursuit of them, it has been endowed with an instinct to entrap them, and with the most wonderful machinery to give that instinct effect.

287. *Why do oxen, sheep, deer, &c., ruminate, or chew the cud?*—Because they have no front teeth in the upper jaw, the place of which is occupied by a hardened gum. The first process, therefore, consists simply in *cropping* their food, which is passed into the paunch, to be brought up again and ground by the back teeth, when the cropping process is over.

Another reason is, that in a wild state, they are constantly exposed to the attacks of carniverous beasts; and as the mastication of the large amount of vegetable food required for their sustenance would take much time, they are provided with stomachs by which they are enabled to fill their paunches quickly, and then retiring to a place of safety, they bring their food up again, and chew it at leisure, in which they seem to have enjoyment; and it is then, perhaps, they best relish their food.

288. *Why can ruminating animals recover the food from their paunches?*—Because they have a *voluntary* power over the muscles of the throat, by which they can bring up the food at will.

289. *Why can they keep the unchewed food in the paunch from the "cud" they have chewed for nourishment?*—Because their stomachs are divided into three chambers: 1, the *paunch*, where the unchewed food is stored; 2, the *reticulum*, where portions of the food are received from the paunch and moistened and rolled into a cud, to be sent up and chewed; and, 3, the *psalterium*, which receives the masticated food, and continues the process of digestion.

290. *Why do quadrupeds that are vegetable-eaters feed so continually?*—Because their food contains but a small proportion of nutrition; so that it is necessary to digest a large quantity in order to obtain sufficient nourishment.

291. *Why do flesh-eating animals satisfy themselves with a rapid meal?*—Because the food they eat is rich in nutritious matter, and more readily digestible than vegetable food; it does not, therefore, require the same amount of grinding with the teeth.

292. *Why, if cattle run around in the field or yard, may thunder be expected?*—Because the elec-

trical state of the atmosphere has the effect of making them feel uneasy and irritable, and they chase each other about to get rid of the irritability.

(NOTE.—It sometimes happens that rational animals are more than usually irritable in such a disturbed state of the atmosphere. It is for the same reason that people feel their corns and decayed teeth ache, and their bones rheumatic, before a storm.)

293. *Why has the* HORSE *a smaller stomach, proportionately, than other animals?*—Because the horse was created for speed. Had he the ruminating stomach of the ox, he would be quite unfitted for the work which he now so admirably performs.

294. *Why is the lachrymal secretion of the horse's eye thick and glutinous, and not watery?*—Because, as his eye is large, and constantly exposed to dust on journeys, it is provided with a *viscid secretion*, which cleanses the eye, and more instantly and securely removes the dust, than a *watery* secretion would.

295. *Why do the furs of animals become thicker in the winter than in the summer?*—Because the *Creator* has thus provided for the preservation of the warmth of animals during the cold months of winter.

296. *Why is man born without a covering?*—Because man is the only animal that can clothe itself. As in the various pursuits of life he wanders to every part of the globe, he can adapt himself to all climates and to any season.

297. *Why are the eyes provided with eye-lids?*—Because the eyes require to be defended from floating particles in the air, and to be kept moist and clean. The eye-lids form the shutters of the eye, defending it when waking by closing upon its surface whenever danger is apprehended, moistening its surface when it becomes dry, and covering it securely during the hours of sleep.

298. *Why are the eye-lids fringed with the eye-lashes?*—Because the eye-lashes assist to modify the light, and to protect the eye, without actually closing the eye-lids. When the eye-lids are partially closed, as in very sunny or dusty weather, the eye-lashes cross each other, forming a kind of shady lattice-work; from the interspaces of which the eye looks out with advantage, and sees sufficiently for the guidance of the body.

299. *Why are we able to see at long or short distances?*—Because the *crystalline lens* of the eye is a movable body, and is pushed forward or drawn back, by fine muscular fibres, according to the distances of the object upon which we look. By these means its *focus* becomes adjusted.

300. *Why do we wink?*—Because by the repeated action of winking, the eye is kept moist and clean; and the watery fluid secreted by little glands in the eye-lids, and at the sides of the eye, is spread equally over the surface, instead of being allowed to accumulate. But the action of winking, or brightening the eye, is so instantaneous that it does not impede the sight.

301. *Why do we perspire?*—Because the skin is filled with very minute pores, which act as outlets for a portion of the water of the blood, that serves to moisten and cool the surface of the body, and to carry away some of the matter no longer needed in the system.

302. *Why does a sudden change from heat to cold bring on illness?*—Because the effect of cold arrests the action of the vessels of the skin, and suddenly throws upon the internal organs the excretory labour which the skin should have sustained.

303. *Why does a chill upon the skin frequently produce inflammation of the lungs?*—Because the

lungs and the skin together discharge the chief proportions of the watery fluid of the body. When the skin's action is checked, the lungs have to throw off a much greater amount of fluid. The lungs, therefore, become over-worked, and inflammatory action sets in.

304. *Why does cleanliness promote health?*—Because every atom of dirt which lodges upon the surface of the body serves to clog and check the working of those minute pores by which much of the fluid of the body is changed and purified. In the internal parts of the system, the CREATOR has made ample provision for cleanliness. Every organ is so constituted that it cleanses and lubricates itself. Every surface of the inner body is perfectly clean, and is as soft as silk. Nature leaves to man the care of those surfaces which are under his immediate observation and control; and he who, from idleness, or disregard of nature's laws, is guilty of personal neglect, opposes the evident intentions of the CREATOR, and must sooner or later pay the penalty of disobedience. A dirty person cannot be a good Christian, apart from consideration of comfort and decency.

305. *Why does exercise promote health?*—Because it assists all the functions on which life depends. It quickens the circulation, and thereby nourishes every part of the body, causing the bones to become firm, and the muscles to become full and healthy. It promotes breathing, by which oxygen is taken into the system, and carbon thrown off, and thereby it produces a higher degree of organic life and strength than would otherwise exist. It promotes perspiration, by which, through the millions of pores of the skin, much of the fluid of the body is changed and purified; and it induces a genial and diffused warmth, which is one of the chief conditions of a high degree of vitality.

(NOTES.—1. Questions and explanatory answers similar to the above and on the same and kindred subjects, might be multiplied to any extent; but I have selected and compiled these few as specimens, with a view of giving my young readers information on some objects and facts of everydays's observation and experience, and of suggesting to them how vast and varied a field of delightful and useful instruction is opened to them in the different branches of natural history involved in the foregoing questions and answers.

2. But a higher object proposed is, to direct attention to the evidence afforded by the facts thus explained and observed by everybody, of design, and a Designer; of law, and a Lawgiver; of order, and a Ruler; of benevolence, and a BENEVOLENT BEING, in what comes under our notice from day to day, as well as in the vast systems and laws of the universe. The student-reader must have been often impressed with this while mastering the lessons in the first part of this book, in considering the elementary substances by which we are surrounded, and their various combinations, the diversities of soils and minerals, the structure and growth of plants; but in the answer to each of the questions of the above lesson respecting water, plants, birds, or animals, there is proof of wonderful design and contrivance, to say nothing of wisdom, power and benevolence.

Take two or three examples which have, perhaps, made the least impression while reading the answers to the above questions. Look at the formation of ice, referred to in questions 247-249, and the fact and cause of its floating on the surface of the water, instead of sinking to the bottom. Now, all bodies—liquids as well as solids—expand by heat and contract by cold. Thus when heat is applied to the bottom of a kettle containing water, the particles heated expand, and thus become lighter in proportion to their bulk, and rise to the surface; giving place to the colder and heavier particles, which being heated in their turn, ascend; and this process continues until the whole liquid is of equal temperature, and if heated to a certain degree, will expand into steam and boil over. In cooling, the opposite process takes place; and even steam, which is water expanded to 1700 times its own dimensions will, on the application of cold, suddenly contract to its original dimensions; and the particles of water as they become cooler at the surface, sink to the bottom, and others warmer or of higher temperature, take their place, and this interchange goes on till the whole

body of the liquid becomes as cool as the surface. (It is thus the property of water, as of other liquids, to communicate both heat and cold, not so much by *conduction*—that is, from particle to particle, as in solid bodies—but by a *motion among the particles themselves.*) Now, according to this universal law, the particles of water contracting as they cool, and their relative specific gravity thus increasing, would constantly descend, and when the freezing point was reached, they would convert rivers and lakes, and seas and the ocean itself, into one solid mass of ice—the freezing beginning at the bottom and spreading upwards. The deep waters once frozen solid, would become the grave of all their inhabitants, and would be destroyed as a means of commerce, as they could not be thawed to the bottom by any known natural means: the heated particles being highest, would constantly float at the top, and the warmth, as in solids, could only be diffused by the slower process of *conduction,* which would be insufficient to thaw water of considerable depth in the intervals of cold and winter in our latitude.

But (and this is the point to which I wish to direct the reader's attention), mark the wise and beneficent provision of the CREATOR in modifying and reversing this universal law in the freezing of water, which is known to take place at 32 degrees above zero. Now, water continues to contract by the application of cold till it approaches within eight degrees of the freezing point; but here, without any cause known to man, the law is suddenly modified or reversed; for when the water is cooled down to 40°, instead of continuing to contract, it suddenly begins to expand, and proceeds to expand, till at 32° it becomes ice; and in the very act of freezing a further expansion takes place. Thus by this mysterious and beneficent operation, the specific gravity of ice becomes less than that of water, is prevented from sinking to the bottom, forms a bridge on the surface of the water, keeps the water underneath above the freezing point (for the most part at 40°), rendering it inhabitable to the finny tribes; and the ice thus formed on the surface of the water is exposed to the first return of a more genial temperature, ready to dissolve with the earliest influences of a warmer sun.

In all this the "fool's heart," and his foolish head, may acknowledge no God; but the thoughtful reader cannot fail to perceive "that the marked and salutary deviation, in this case, from the

law by which matter is expanded by heat and contracted by cold, is an arrangement of an intelligent and beneficent CREATOR."

Take two more illustrations of mechanical and creative design in regard to two insignificant creatures, referred to in questions 279 and 280—the *hook* in the wing of a *bat*, and the *tongue* of a *woodpecker*. "In the angle of the bat's wing," remarks Paley, in his *Natural Theology*, "is a bent claw, exactly in the form of a hook, by which the bat attaches itself to the sides of rocks, caves and buildings, laying hold of crevices, joinings, chinks and roughnesses. It hooks itself by this claw; remains suspended by this hold; takes its flight from this position; which operations *compensate* for the decrepitude of its legs and feet. Without her hook, the bat would be the most helpless of all animals. She can neither run upon her feet nor raise herself from the ground. These inabilities are made up to her by the contrivance in her wing; and in placing a claw on that part, the CREATOR has deviated from the analogy observed in winged animals."

"The *tongue of the woodpecker*," says Paley, "is one of those singularities which nature presents us with when a singular purpose is to be answered. It is a particular instrument for a particular use; and what except *design* ever produces such? The woodpecker lives chiefly upon insects, lodged in the bodies of decayed or decaying trees. For the purpose of boring into the wood, it is furnished with a bill, straight, hard, angular and sharp. When, by means of this piercer, it has reached the cells of the insect, then comes the office of its tongue; which tongue is, first, of such a length that the bird can dart it out three or four inches from the bill—in this respect differing greatly from every other species of bird; in the second place, it is tipped with a stiff, sharp, bony thorn; and, in the third place (which appears to me the most remarkable property of all), this *tip* is *dentated* on *both* sides, like the beard of an arrow or the barb of a hook. The description of the part declares its uses. The bird having exposed the retreats of the insects by the assistance of its bill, with a motion inconceivably quick, launches out at them this long tongue, transfixes them upon the barbed needle at the end of it, and thus draws its prey within its mouth. This is accomplished by a most curious piece of mechanism, thus: two curved cartilages, nearly as elastic as steel springs, pass from the bone which supports the tongue, to the back of the neck and round the head; a muscle is attached to the inner

curvature of each cartilage, and their combined action projects the tongue to a considerable distance. The elasticity of the cartilages retracts the tongue into the mouth. If this be not mechanism, what is?"

I leave the reader to draw the inferences and make the reflections for himself, in regard to the indications of contrivance, wisdom and benevolence suggested by the questions and answers of the foregoing lesson relative to various soils and plants, fishes, birds and animals. In contemplating these few of the wonderful works of nature, he can hardly otherwise than feel and say with the royal author of the 104th Psalm: "O Lord, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches."

That Divine Being, by the highest and most affecting considerations, claims our love and service, as well as our homage and worship.

INDEX AND EXPLANATION OF TERMS.

The *figures* in the following table refer to the *pages.* Explanation is given of many terms used but not defined in the book, and the less common terms are *accentuated*, to assist, as may be required, in their correct pronunciation.

ABDO'MEN, the region of the body containing the stomach, intestines, liver, spleen, pancreas, kidneys and bladder. It is lined by a serous membrane, called the peritone'um.

ABNOR'MAL, (from the Latin *ab*, from, and *norma*, a rule) irregular or unusual; not conformed to rule: applied to deviations from the ordinary development of parts of animals and plants.

ABSORB, to soak up a liquid, or to take substances from air or from watery solutions.

AC'ID, what, 26; carbonic, 27; nitric, 27; nitrous, 24; phosphoric, 27; sulphuric, 27.

AC'IDS, how formed, 27; how distinguished, 27, 28.

AC'RID, bitter, sharp, or pungent taste; as *acrid* salts.

AFFIN'ITY, in natural history, the close resemblance of animals and plants in their organization; in chemistry, the force which combines dissimilar bodies together in precise proportions, 23.

AGRICULTURE, 9; its dignity and importance, 9, 10.

ALBU'MEN, (from the Latin *albus*, white) a chemical term, denoting an organic substance which exists nearly pure in the white of an egg. Animal and vegetable albumen are of nearly the same composition—the substance surrounding the embryo in the seed.

AL'KALI, a term originally applied to the ashes of plants; the direct opposite of an *acid*, with which it has a tendency to unite, and of great importance in manufactures, 43–46.

AL'KALINE, having the properties of an alkali.

" earths, 46–48.

ALLOY', in chemistry, a compound of two or more metals (except mercury), as bronze is an alloy of copper and tin, brass an

alloy of copper and zinc, &c., 57–59. In *coinage*, alloy is baser metal mixed with a finer, 59–62.

ALLU'VIUM, a deposit formed of matter transported by rivers, floods, or currents of water.

AL'UM, sulphate of alumina and potash, 44.

ALU'MINA, 49; crystals of, 49; silicates of, 49.

ALU'MINUM, 48, 49.

AMAL'GAM, a compound of mercury with another metal, 57–64.

AMEND'MENTS OF SOILS, 105–113.

AMMO'NIA, volatile alkali, spirits of hartshorn, an important manure, 35.

AMPHIB'IOUS, having the faculty of living in two elements—on land and in water.

ANAL'YSIS, separating the components of any substance.

ANIMALS, organic and mineral parts of, 19; bones, hair, &c., for manure, 87; care and feeding of, in winter, 168, 169.

ANIMAL MANURES, 87, 88.

AN'NUALS, plants that grow, ripen their seed, and die in one year, 71.

ANTHER, 74.

AQ'UA FORTIS, nitric acid, usually diluted, 27.

AQUA REGIA, royal water, a mixture of nitric and muriatic acids, 65.

AR'ABLE LAND, fit for tilling.

ARGILLA'CEOUS SOILS, how improved, 105, 106.

ASHES, the incombustible part of animal and vegetable substances; quantity of, left by animals and plants; uses of, in manufactures, and as a manure, 98–100.

ASSIM'ILATE, to convert into a like substance, as *assimilated* by conversion into animal substances.

ATOM'IC WEIGHTS, or ATOMS, 21, 22.

AZOT'E, old name of nitrogen, 35.

BARLEY, proper land for, 81; how to grow, 128; when to harvest, 129.

BARN, properties of good, 163, 164.

BARREN LAND, 78.

BAT, curiosities of the, 195, 202.

BEAN, proper cultivation of, 139–141.

BEET, soils for, cultivation and care of, 149–151.

BIEN'NIALS, plants which do not bear flowers and seed till the *second* year, and then die, 71.

Bi'nary, by twos, or in pairs, as *acids* and *bases*, formed each by two elements united, 30.
Bleach'ing, 39, 40.
Bones, composition of and value as a manure, 88.
Botany, the branch of natural history which treats of the structure, properties and growth of plants from the largest tree to the simplest sea-weed.
Bran, value of, 184.
Britannia Metal, 57.
Bread, how to make and bake good, 182–184.
Brass, 59.
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Broom Corn, 161.
Buckwheat, culture, care and harvesting of, 138, 139.
Butter, how to make good, 178–181.

Cal'cium, 46; compounds of, and their mechanical uses, 46, 47.
Calor'ic, another name for heat.
Ca'lyx, 74.
Car'bon, 36; its uses, 36; compounds, 37.
Carbonates, 31, 32.
Carbonif'erous, coal-bearing.
Carburet'ted Hy'drogen, 37.
Ca'sein, 176.
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Caustic potash, 44.
Charcoal, 36.
Cheese, how to make good, 181, 182.
Chemical terms explained, 21–27.
Chemistry, the science which investigates the nature of matter, and the laws which govern the movements of its atoms.
Chlo'ride, 39.
Chlorine, 38; constituent of common salt, 39; bleaching properties of, 39.
Choke-damp, 36.
Churning, how butter should be churned, 180.
Cinnabar, 63.
Circulation in plants, 73.
Clay, a mixture of two simple earths, alumina and silica, 68; clay loam, 68; clay soils, 68; influence of air, frost and water on, 189.

CLOVER, soils for, 81; harvesting of, 156.
COKE, cinder of bituminous coals, after being heated for gas.
COLLAP'SE, falling together, as of the sides of a hollow vessel; loss of strength.
COMBINA'TIONS, in chemistry, the chemical union of atoms, whereby the sensible properties of the combining parts are altered, 24.
COMBIN'ING NUMBERS, 22.
COMBUS'TION, burning; the chemical combustion of a body is attended with heat or light.
COMMON SALT, as a manure, 101.
COM'POST, any compound of manures.
CONDUCTOR, any body which possesses the property of transferring or passing heat or electricity.
CONGELA'TION, freezing, or the act of a fluid passing into the state of ice or other solid form.
COOKING, importance of good, 171, 172.
COPPER, what and where found, 58; uses and alloys of in bell-metal, bronze, Dutch gold, German silver, &c., 59.
CORK, the bark of a species of oak which grows abundantly in Italy, Spain, Portugal, in southern provinces of France, and in South America.
CORN, applied *in Great Britain* to wheat, rye, oats, and barley, but *in America*, restricted, for the most part, to maize, or Indian corn, 138.
CORN, INDIAN, how to cultivate, 132–135; harvesting and care of 135–138.
COROLLA, 74.
COTYLE'DON, a seed lobe, or seed-leaf of seeds.
CREAM, composition and care of, 176–178.
CROPS, different kinds of, as grain, leguminous, esculent or root, 117, 118; rotation of, 113; how to secure good, 81.
CUD, in cattle, the food in first stomach, which is to be chewed over again, and passed into the third to be digested, 196.
CURD, the coagulated or thickened part of milk, which is formed into cheese, or, in some countries, eaten as food, 176.

DAIRY, where and how it should be kept, 178.
DECANTA'TION, pouring off the clear liquid from any sediment or deposit.
DECID'UOUS, falling off, withering; applied to plants whose leaves fall off in autumn, to distinguish them from evergreens.

Decomposi'tion, in chemistry, the separation of the constituent parts of any compound body or substance, whether organic or mineral.

Detri'tus, the pulverized remains or deposits of rocks. The larger fragments are usually termed *débris*.

Dew, the deposit of the water from the air produced by cold. As soon as the sun sets, the surface of the earth begins to cool by the radiation of its heat into space. The cold of the surface chills the air lying above it and causes the deposit of its water; hence the dew. If there are clouds present, the heat does not radiate from the earth. Dew, therefore, only falls on clear nights, and frost observes the same rule.

Dew Point, the temperature at which dew falls.

Dilu'vium, deposits of gravelly pebbles, sand, or superficial loam found upon ordinary rocks, caused by the deluge or by ancient currents of water.

Dorsal, belonging to the back.

Drainage, drawing off excess of water from lands by means of *drains*; kinds of drains, their depth and distance from each other, 109; summary of the advantages of, 109–112 construction of drains, 112, 113.

Drill, in husbandry, a long straight line, in which seeds or plant are set; or a row of grain sowed by a drill-plough.

Ductil'ity, property of being drawn out without breaking.

Dung, value of different kinds of, 89; how to preserve for manure, 89.

Econ'omy of the Farm, nature and importance of, 162–171.

Economy ofthe Household, remarks on, 171, 175.

Education of Farmers, 12, 13; of farmers' sons, 1–3; of farmers' daughters, 173, 174.

Elastic'ity, the power possessed by certain bodies to return back to their bulk or position when compressed or bent, as gases, India rubber, steel, &c.

El'ements and Elementary Bodies, simple substances, 20, 21.

Em'bryo, the growing point, eye or chit of a seed.

Endog'enous Plants, inside growers, 71.

Equiv'alent (chemical), 22, 23.

Es'culent Plants, 143.

Evapora'tion, the passing of solids or fluids into vapour.

EXCREMENT, the matter given out by the organs of plants and animals, being those parts of their food which they cannot assimilate.
EXOG'ENOUS PLANTS, outside growers, 71, 72

FARM ACCOUNTS, importance of, 170.
FARMER, his dignity, importance and education, 12–14.
FARM-YARD MANURE, 88, 89.
FELDSPAR, a simple mineral and leading constituent of granite.
FENCES, kinds of, economy of good, 165.
FERMENTATION, a kind of decomposition, 89.
FI'BRIN, the principal constituent of muscles, and exists in the blood and in some vegetables.
FIRE DAMP, 37
FLAX, soil for; cultivation and harvesting of, 158–160.
FLEXIBILITY, the capacity of bending without breaking.
FLOWER, 74; parts of, 74.
FODDER, how to be cared for and fed to cattle, 163, 164.
FRUITS, cultivation of, 157, 158.
FULLER'S EARTH, a clayey mineral, used for fulling, scouring and cleansing cloth, 49.
FUR, why next to the body of certain birds and animals, 193.
FUSIBILITY, the quality of being convertible from a solid to a liquid state by heat.

GAS, air, æriform matter.
GEMS, composition of various, 49–51.
GEOL'OGY, its relations to agriculture, 67.
GIZZARD, functions of, 194.
GLUE, how made, 19
GLUTEN, 18.
GOLD, how found, and properties of, 65, 66.
GRASSES, 152.
GREEN CROPS, 85; as manure, 85.
GUA'NO (Goo-ah'.no), 90, 91.
GUNPOWDER, 44.
GYPSUM, native sulphate of lime, converted into plaster-of-paris by heat, 31.

HAIR, as a manure, 87.
HAL'OID SALTS, 33.

HAY, when to be cut and how to be cared for, 154–156.
HEMP, culture and harvesting of, 160, 161.
HERBIV'OROUS, applied to plant or herb-eating animals, in contradistinction to *carnivorous* or flesh-eating animals.
HYDROGEN, 34.

ICE, mystery and wonders in the formation of, 188, 189, 200–202.
INDIAN CORN, 132–138.
INDIG'ENOUS, native of a country.
INGREDIENT, component part.
INORGANIC, mineral, without organs or organization, 16.
IRON, 51; uses of, 51; ores, 52; how produced, 52, 53; varieties of, 53.
IRRIGATION, methods and benefits of, 107, 108.

KA'LIUM, the Latin and former name of potassium, 21.

LAB'ORATORY, the workshop of a chemist.
LACTIC ACID, the acid of sour milk, 177.
LAM'INA, a thin leaf or slice of any thing.
LAUGHING GAS, 35.
LAV'A, substances which flow in a melted state from volcanoes.
LAWN, ground covered with the small perennial grasses, kept short by mowing, and usually situated in front of the house. When once established, a lawn requires little labour to be kept neat by the ordinary routine of rolling, mowing and sweeping, except keeping the surface perfectly even by filling up the small hollows with screened mould early in the spring.
LEAD, 61; compounds, alloys and uses of, 62; lead shot, how made, 62, 63.
LEAVES, structure and functions of, 73.
LEGUM'E, LEGUMEN, a *pod* fruit, as pea or bean, 117.
LEGU'MINOUS PLANTS, 117.
LIME, the oxide of calcium, and how produced, 46; mechanical uses of, 47; constituent of grains and vegetables, 47; constituent of good soils, 47; uses of as a manure, 96
LINSEED CAKE, LINSEED OIL, 160.
LIQUID MANURES, 89.
LIVE STOCK, the cattle, horses, sheep and swine, kept on the farm, 168.
LOAMY SOILS, 81.

LUCERN, French clover, a perennial, herbaceous, forage plant of the clover family.
LUCIFER MATCHES, 42.

MAGNESIA, MAGNESIUM, 47, 48.
MALIC ACID, the sour principle of apples and some other fruits.
MAMMALIA, the name of a class of animals which *suckle* their young.
MANGANESE, 55, 56.
MANURES, kinds of, 84, 85.
MARLS, 69, 95.
MATTER, how divided, 16.
MEADOW LANDS, 81, 82.
MENSTRUUM (plural, *menstrua*), any fluid which dissolves a given body.
MERCURY, or QUICK-SILVER, 63; where found and how used, 63, 64.
METALLOID, not metal, but resembling it, 29.
MEMBRANE, tissue of animal or vegetable matter.
MEMBRANOUS, skin-like body.
METALS, classification of, 29, 43.
MILK, how to take care of, 176, 177.
MINERAL MANURES, 91–104.
MINERALOGY, the science which examines and describes minerals.
MIXED MANURES, 88–92.
MURIATES, salts containing chlorine, mostly called chlorides: muriate of soda is common salt, 31.
MURIATIC ACID, or hydrochloric acid, 39.
MUSCLE, fleshy fibres, susceptible of contraction and relaxation, by which the phenomena of motion in animals take place.

NAILS, the horny extremities of the skin, modified into claws, talons, hoofs, &c., are of the same composition as the hair, and yield an equally valuable manure. 87.
NAPHTHA, 43.
NATRIUM, the German name of sodium, 45.
NATURAL HISTORY, a description of natural objects, whether minerals, plants or animals. These productions make up what are called *the three kingdoms of nature;* the *mineral kingdom,* including the earth, its rocks, metals, crystals, and all bodies not endowed with life, the history of which is called GEOLOGY

and MINERALOGY; the *vegetable kingdom*, comprehending vegetables and plants, the history of which is called BOTANY; the *animal kingdom*, embracing all animals, the history of which is called ZOÖLOGY.

MEUTRALIZE, to overcome the characteristic properties or effects of, 31, 32.

NIGHT SOIL, the contents of privies.

NITRATE, of ammonia, of potash, of soda, 35.

NITRATES, 31.

NITRE, salt petre, nitrate of potash, 31.

NITRIC ACID, 31; *nitrous acid, nitric oxide*, 24–27.

NI'TROGEN, 34, 35.

NOBLE METALS, 63.

NO'MENCLATURE, chemical, the system of naming, in which the structure of the terms employed expressed the composition of the substances to which they are applied; the most perfect found in any of the sciences, and very simple, giving the mind great power over the subject, 21.

NON-CONDUCTOR, a body which does not possess the property of transmitting heat or electricity, 193.

NORMAL, regular, according to established rule of principle.

NU'CLEUS, the kernal of a nut; the central part of any body, or that around which matter is collected.

NUTRI'TION, the act or process by which the growth of animals or plants is promoted, and by which the waste of animal bodies is repaired.

OAK, why its leaves are so abundant, 191.

OATS, how to cultivate and when to harvest, 130, 131.

OIL CAKE, 158.

ORCHARD, a collection of fruit trees; remarks on planting, 118, 157.

ORGANIC BODIES, 16; how distinguished from inorganic, 16.

ORGANIC CONSTITUENTS, of plants, 18; of animals, 19.

ORGAN'OGENS, 37.

O'VARY, 74.

OX, castrated male of neat cattle; called a *calf* until he is a year old, a *steer* until he is four years old, and after that an *ox* or *bullock*.

OXIDATION, OXIDIZING, a slow combution, or burning, 40; the act of combining with oxygen, 27.

Oxide, what, 26.
Oxygen, what, 33; forms compounds with acids and metals, 27, 28.
Parasite, a plant which attaches itself to other plants, or an animal which lives in or on the bodies of other animals—so as to subsist at their expense. The mistletoe is a parasitic plant, and the tick is a parasitic animal on the sheep.
Peas, soil suitable for, how to cultivate and harvest, 141, 142.
Peach Trees, how to renew, 118.
Peat, use of, 86.
Peat Lands, 82.
Parennial, plants that live several years, and bear flowers and fruit often, 71.
Petals, 74.
Phosphates, how formed, 42.
Phosphorous, what 41; its compounds and uses, 42.
Phosphuret'ted Hydrogen, 42.
Pistil, 74.
Plat'inum, what, and uses of, 65.
Plants, organic constituents of, 18; parts and organs of, 70; structure and functions of the roots, stem and leaves of, 71–73; flowers of, 74–76.
Pollen, 75.
Potash, how obtained, properties of, caustic, 44.
Potass'ium, what, and compounds of, 43.
Potato, composition of, 79; soil for, and how to cultivate, 143, 144.
Poultry, 170.
Preservation of Timber, 167, 168.
Pungent, pricking.
Pyrites, 52.

Quartz, 50.
Quick Lime, 46.
Quick Silver, mercury, 63, 64.

Radiate, to emit or send out from a point or surface, rays, as light or heat.
Radical, a base in chemistry.
Radicle, a little root; part of the embryo of the seed which grows downward, and bomes the roots.
Rags, woollen, richest of manure, 92.

Reservoir, a tank or artificial excavation to hold water.
Respira'tion, the art of breathing.
Roots of the Plants, 71.
Root Crops, 118, 143.
Rota'tion of Crops, reason for, object and principle of 113–116; advantages of, 116, 117; order of rotation of, 116–119; how practised in Great Britain and the United States, 119–122.
Ru'minant, an animal which chews the cud, and therefore has four stomachs, as the ox, sheep, or deer. *Ruminate*, to chew the cud, 195, 196.
Rural Economy, the management of all things, pertaining to the farm, and the farm household.
Rust, oxide of iron.
Rye, soils suitable for, and cultivation of, 81, 127, 128.

Safety Lamp, 37.
Sainfoin, a long rooted, perennial, leguminous plant with red flowers, which greatly improves the value of the calcareous soils.
Sal Ammo'niac, muriate or hydrochloric of ammonia.
Salpetre, 31–44.
Salts, what, 33; how named, 31, 32; common salt, 23; *Epsom salts*, 33–41; *Glauber salts*, 41.
Saturation, the impregnation of one body with another by affinity, till the receiving body can contain no more. *Saturate*, to *fill* the pores of any substance, as a sponge with water, or charcoal with ammonia.
Sepal, 74.
Sheep, manure of, 89; feeding and care of, 169, 170.
Sil'ica, and crystals of 50, 51; *silicate*. 50; *silex*, 50.
Silicic Acid, 50.
Sil'icon, 49, 50.
Silver, 64; how alloyed in English, French, German, and American coin, 64.
Soap, how made and kinds of, 45, 187.
Soda, 45; properties and compounds of, 45.
Sodium, 44, 45.
Soil, Soils, what and how made up, 66; origin of, 67: organic parts of, 67; inorganic parts of, 16; kinds of, 68, 69; fertile and barren compared, 78; how to conserve and improve, 82, 83; how to amend, 105; soils adapted to different grains and vegetables. 81, 82,

SOL'UBLE, susceptible of being dissolved in a fluid.
SOLU'TION, the act of dissolving a solid substance in liquid, leaving the liquid clear, as sugar or common salt in water. The liquid which effects the solution is called the *solvent.*
SOOT, uses of, as a manure, 101.
SPONGIO'LES, spongy tips of the rootlets or little roots.
STABLE, properties of a good, 164–169.
STALL-FEEDING, advantages of, 163–169.
STA'MEN, the principal organ of the flower, 74.
STARCH, what and how made, 18.
STEEL, how made, and varieties of, 54, 55.
STIGMA, the apex of the pistil, 75; *style,* 75.
STOMA'TA, pores or mouths of the cuticle or skin of flowering plants.
STRAW, ashes, care and uses of.
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SULPHATE, SULPHATES, SULPHITES, 31.
SULPHUR, 40; SULPHURET, sulphuretted, 41.
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TREES, why different kinds succeed each other 118; kinds and advantages of *shade trees,* 166, 167; age of, how determined, 72.
TUBERS, the fleshy enlargement of a stem, formed underground, consisting mostly of starch, having *eyes* or buds, as the common potato and artichoke.
TURNIP, cultivation, care and uses of, 144–147.
TYPE-METAL, of what composed, 62.

UNRIPE FRUIT, why sour, 191.

VAPOUR, the temporary gaseous condition of fluids; or, a visible fluid floating in the atmosphere, as steam, fog, or smoke.
VAS'CULAR, containing *vessels* or tubes.
VEGETABLE MANURES, 85, 86.
VITRIOL, oil of, sulphuric acid.

VIVIP'AROUS, producing *living* young, and not eggs, the producers of which are called *oviparous*, as birds, fishes, insects, and serpents.

WATER, composition of, 34; singular law of the freezing of, 188, 189, 200–202.
WOOD ASHES, how forming potash, 44; uses of, as a manure, 98, 99.
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GOÖLOGY, the history and classification of animals.

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