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The Royal School Series.

# ELEMENTARY LESSONS

IN THE

# PRINCIPLES OF AGRICULTURE.

*SPECIALLY ADAPTED TO THE REQUIREMENTS OF THE NEW CODE OF 1882.*

BY

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# PRINCIPLES OF AGRICULTURE.

## *PART I.—THE PRINCIPLES REGULATING THE GROWTH OF CROPS.*

## I.—THE CROPS OF THE BRITISH ISLES.

**1. Area of the Land—2. Cultivated and uncultivated Land—3. Crops of the British Isles—4. The Crops insufficient for the People.**

1. **Area of the Land.**—In measuring how much land there is in the British Isles, it is convenient to first state the extent in *square miles.* Just as a square inch is the space occupied by a square whose sides are each one inch in length, so is a square mile the tract of land included in a square each of whose four sides is *one mile* in length. Measuring in this way we get the following results :—

| | Square Miles. | Acres. |
|---|---|---|
| England and Wales | 58,000 | 37,120,000 |
| Scotland | 30,000 | 19,200,000 |
| Ireland | 32,000 | 20,480,000 |
| Total | 120,000 | 76,800,000 |

Farmers, however, are more used to reckon the area of land in *acres* than in square miles : to bring square miles to acres it is only necessary to multiply by 640, for there are 640 acres in one square mile. An acre itself contains 4,840 square yards, so that to form an idea of an acre it is a good plan to mark out a square yard upon the floor, and then to think of 4,840 such portions.

The table given above tells us that there are 120,000 square miles of land in the country we inhabit; and this, multiplied by 640, gives nearly seventy-seven million acres.

**2. Cultivated and uncultivated Land.**—But is the entire area of the British Isles—this seventy-seven million acres of land—under cultivation producing crops? Certainly not: there are great districts of mountainous country where bare rocks and steep hill-sides render cultivation impossible; elsewhere bogs and peat-mosses, or heaths, forests, and sandy wastes, abound; while houses, railroads, and canals cover much ground.

Altogether, there are at present about twenty-nine million acres of land in the British Isles which are not occupied for agricultural purposes, leaving forty-eight million acres on which are grown the crops of which we have to treat in this volume.

**3. Crops of the British Isles.**—We have now to mention the principal crops which are grown on the forty-eight million acres of land occupied by the farmers of the British Isles.

*Bare Fallow.*—First, we reduce the area by one million acres, because that area, or nearly so, lies in bare fallow, or unused, every year. There are many reasons for the waste, as it really is, of this quantity of land. The principal one is the bad seasons which farmers have had to contend with for the last few years, so that many of them have had to give up their farms, while their landlords have not always been able to find new tenants. Of course, most of the land which thus lies fallow is of a poor description.

*Permanent Pasture.*—The climate of the British Isles—moist and temperate—is specially favourable to the growth of a good turf. When we remember this we shall not be surprised to learn that not less than twenty-five million acres are in permanent pasture—that is, remain as old turf land, or grass land, which is yearly eaten by cattle and sheep, or mown for hay.

*Grain Crops.*—The tall cultivated grasses which we call *cereals*, and which yield our crops of grain, occupy ten million acres yearly. *Oats* occupies the largest area (about four and a half million acres), then wheat (three million acres), and barley (two and three-quarter million acres).

*Fodder Crops.*—By fodder or forage crops we mean such as clover, sainfoin, and grasses, which are sown in order to be cut and given to the live stock of the farm, or else fed off upon the land on which they grow. These plants are grown for their leaves and stems. A large extent of land—six and a half million acres—is occupied by these forage crops.

*Green Crops.*—The "green crops" are mainly root crops, and cover an area of four and three-quarter million acres. They include turnips, swedes, mangels, carrots, parsnips, kohl-rabi, the potato, etc.

*Miscellaneous Crops.*—The small area of cultivated land which remains, after the regions occupied by the crops mentioned above have been subtracted from the grand total, is occupied by certain plants which, although they may be of great interest, and even very profitable in the limited districts in which they are grown, are not of leading importance. *Flax* occupies 160,000 acres, nine-tenths of which lie in the north of Ireland. *Hops*, 60,000 acres, in Kent, Sussex, Hants, Worcester, and Hereford; a most profitable crop in good seasons, but very uncertain. *Hemp*, grown in Lincolnshire and Dorset. *Canary seed*, in Essex and Kent. *Teasels*, used in the manufacture of cloth, are grown on stiff clay soils in the southern counties. *Liquorice*, grown for the sake of the sweet juice which its roots contain, is grown near London and round Pontefract in Yorkshire.

*Orchards* occupy 190,000 acres, and *market-gardens* 50,000 acres.

Putting together these results, and adding up the areas occupied by the different crops mentioned, it will be found that we have now accounted for the forty-eight million acres (75,000 square miles) occupied by the crops of the British Isles.

**4. The Crops insufficient for the People.**—The population of the British Isles is now about thirty-five million, of whom twenty-six million live in England, five million in Ireland, and nearly four million in Scotland. This shows an immense increase during the last sixty years, for in 1821 the population was only a little more than twenty-one million. The consequence of so many people living in so small a country is that the crops are insufficient to supply them all with cheap food. For instance, the total wheat crop of the British Isles amounts to about eleven million quarters; but this was so far below our wants that in 1881 we had to import fourteen million quarters from other countries. Of this, the chief part (nine million quarters) came from the United States, although India, Russia, Australia, and Canada also sent large supplies. The value of this great quantity of wheat was no less than £31,500,000. But in the same year—and indeed every year—we imported wheat-flour to the value of over £9,000,000; for barley we paid the farmers of other countries £4,000,000; for oats, £3,750,000; and for maize (or Indian corn), £9,250,000. It is the same with meat, and indeed with every article of food. The quantity of meat imported in the same year was 1,815,000 cwt., of the value of £4,750,000.

## II.—PERMANENT PASTURE.

5. Meadows and Pastures—6. Geographical Distribution of Pastures—7. Clay-land and Pastures—8. Classification of Pastures—9. The Plants of the Meadow—10. The Battle in the Meadow.

**5. Meadows and Pastures.**—A meadow is a field which is permanently occupied by grass. When the grass is eaten off by animals, the field is called a pasture, and we say it is used for pasturage. But when the grass is allowed to grow, and is then made into hay, we call it "meadow-hay."

Some meadows are very old indeed; nothing but grass has grown on them, it may be for centuries, and such old meadow-land is usually covered with excellent turf. But of late years a great deal of arable or ploughed land has been converted into meadow or pasture land by being sown with grass seeds. We can usually tell this new pasture-land by the rounded ridges which were formed on its surface when it was under the plough.

**6. Geographical Distribution of Pastures.** — The grasses which grow in our meadows like a moist climate, rejoicing in abundance of rain. Now the rainfall of the British Isles is not equally distributed over the entire surface. In the east and south-east of England from 17 to 20 inches of rain fall every year; that is, if all the rain which falls in any one year were to remain on the surface just where it fell, it would cover the east and south-east of England to a depth of from 17 to 20 inches. But as we go westwards the rainfall increases. In the Midland Counties it is 25 inches; in Wales, 35 to 45 inches; in Scotland, 30 to 40 inches; and in Ireland, 30 to 50 inches.

The consequence of this unequal distribution of rain is, that there is much more permanent pasture on the western side of the British Isles than on the eastern. Ireland, indeed, has been named the "Emerald Isle" from the large extent of its pasture-land, and from its usually green and flourishing appearance, the result of the large amount of rain which falls in that country.

Still in every county we shall find a certain amount of permanent pasture. It is so useful and valuable that few farms are without a certain area of this meadow-land.

**7. Clay-land and Pastures.**—Stiff clays are rather difficult and expensive to cultivate. Hence we find that such soils are largely occupied by grass.

**8. Classification of Pastures.**—Besides the ordinary meadows, such as we may meet with on any farm, we may notice—

(1.) *Moors and hill-sides,* of which there is a great extent in Scotland, in Wales, and in the northern counties of England. Most of this is very poor land, the pasturage not letting for more than from five to ten shillings per acre. To the same class belong the slopes of the chalk downs in the south and south-east of England. These produce a short, sweet herbage, well fitted for the nourishment of sheep.

(2.) *The Commons*, or unenclosed land, of which in former times every village was possessed, and on which every villager had the right of pasturage.

(3.) Low, flat lands, bordering rivers and liable to floods. These are known as water-meadows, and

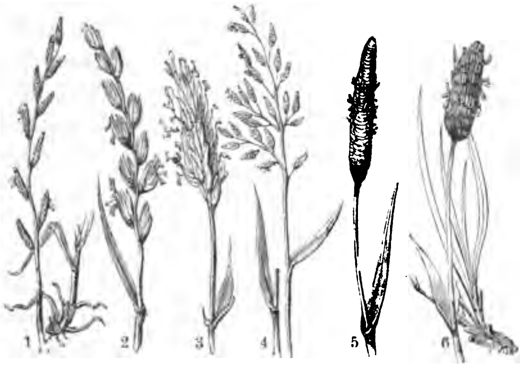

FIG. 1.—GRASSES.

1 Fescue Grass. 2. Ray Grass. 3. Meadow Foxtail Grass. 4. Meadow Fescue. 5. Catstail, or Timothy Grass. 6. Foxtail Grass.

yield a rich growth of grass in the driest summers. Such land is frequently of great value; for instance, the meadows of Somersetshire, which lie near the rivers Tone and Parret, are frequently let for as much as five pounds per acre.

(4.) *Irrigated Meadows*, so laid out that they can be supplied with water when required. We have already seen (in the second volume of this work) that the water so supplied acts to some extent as a manure, in addition to doing its proper work as a source of moisture.

**9. The Plants of the Meadow.**—The turf of good natural pasture-land should be composed mainly of certain species of grasses and clovers. The grasses which we desire to encourage are those which are hardy and will grow rapidly and regularly; they should be soft and juicy, but above all they must

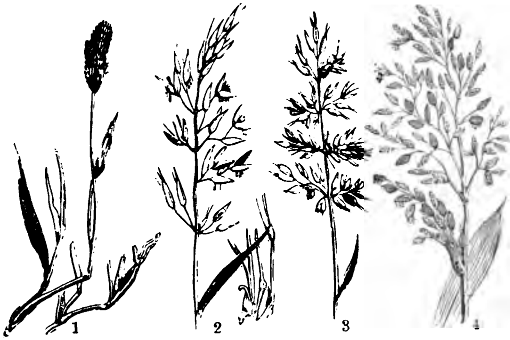


FIG. 2.--GRASSES.

1. Floating Foxtail Grass. 2. Oat Grass. 3. Yellow Oat Grass. 4. Meadow Grass.

be *nutritious*—that is, their leaves and stems must contain matters able to nourish the bodies of the animals which feed upon them. The following is a list of the *good* or "*sweet*" *grasses* whose growth we ought to try to promote:—

Meadow Foxtail Grass.
Catstail, or Timothy Grass.
Sweet Vernal Grass.
Ray Grass (or Rye-Grass).
Cocksfoot Grass.
Rough-stalked Meadow Grass.
Smooth-stalked Meadow Grass.
Meadow Fescue.
Sheep's Fescue.
Hairy Oat Grass.
Yellow Oat Grass.

Along with these grasses we shall be certain to find, in any good ordinary meadow, some one or more of the following species of clovers:—

Broad Clover, in rich land.
Zigzag Clover, in sandy ground.
Dutch Clover, in ordinary soils.
Strawberry-headed Clover, on wet land.

The farmer would be well pleased to see all his turf composed of a strong growth of the plants we have now named; but in all permanent pasture, even in the very best, a number of other plants are certain to be met with which are not so useful. These include the *rough* or "*sour*" grasses, called

| | |
|---|---|
| Brome Grass. | Wall Barley. |
| Couch Grass. | Water Meadow Grass. |
| Quaking Grass. | Tussac (or Hair) Grass. |

With these grow certain *weeds*, which will be more or less numerous according to the skill of the farmer. Where the pastures are properly drained, manured, and weeded, there the good nutritious grasses and clovers will thrive; but where there are neglect and carelessness the pastures will soon bear little else than a crop of weeds.

Of common weeds we may name—

(1.) Cowslip, daisy, rest-harrow, orchid, etc. Where these flourish the soil is pretty certain to be poor.

(2.) Thistles, docks, nettles, fox-glove, gorse, fern. An abundant growth of these weeds indicates careless farming. The thistles should be drawn or spudded, or if very numerous should be cut down with the scythe before they can seed. Nettles can soon be got rid of by mowing; they indicate good land, often growing on the site of an old garden.

(3.) The common rush, the various kinds of sedges, the lady's smock, docks, and the buttercup, indicate wet, ill-drained land; while the rushes and sedges tell that it is poor land also.

**10. The Battle in the Meadow.**—Botanists tell us of a continual strife between the various kinds of plants which grow in our pastures. There is neither enough plant-food nor room enough in the soil for *every* plant which tries to grow therein, and the "sweet" grasses and the clovers require much plant-food. If the land is poor, the rough grasses and the weeds increase at the expense of the better kinds of plants; for these "weeds," as all the useless plants may be called, are able to live and grow in places and under conditions where more highly cultivated plants would die. On the other hand, in manured and well-cultivated land, the nutritious grasses grow more rapidly than the poor ones. This fact ought to be a great encouragement to the farmer; he ought to try to aid the useful plants in their battle for life with the "weeds."

## III.—CULTIVATION OF GRASS LAND.

**11. Meadows and Pastures require Culture—12. How to cultivate Pasture-land—13. Preparations for Hay-making—14. Mowing-time—15. Processes of Hay-making—16. Composition of Grass and Hay.**

**11. Meadows and Pastures require Culture.**—Many men imagine that a meadow requires little care or cultivation; they think that if it is "let alone" the grass will grow, and that all will be well. But the fact is that grass land requires as much care as land under the plough.

**12. How to cultivate Pasture-land.**—In the first place, the *right sorts of grasses* must be grown. If the good grasses we have already named do not form the mass of the herbage, we must sow their seeds.

In grazing the pasture we must try to keep a *variety of stock* upon it. The grass will be eaten off more uniformly when horses, cattle, and sheep all feed together in a pasture than by one kind alone. Horses will graze the rank places which the cattle avoid; while the sheep will feed on many weeds, especially the buttercup, which the other animals dislike.

Pastures must *not be grazed too closely*, especially in winter. If all, or nearly all, the leaves of grass be eaten off, the plant cannot grow well, for plants feed by their leaves as well as by their roots; moreover, the grass leaves act as a covering, protecting the ground from the effects of severe frosts. It is therefore a good plan to clear the pastures of stock at Christmas, and allow two or three months for the healthy, undisturbed growth of grass. Meadows and pastures should be well *rolled* in the spring; when manure is applied, it should be followed by the *chain* or *bush harrow*, to comb the manure into the roots.

Grass-land requires manuring. The droppings of the stock fed on the land must be frequently spread over the surface, or they will cause a very rank growth in patches here and there. But we must also return to the land the salts of lime which have gone to form the bones of the animals feeding on it: this is best done by the application of superphosphate of lime at the rate of 3 or 4 cwt. per acre, or bone manure (5 cwt.), or a plentiful dressing with farm-yard manure.

In considering the most profitable use to make of a pasture, we may say that if the soil be strong and rich in plant-food, producing a rapid growth of juicy grasses, it will fatten cattle quickly; if it be ordinary soil, it will be better fitted for the purposes of a dairy-farm; while if the land be dry and hilly, it is well adapted for the rearing of sheep.

**13. Preparations for Hay-making.**—In the meadows which are devoted to the growth of hay, the stock must be cleared off the land in time to allow of the proper growth of the grass to be mown. If the land is in poor condition, the stock must be removed before Christmas; but rich land may be grazed until March or April without injury. In any case the meadows must be well manured if a good hay-crop is desired. It is an excellent plan to feed sheep with roots and oil-cake on the meadows during the winter, especially if the arable land be stiff and wet.

All sticks and stones should be picked off the meadows early in spring, or they will interfere with the cutting. At the same time, a dressing of guano or nitrate of soda should be applied to any bare places, so as to get as uniform a growth of grass as possible.

**14. Mowing-time.**—Our object should be to cut the grass at the time when it contains the largest amount of nutritious substances, which will be when it has just come into flower. In the south of England the early part of June usually finds the haymakers at work; in the middle of the same month the hay-harvest of the Midlands commences; while it is not till the end of June, or the early part of July, that the Scottish farmers are able to secure their hay.

**15. Processes of Hay-making.** — (1) The grass is best *cut* early in the day with a mowing-machine, which will get over about eight acres per day; it is laid with the machine or with the scythe in long rows called swathes. (2) The grass must then be spread out either with hand-rakes or with a teddingmachine, and left exposed for several hours to the drying action of the sun and wind. (3) The further treatment of the hay varies in different parts of the country; but in the counties round London, a district in which perhaps the best hay in England is made, the next step is to draw the grass loosely together into long lines called *wind-*

FIG. 3.—HAY-MAKING.

*rows,* in which it continues to dry till evening. (4) The work of the first day is concluded by drawing the windrows into small heaps called *foot-cocks,* in which it remains all night. (5) On the second day the same grass is once more spread over the field for several hours, and then (6) again raked into windrows. By the morning of the third day the grass is fairly dry, and it is then (7) collected into large heaps, in which it slightly ferments or "sweats." Lastly (8), the hay is carried to the stack. The best hay is made in dry, sunless weather, with gentle winds; it should be of a greenish tint. A hay-barn is much better than a thatched rick. But however the hay is stacked, it has a tendency to heat; not unfrequently, if the hay has been carried too soon, it heats so much, by fermentation taking place in the rick, that the whole takes fire and is destroyed. To prevent this, a long iron rod may be thrust into the rick: if the rod should feel too hot when withdrawn, the rick must be quickly cut into and laid open. As, however, "prevention is better than cure," farmers often build bundles of straw into the stack, so as to form passages by which the heated air from the interior of the stack may escape. In any case the hay-stacks must be carefully watched for at least a month after they are made, to see if there are any signs of over-heating. As the hay lies in the stack, it ripens, so that old hay is superior, as a food, to new hay.

**16. Composition of Grass and Hay.** — The chief difference between the grass growing in the meadow and the same grass after it has been made into hay, consists in the smaller proportion of water contained in the hay. In 100 lbs. weight of freshly-cut grass there will usually be 75 lbs. of water; while in the same weight of hay there will be some 15 lbs. weight of water only. In consequence of this loss of water, we find that the produce of an acre of meadow-land—say five tons by weight of grass—only yields about a ton and a half of hay. Meadow-hay is much used for feeding dairy cows; while clover-hay, which contains more flesh-forming matter, is better for horses and sheep. A table is given on page 102 which clearly shows the great superiority of hay over grass—weight for weight—as food.

## IV.—CEREAL CROPS: WHEAT.

**17. Arable Land—18. Cereals—19. Origin of Wheat—20. Soil and Climate for Wheat—21. Choice of Seed—22. Varieties of Wheat—23. Seed-sowing—24. Cultivation of Wheat—25. Harvesting—26. Storage of Wheat.**

**17. Arable Land.**—On any ordinary farm the land may be divided into two parts—(1) that which is in permanent pasture; and (2) that which is under the plough. To the latter portion the term *arable* is applied, from the Latin word *aro*, I plough.

**18. Cereals.** — We apply the name of cereals to all those grasses which are cultivated for the sake of their seeds. No doubt they all were once wild species, such as may still be found growing in almost every country; but by cultivation for thousands of years the cereals have been so altered in appearance that we cannot be certain as to the exact kinds of wild grasses from which they have been derived. The most commonly cultivated cereals are *Wheat*, *Barley*, *Oats*, and *Rye*.

**19. Origin of Wheat.**—Wheat has been cultivated for a very long period. Grains of wheat, certainly not less than four thousand or five thousand years old, have been found; and although these grains are a little smaller, yet there is hardly any difference between them and the wheat-grains grown last year. It is believed that wheat is the result of the cultivation of a grass which grows wild in the countries bordering the Mediterranean Sea. Experiments which have been tried on this wild grass show that when it is supplied with abundance of plant-food, and placed in other respects under favourable conditions, it increases in size, and its ears and seeds become larger and heavier, until after a few years of cultivation they much resemble ordinary wheat.

FIG. 4.—WHEAT.

And if we were to neglect a wheat crop, if year after year we were to pay no attention to the plants of wheat, but suffer their seeds to sow themselves in a poor soil, we should soon find a decrease in the size of the plant, and in the number and weight of the grains in each year; and at last, after many years, the uncared-for wheat would either die out or return to the condition of a wild grass.

**20. Soil and Climate for Wheat.**—Wheat rejoices in a deep clayey loam, with a dry subsoil. It grows best in a rather dry and warm climate, like that of the middle, south, and south-east of England. Of the three million of acres on which wheat is usually grown in the British Isles, fully two and a half million lie in England. The climate of Scotland is rather too cold for wheat; while that of Ireland is too damp. The English counties especially noted for wheat are Lincolnshire, Norfolk, Suffolk, and Essex.

**21. Choice of Seed.**—The use of good seed makes an immense difference in the wheat crop. Farm

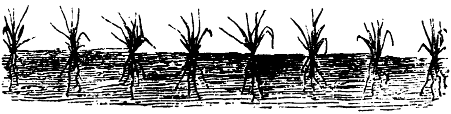

FIG. 5.—Wheat in Close Drills, Untillered.

seeds of all kinds can be greatly improved by care in their growth and selection; and this is so well known that the growth of plants for seed has now become quite a separate branch of farming, which is carried on very profitably by men who have devoted much care and time to the subject.

Wheat has been greatly improved within the last twenty years by carefully cultivating a good sort, then selecting the best grains of the best ears of the best plants, and sowing these only for a second crop. When this process is repeated over and over again, it is found that the final result—the last crop—shows an immense improvement on the first one. Wheat which has been grown in this way is called *pedigree wheat.*

**22. Varieties of Wheat.**—Many names have been given to wheat plants which differ a little from one another; but they may all be classed under a few main heads. There are *autumn* wheat and *spring* wheat, for example, so called because they are sown at these seasons of the year; yet by gradually sowing autumn wheat later and later, or spring wheat earlier and earlier, one kind may be made to change into the other. The *red* and the *white* wheats are so named from the different colours of the grains.

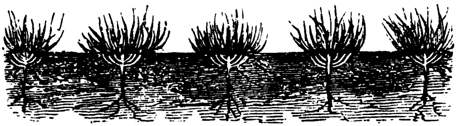

FIG. 6.—Wheat Tillered out; wide apart, well hoed.

Red wheat is the hardier of the two, and is therefore grown in the colder and wetter districts; while the white wheat produces the finest quality of flour. Again, we have bearded and beardless wheat; the ears of the former bearing awns, while the latter has none. *Rivetts wheat* has a coarse straw, with a yellowish grain. It is well suited for poor soils.

**23. Seed-sowing.** — The months of October and November are the best in which to sow wheat. About six pecks of seed-corn should be allowed to an acre. The plan of sowing the seed in drills by means of a machine is better than the old plan of sowing "broadcast;" that is, scattering the seed over the soil by hand. Dibbling is sometimes adopted, the seeds being dropped singly into separate holes in the ground. There is no machine, however, which can do this well; and the hand-dibbling of wheat is very expensive.

**24. Cultivation of Wheat.**—The young wheat-plant makes much growth, chiefly by its roots, be-

FIG. 7.—WHEAT HOE AT WORK.

fore the severe cold of winter sets in. In spring the wheat-land should be well rolled, to press the earth firmly to the plant. As the wheat-plant makes more growth, the spaces between the drills should be hoed, to destroy weeds and open the soil. Wheat is a deep-rooted plant; its roots go down two or three feet in search of moisture and plant-food.

**25. Harvesting.**—The greater part of the wheat crop is reaped during the month of August. Reaping-machines, which also bind the sheaves by means of string or wire, are now largely employed. The crop should be cut when the upper part of the straw is turning yellow, and when the wheat grains no longer yield a milky juice when pressed between the fingers. If allowed to stand until "dead-ripe," the outer coats of the grains thicken at the expense of the contents inside, and the result, when the wheat is ground, is less flour and more bran.

When the sheaves of corn are made, they are set in stooks (each composed of five sheaves) and left till dry, when they are carted to a rick and thatched. The average cost of reaping an acre of wheat is about twelve shillings. The average yield for this country generally may be stated as 28 bushels per acre. On good land, however, 40 bushels per acre are not uncommon; while instances are known where even 80 or 100 bushels have been obtained. The prospect of such crops ought to encourage every farmer to study carefully the science of agriculture, and to endeavour to combine "practice with science" in the cultivation of his land, for in that way only can such remarkable results be obtained.

**26. Storage of Wheat.**—The wheat-stacks ought to be raised a foot or two above the ground, in order to keep out rats and mice and promote ventilation: iron stands or staddles are now used for this purpose. The stacks should be about sixteen feet in height, and the same in thickness, but three feet wider at the eaves than at the base.

The old method of thrashing out wheat with the flail has now been almost entirely superseded by the use of steam-power, which does the work at about one-quarter of the cost.

## V.—CEREAL CROPS: BARLEY, OATS, ETC.

**27. Growth of Barley—28. Malting Barley—29. Feeding Barley—30. Cultivation of Barley—31. Growth of the Oat—32. Seed Oats—33. Cultivation of Oats—34. Feeding Qualities of Oats—35. Rye as a Grain Crop—36. Prices of Cereals—37. Diseases of Cereals.**

**27. Growth of Barley.**—Barley, like wheat, is a grass which is cultivated for the sake of its seeds. The ordinary spring barley has its grains arranged on the ear in two rows; a variety known as *bere* has four or even six rows on each ear. Of the two and three-quarter million acres usually sown with barley in the British Isles, only about two million lie in England; so that Scotland and Ireland each grow a much larger proportion of barley than of wheat.

**28. Malting Barley.**—The best soil for barley must be considered with reference to the object for which the barley is grown. Many farmers grow barley for the purpose of making *malt*, since barley suitable for this purpose fetches the highest price. Malting barley grows best on light land, rich in lime, such as chalky soils or sandy loams; there is less straw, but the grains are large, plump, and thin-skinned, containing much starch. Now, a large quantity of starch is what the brewer requires in the malt; for it is this starch which, in the process of brewing, becomes changed, first into sugar, and afterwards into the alcohol which gives strength to the beer produced. Fine malting barley fetches a high price: in 1881 the average of the best samples was forty-six shillings, and in 1882 fifty shillings, per quarter.

FIG. 8.
BARLEY EAR.

**29. Feeding Barley.**—On clays and loams a greater weight both of barley-straw and grain can be obtained, and the grains contain a larger amount of nutritious or flesh-forming material. Such barley is therefore excellent for feeding purposes. Barley-meal is much used for fattening cattle and pigs, and horses like it in the form of a boiled mash. When the outer coatings of the grain are rubbed off, it is known as pot or pearl barley, and in this form is much used for barley-broth, and in soups, stews, etc. In the Lowlands of Scotland barley cakes or "bannocks" are still eaten.

**30. Cultivation of Barley.**—Barley is commonly made to follow a turnip crop which has been fed off by sheep. The droppings of the sheep are ploughed in, and from 2½ to 3 bushels of seed barley are sown per acre on the soft fresh furrow. March is the best month for sowing barley, although the variety called bere may be sown, in cases of necessity, as late as May. Barley is a shallow-rooted plant, and hence, on rich, well-cultivated land, excellent crops of barley have been grown immediately following equally good crops of wheat. The wheat draws its nourishment chiefly from the lower part of the soil, while the barley obtains its supplies of plant-food mainly from the surface layer. Where this plan is adopted the wheat-stubbles should be steam-ploughed in autumn, and the surface left as rough as possible, that the winter frosts and weather may exert their full influence on the soil, breaking it up to a fine powder, and changing dormant matter into active plant-food. On heavy soils the application of super-phosphate of lime at the rate of 3 cwt. per acre at sowing-time will be well repaid by a heavy weight of grain; while nitrate of soda (½ cwt. per acre) will produce much straw.

FIG. 9.
COMMON BERE.

On good land the average yield of barley may be reckoned at 36 bushels per acre. It should not be cut until the ears drop and the reddish colour disappears; it is then perfectly ripe. It may be cut either with the scythe or with a reaping-machine; but care must be taken during this operation, or the ripe ears will break off and the seeds spill out. Good barley, well grown and well harvested, should weigh from 52 to 56 lbs. per bushel.

Barley likes a well-worked dry seed-bed. If heavy rains should come on during sowing, it is a good plan to stop the sowing and wait for a few days until the soil has again become fairly dry. This is a matter in which the farmer must exercise good judgment, and he will be well repaid for his thoughtfulness by a heavier crop.

## OATS.

**31. Growth of the Oat.**—In the oat we have a corn-producing grass which differs from wheat and barley in the loose arrangement of its seeds on the stalk, forming what is botanically termed a *panicle*, and so differing from the close and compact manner in which the seeds of wheat and barley are packed in the ear.

The oat is a *hardy* plant, well able to bear cold and moisture. This accounts for the large acreage occupied by this crop in northern countries, amounting to over one million acres in Scotland, and to nearly one and a half million acres in Ireland; but oats are also largely grown in the north and west of England and in Wales, where they occupy nearly two million acres.

**32. Seed Oats.**—By careful selection of the seed, oats have been greatly improved within the last century. Names have been given to many varieties of oats, and there are perhaps a dozen sorts in common use, including the Potato Oat, Poland, Tartarian (white and black), Canadian, Hopetoun, and Tam Finlay Oats. A recent introduction is the Swiss Oat, from the warm valleys of Switzerland, which ripens two or three weeks earlier than any other sort. This is a valuable quality, for it may

FIG. 10.—OATS.

make all the difference between a good and a bad harvest. The oat grows to great perfection in

Scotland, and seed-oats from Scotland are much prized. In the cultivation of oats, and indeed of plants generally, it is important to have an occasional *change of seed.* Now the hardy seed of oats grown in the cold climate of Scotland produces splendid crops when sown in the rich soil and under the brighter skies of England. On the Highland farms of Scotland, in the damp fields of Ireland, and everywhere under conditions of climate and temperature which often would be fatal to wheat or to barley, the oat struggles bravely, and generally yields a fair crop.

**33. Cultivation of Oats.**—Oats are sown at the rate of four bushels to the acre, in the months of March and April. The plant has very strong roots, and delights in abundance of organic matter in the soil; hence oats are often sown on grass land which has lately been ploughed up, for the rootlets push their way vigorously through the sods and feed upon the decaying vegetable matter. For the same reason oats are almost always chosen as the first crop on peat or moorland, or on old turf, which is about to be broken up and brought under the plough.

The oat is a very large cropper. On suitable ground it yields an average of 50 bushels per acre, and will produce from 35 to 40 bushels on poor ground. The weight of grain to the bushel is usually from 35 to 40 lbs. But crops of even 80 bushels of oats per acre can be obtained on suitable land by good farming. As an instance of the effect of proper cultivation on the oat crop, it was found that the crop in a certain thoroughly well-cultivated field yielded 50 bushels per acre, weighing 43 lbs. per bushel; in an adjoining field, of precisely the same land, but which belonged to another farm, and had been much neglected, the oat crop of the same year was only 10 bushels per acre, weighing 22 lbs. per bushel!

**34. Feeding Qualities of Oats.**—The oat contains a large proportion—about 15 lbs. in 100—of a flesh-forming substance called *fibrin*. In addition, there are (in 100 lbs. of oatmeal) 10 lbs. of fat and 63 lbs. of starch. Oatmeal is the national food of the Scots, and the size, strength, and healthy appearance of Scottish people generally is a good testimony to the nutritious properties of oatmeal.

Horses are largely fed upon oats, but new oats should not, as every groom and ploughman knows, be given to them. When oats are reaped and stacked the grains are not fully ripened. Lying in the stack, the frosts of winter, combined with the moderate warmth produced by their close packing, complete the work of maturing the flesh-forming matters contained in the grain. *Old oats* form an admirable food for horses in hard work.

## RYE.

**35. Rye as a Grain Crop.**—Rye is the hardiest of the cereals cultivated in the British Isles. It will grow on poor sandy soils, and is able to bear a severe climate. Although the quantity of rye sown as a grain crop amounts to only 50,000 acres, yet this does not measure the full extent of its cultivation, since it is also sown to be cut when green for fodder. Rye is sown in autumn, at the rate of two bushels per acre, and is ready for the scythe in July, yielding from 30 to 40 bushels per acre. The straw makes excellent thatch.

FIG. 11.—RYE.

The "black bread" eaten by the peasantry of Russia and North Germany is made from the rye which is very extensively grown on the sandy plains of those countries.

**36. Prices of Cereals.**—Our grain crops are usually sold by the "quarter." In considering the selling price of each kind of grain, we must remember that they differ much in weight. Thus—

| | | | | |
|---|---|---|---|---|
| One quarter of | wheat | weighs | 485½ | lbs. |
| ,, | barley | ,, | 400 | ,, |
| ,, | oats | ,, | 308 | ,, |

The average price of all kinds of grain is now much lower than it was in the early part of this century; and it is not probable that it will rise much higher than it is at present. The reason of this is that immense crops of grain are now grown in several foreign countries, so that if a bad season should spoil the crops in one country, another will be pretty certain to make up for it. Indeed, we now import, every year, more grain from abroad than we grow in England. In 1884 the average price of white wheat was from 40s. to 50s. per quarter, according to the quality; of red wheat, from 40s. to 45s.; of malting barley, 40s.; of ordinary barley, 35s.; and of oats, 22s. per quarter.

**37. Diseases of Cereals.**—Young wheat frequently suffers from the wire-worm. The ears of all grain-crops often show the disease called *smut*, by which the grain is changed into a black powder. *Smut-ball* or *bunt* has a similar appearance, but affects wheat only. To cure "smut" and "bunt," we must use clean seed, and also pickle the seed before sowing. Dissolve half a pound of blue vitriol (sulphate of copper) in a gallon of water, and use it to wet every grain of each sack of wheat.

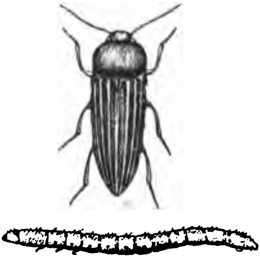

FIG. 12.—CLICK-BEETLE AND WIRE-WORM.

*Rust*, *blight*, and *mildew* are names given to diseases which attack the stems and leaves of cereals and other plants. They first appear as small discoloured patches, and gradually spread over the entire plant. This is due to several extremely small species of plants belonging to the fungus tribe, which can only be seen distinctly with a powerful microscope. The germs or seeds of these fungi settle upon the plants and live on their juices, thus doing much injury.

## VI.—LEGUMINOUS CROPS: BEANS AND PEASE.

38. How to distinguish Leguminous Plants—39. Cultivation of Beans—40. The Bean Crop—41. Beans as Food—42. Growth of Pease—43. Cultivation of Pease.

**38. How to distinguish Leguminous Plants.**—The plants of which we have now to speak contain, in their seeds, a large quantity of a flesh-forming substance called *legumin*, which strongly resembles the part of milk (called *casein*) from which cheese is made; hence these plants have received the name of the *leguminous* class or tribe.

To distinguish leguminous plants we must examine their *flowers*, which are constructed in a very remarkable manner. The brightly-coloured petals which form the corolla are five in number, and of varying shapes; the two smallest petals are partly united, and form the lower part of the flower (the *keel*); there is one petal placed on each side (the *wings*); while at the back rises a single large petal called the standard. (See Fig. 13.) No doubt the object of this large, brightly-coloured, sweet-scented flower is to attract insects, so that the pollen may be carried from flower to flower, and the formation of strong, healthy seeds thereby secured.

Many species of leguminous plants are grown by British farmers, but in this chapter we shall only speak of two which are grown mainly for the sake

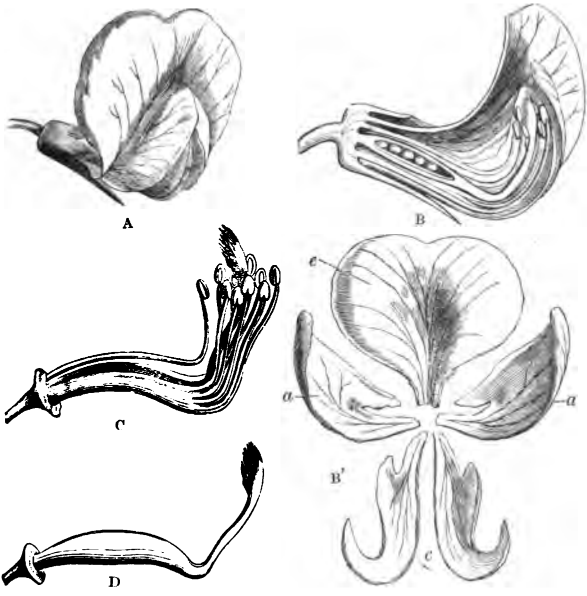


FIG. 13.—A, Flower of the Pea. B, Section of same. B', Parts of the Corolla: *c*, the Keel; *a*, *a*, Wings; *e*, Standard. C, Stamens and Pistil. D, Pistil.

of their seeds—that is, beans and pease; or, as they may be called collectively, *pulse*.

**39. Cultivation of Beans.**—Beans like a strong clayey or loamy soil, and large quantities are grown in the rotation with wheat on the rich soils of the eastern and south-eastern counties of England. The total area sown with beans in the British Isles in any one year may be taken to average half a million acres. There are two principal sorts of field beans—(1) the Scotch or horse bean, and (2) the tick bean.

FIG. 14.—BEAN.

Besides these, there are many varieties of garden beans, such as the long pod and broad windsor.

Beans may be sown either in the autumn (October or November) or in the early spring, not later than March. Three to four bushels of seed-beans to the acre may be sown, either in rows or broadcast. The land must be in good condition and thoroughly well manured to grow good crops of beans, for top-dressings of manure applied while the plant is growing seem to have but little effect. The seed-beans are best sown in rows twenty inches apart, as they can then be easily hoed after the plants are up.

**40. The Bean Crop.**—The produce of beans is about equal to that of wheat, yielding an average of about 30 bushels per acre. It is ready for harvest at the end of July. After being cut and allowed to dry, the beans are tied into sheaves and set in stooks for two or three days, after which they are carted to the rick. Although beans are a precarious crop while growing, suffering from winter frosts, and from blight, mildew, and various insect foes, yet after the seeds in the pod have hardened, beans will stand bad weather extremely well.

**41. Beans as Food.**—Field beans are not used as food for man, but *old beans* are an excellent food for cattle, horses, and pigs, especially when ground into bean-meal. In 100 lbs. of beans there are 23 lbs. of flesh-forming material (legumin), 55 lbs. of heat-givers (chiefly starch), about 3 lbs. of mineral or bone-making food, and only 14 lbs. of water.

## PEASE.

**42. Growth of Pease.**—Pease are not cultivated so extensively as beans, the total area under this crop in the British Isles being less than 200,000 acres. Large quantities of the early sorts are grown near towns for sale while green; while it is estimated that one-third of the whole crop is grown in the four counties of Essex, Kent, Lincoln, and Suffolk.

**43. Cultivation of Pease.**—Pease rejoice in a rather light or loamy soil, containing much lime. They are often sown as a mixed crop with beans, and their long twining stems are then used to tie up the sheaves of beans.

They should be sown by the drill, in rows fifteen inches apart, in February, at the rate of three bushels per acre, the seed being placed about two inches deep. The roots of pease lie near the surface, and this plant is therefore a *surface-feeder*. Pease grow and ripen quickly, and are generally the first "corn" crop to be harvested. They yield an average of 32 bushels per acre.

The straw of both beans and pease is a useful fodder, containing more nutritious matter than the straw of the cereals, and approaching hay in value.

Pease are not now cultivated to anything like the extent they formerly were; the reason probably being that as a crop they depend much upon the weather, not succeeding well in moist seasons, such as we have lately had for several years in succession.

Pease will not only grow on a lighter class of soil than beans, but on a *shallower* soil, since the roots lie nearer to the surface. After sowing, the fields should be watched to prevent the ravages of birds, especially pigeons, which turn over the soil and pick out the newly-sown pease with their bills.

Both beans and pease suffer much from the attack of a fungus or "blight," and from numerous insect foes, chiefly of the beetle tribe.

## VII.—FODDER CROPS: CLOVER.

44. Plants grown for Fodder—45. Leguminous Plants grown for Fodder: growth of Clover—46. Varieties of Clover—47. Cultivation of Clover—48. What to do with the Clover Crop—49. Aftermath.

**44. Plants grown for Fodder.**—By fodder or forage crops we here mean those which are grown in order to be cut in a green state, and the leaves and stems given as food to the stock of the farm. The plants grown for this object include—

| | |
|---|---|
| 1. Common Red Clover | Leguminous Plants grown for Fodder. |
| 2. Zigzag or "Cow-grass" Clover | |
| 3. Crimson Clover | |
| 4. White or Dutch Clover | |
| 5. Alsike or Swedish Clover | |
| 6. Yellow Trefoil or Hop Clover | |
| 7. Common Vetch or Tare | |
| 8. Lucerne | |
| 9. Sainfoin | |
| 10. Rape | Crucifers. |
| 11. Mustard | |
| 12. Cattle Cabbage | |
| 13. Rye | A grass. |

Of these thirteen plants, the first nine belong to the leguminous tribe; the next three belong to another family of plants called the *Crucifers*, or cross-bearers, because the four petals of their flowers are arranged in the form of a cross; while the last plant—rye—

is, as we have already learned, a grass. Just as some grasses (the cereals) are cultivated for the sake of their seeds, while others are mown for hay or eaten on pastures, so, of the leguminous plants, we see that while pease and beans are grown to be harvested as "corn" crops, numerous other plants of the same family are grown for the sake of their stems and leaves, which yield a succulent food for stock, mixing well with such drier foods as oats, beans, etc.

Of the six and a half million acres occupied by fodder crops, about one-third lies in Ireland. Very large crops of clover are also grown in Lancashire, Cheshire, and North Wales.

**45. Leguminous Plants grown for Fodder: growth of Clover.**—Clover is one of the most useful crops which a farmer can grow. While its broad leaves absorb nitrogen (in the form of ammonia) from the air, its roots are busily at work in the ground collecting and storing up a large amount of plant-food. When the leaves and stems of the clover-plant are cut or eaten, the roots remain in the soil, and by their slow decay furnish a rich supply of plant-food to the next crop, while they also render the soil more open and moist.

**46. Varieties of Clover.**—The common broad or red clover is the kind most generally grown. The zigzag clover is so named from the manner in which its stem bends first in one direction and then in another; it flowers later than the red clover, which it much resembles in appearance. The white or Dutch clover grows in good pasture land; each stem bears a single head of flowers. Sheep are very fond of it. Crimson clover gives one excellent hay crop. Alsike or Swedish clover, on the contrary, will grow strongly for two or three years in succession, yielding a very fair crop each year. It has a pink flower, and bears cold and wet well.

**47. Cultivation of Clover.**—Red clover is sown in spring, along with the barley or among the young wheat, at the rate of from 15 to 20 lbs. per acre. When the corn is cut, the young clover remains the sole occupant of the soil; it should immediately receive a good dressing of farm-yard manure, so that it may now make a fresh start. Sheep are often allowed to feed on the young clover in the autumn; but this is a bad practice, as their sharp noses find out the very centre or *crown* of the clover-plants, and if this is seriously injured the plant dies. Farmers who treat their clover in this way must not be surprised to see many *bare places* in their clover-fields the next spring. When the clover is allowed to grow uninjured it makes a strong root, and in the spring is ready to commence a vigorous growth.

FIG. 15.—CLOVER.

**48. What to do with the Clover Crop.**—On good land, and especially on clays, the most profitable treatment of clover is to allow it to make its full growth, and then either to cut it and carry it off the land as green food for stock, or mow it when in full bloom (in June) and make it into hay. On light land it is perhaps advantageous to feed sheep in the clover-fields during May and June, confining them by hurdles so that they cannot range all over the field, but must thoroughly consume the crop in one part before commencing on another. The treading of the sheep and the mass of rootlets put forth by the clover-plants tend to give that firmness to light soils of which they stand so much in need, while the droppings of the sheep are a valuable manure.

**49. Aftermath.**—After the removal of its leaves and the upper part of its stem by the June mowing, the clover soon sends out fresh shoots; and in August it puts forth a second set of blossoms, and a second hay crop may then be obtained from it. This second crop, or *aftermath* as it is called, is, however, more usually fed off by sheep. Very hot sunny weather is not the best for making clover-hay; the heat makes the leaves brittle, and they break off and are lost.

## VIII.—FODDER CROPS: VETCHES, LUCERNE, SAINFOIN, RAPE, ETC.

**50. The Vetch or Tare—51. Lucerne—52. Sainfoin—53. Crucifers—54. Mustard—55. Cabbage.**

**50. The Vetch or Tare.**—In appearance the vetch somewhat resembles the pea. The kind known as the "winter" vetch is sown in autumn, and is ready to cut in May; spring vetches are sown in February and March, and yield a nice cutting from June to August. The vetch likes clayey or marly soil, and is usually cut little by little and carried off the land as fodder for cattle and horses; while sheep are penned upon it. The winter vetch is a very useful crop, as it comes to hand at a time when other forage is scarce.

FIG. 16.—VETCH OR TARE.

**51. Lucerne.**—The flower of lucerne somewhat resembles that of the vetch, while its leaves are more like those of clover. It should be sown in April in rich, clean land, at the rate of 10 lbs. of seed to the acre. The first cutting may be taken in September, after which a good dressing of manure must be applied. Lucerne is a perennial plant, and will yield well for six or eight years, producing twenty to thirty tons per acre of most valuable forage for cattle or horses. In the south-east of England lucerne is a very favourite crop. It affords a green food which is specially valuable for dairy-cows, since it imparts no unpleasant flavour to the milk or butter.

FIG. 17.—LUCERNE.

**52. Sainfoin.**—On dry, chalky soils, where hardly any other crop will grow, the sainfoin rejoices the farmer's heart by producing a large bulk of wholesome green food. It is a perennial plant, and may be left on the land for six or seven years, or until it is smothered by the weeds, couch-grass, etc., which are certain to make their appearance.

FIG. 18.—SAINFOIN.

**53. Crucifers grown for Fodder: Rape.**—The plants called by botanists "crucifers," or "cross-bearers," include numerous species which are of great use to mankind. Unlike other divisions of plants, no crucifer is known to have any poisonous properties; and it has been remarked that if any one were wrecked on some wild, uninhabited island—say, one of the isles of the Pacific—he would be perfectly safe in eating any plant which he could recognize as a "crucifer."

FIG. 19.—RAPE.

Rape has a leaf like a swede's, with a stem resembling that of a cabbage. It may be sown in June, in rows fifteen inches apart, which are afterwards hoed out like turnips. The plant grows very rapidly, and sheep may be fed on its stems and leaves in September. Its roots penetrate deeply into the soil, and it flourishes in peaty soils and clays. The quick growth of rape enables the farmer to use it as a "*catch crop*," by which we mean a crop taken in the interval between two of the crops of a regular rotation, instead of letting the land lie bare. For the same reason rape is often sown to fill up bare patches in a field caused by the partial failure of some other crop—such as turnips.

**54. Mustard.**—Mustard has long been grown for its *seed* on the rich, flat soil of South Lincolnshire; but of late years it has also come into use as a fodder crop. It is also sown in order to be ploughed into the land after it has attained its full growth, thus serving as a "green manure." It is a plant of extremely rapid growth, and may be sown immediately after an early corn crop of any kind, and it will be ready for sheep-food in about two months.

FIG. 20.—MUSTARD.

**55. Cabbage.**—Cattle or drumhead cabbage is an excellent fallow crop on clay soils, and will produce from 40 to 80 tons per acre of succulent food, very useful for sheep or cattle; although it imparts a strong flavour to the milk of dairy-cows.

Cabbage-seed should be sown in August, in good garden soil. The young plants will be ready to plant out in the following April; and about seven thousand will be required for every acre of ground. The soil must be supplied with farm-yard manure, at the rate of 20 or 30 tons per acre, with 4 cwt. of common salt, and a like quantity of super-phosphate of lime.

The young plants must be put in by the dibbler, and the earth pressed round the stems; showery weather should be selected for this operation. Weeds must be kept down by the use of the horse-hoe while the crop is growing. Slugs and caterpillars attack the plants during their summer growth, but by good cultivation their numbers may be greatly reduced. The cabbages are fully grown by October, and may be fed off by sheep on light land, or cut and stored for use on heavy clays.

FIG. 21.—THOUSAND-HEADED KALE.

*The Thousand-headed Kale,* which is now coming into use, is a plant closely allied to the cabbage. It is sown in April, and produces a very large quantity of food for sheep in the autumn.

## IX.—GREEN CROPS OR ROOT CROPS: TURNIPS.

**56. Fallow Crops—57. Root Crops—58. The Turnip Crop—59. Cultivation of the Turnip—60. Varieties of the Turnip—61. Cultivation of Swedes.**

**56. Fallow Crops.**—In the old system of farming, such as was pursued in England several centuries ago, the land was allowed to lie bare, or "fallow," between successive corn crops. During this interval, the kind of plant-food of which the soil had been exhausted by the corn crop—say the soluble silica—became renewed by the conversion of dormant matter into *active* plant-food, so that corn could again be grown on that land.

But after a time farmers found out that crops of other plants—those called "roots," for instance—could be grown during the intervals between the corn crops; and this was of course a great advantage, as the land was then doing good and profitable work, instead of lying bare. To such intervening crops the name of fallow crops was naturally applied. The reason why turnips, for instance, will grow well on land which is exhausted, so far as wheat-growing is concerned, is that different plants feed on different kinds of plant-food;

thus the turnip requires little of the soluble silica which is so necessary to wheat; but instead of this it uses up a very large quantity of *potash.*

57. **Root Crops.**—The root crops or green crops of the British Isles include an area of nearly five million acres. Included under this heading, however, we have several plants which, although they are classed by farmers as "roots," are known by botanists not to be roots at all. Thus, the potato is a tuber or swollen part of an underground stem; the bulb of kohl-rabi, on the other hand, is an enlargement of the stem just above the surface of the ground.

On light soils, a root crop is even better for the land than leaving it in bare fallow. When the land is exposed and unoccupied by any crop, the rains beat upon it, soak through it, and wash out the soluble matters—the plant-food. But if root crops be grown in the same soil, they will absorb the plant-food, retain it, and so prevent its being washed away. It may be urged that if the roots are carted off the land and given to stock, or even if they are fed off by sheep, much of the matter stored up by and in the roots is lost to the land. We must remember, however, that the manure from the animals feeding on the crops can be restored to the land, so that much of the plant-food abstracted from the soil by the growing crop will be returned to it; and, further, that the profit obtained by the fattening, etc., of the stock will enable the farmer to buy artificial manures, which, being added to the soil in addition to the farm-yard manure, will leave the soil richer than it was before the root crop was planted.

Root crops, coming in alternation with corn crops, also enable the farmer to thoroughly *clean* his land, and free it from those weeds whose growth would otherwise be difficult to check.

FIG. 22.—TURNIP.

**58. The Turnip Crop.** — Turnips were introduced into England in 1730. The turnip crop usually follows the wheat crop in the rotation. After the removal of the latter, in autumn, the stubbles must be scarified or shallow-ploughed, the weeds collected with harrows, and either burned or mixed with lime and soil, and left to rot, when they will form a useful manure. These light lands must not undergo the deep autumn ploughing which is so profitable on clayey soils; if they were left ridged up and open, exposed to the winter rains, much of their plant-food would be washed out, and they would be impoverished.

**59. Cultivation of the Turnip.**—For turnip culture, light land should be deeply ploughed in the spring, and the soil afterwards stirred by the grubber. On heavy land, on the contrary, steam-ploughing in autumn, with the addition of strawy, half-rotted manure, well worked in, will leave the land in fine condition for turnips in the following spring; for the winter frosts will have reduced the clods to a fine earth, and the farm-yard manure will render the clays more open. On the whole, turnips succeed best on light land, yielding there about twenty tons per acre. Nine-tenths of the weight of an ordinary turnip is nothing but water; so that turnips, and indeed roots generally, are extremely succulent, but not so nourishing as might be expected.

**60. Varieties of the Turnip.**—The early white turnip is sown in April and May, and is ready for use in September. It is the most suitable sort for clay land.

Of the common late turnips there are many kinds—as the yellow, white globe, red globe, and stone turnips. The main crop is sown in June and July, in drills eighteen inches apart. The young plants are "singled" after they are well up, so as to leave them about nine inches apart. The early frosts ripen and sweeten the roots; and sheep are turned on the land in October and November.

The Swedish turnip, or swede, is a hardy kind, usually sown in May or the first half of June.

The swedes may be taken up in winter and stored in long heaps covered with soil.

**61. Cultivation of Swedes.**—The swede is considered the best of the turnip family, because it contains a less proportion of water than the other sorts. Like all turnips, it prefers a finely-divided soil for its seed-bed; and as a mineral manure, the *reduced* super-phosphate is found most suitable. There is no doubt but that the pure "super-phosphate of lime" will produce the most rapid growth of the young turnips for the first few weeks; but it is then nearly exhausted, and the crop thus *rushed through* the first stages of its existence is then left to itself. The "reduced" super-phosphate is less active at first, but is more lasting, insuring a steady and continuous growth. One reason why farmers have been anxious to secure very rapid growth during the first stages of the young swedes (and indeed all kinds of turnip) is that the plants are thereby soon brought out of reach of the attacks of the turnip-beetle, an insect which often appears in such numbers as to entirely destroy the crop, but whose ravages cease as soon as the young turnips put forth their rough leaves. A better plan to accomplish this end is to sow a little mustard-seed with the turnips: the two plants spring up together, and as the turnip-beetle prefers the mustard-plant

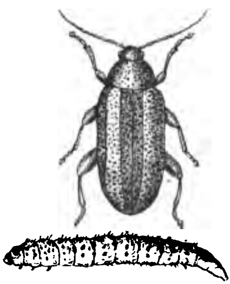

FIG. 23.—TURNIP-FLY, OR FLEA-BEETLE, AND LARVA.

to the turnip, the latter is enabled to grow up in safety.

Another reason against using extremely soluble manures for swedes is that the rapid growth weakens the plants, and renders them more liable to *mildew*, a disease caused by a fungus which settles on the young swedes and feeds on their juices. Swedes which grow steadily grow *strongly*, and are therefore better able to withstand this mildew.

Properly-grown swedes are compact and heavy, although of medium size only. They *sink* quickly when placed in water, while the too rapidly-grown and large bulbs will float; the latter will become rotten after moderate frosts, which only help to ripen the steadily-grown swedes. As food for the flocks, the one bears no comparison with the other. The weight of swedes obtained per acre varies from 10 to 30 tons; perhaps 15 tons may be taken as the average.

The distribution of the turnip crop (including all varieties) in the British Isles is as follows:—

| | |
|---|---|
| England and Wales | 1½ million of acres. |
| Scotland | ½ million of acres. |
| Ireland | 300,000 acres. |

## X.—ROOT CROPS: MANGEL-WURZEL, POTATOES, ETC.

62. Growth of Mangel-wurzel—63. Cultivation of Mangel-wurzel—64. Weight of the Mangel Crop—65. The Parsnip and the Carrot—66. Kohl-rabi—67. The Potato—68. Varieties of the Potato—69. Diseases of Root Crops.

**62. Growth of Mangel-wurzel.**—Of the mangold, or mangel-wurzel, about 400,000 acres are planted yearly in the British Isles, nine-tenths of this area, however, lying in England and Wales. The mangold is derived from the wild beet-plant of our coasts, and, under the name of "beet-root," has long been cultivated in gardens. From a white variety of this root beet-sugar is manufactured in large quantities on the Continent. The mangold is a deep-rooted plant, and is consequently able to flourish in the dry districts of the south and east of England, where the turnip (a surface-feeder, shallow-root) fails for want of sufficient moisture.

FIG. 24.—MANGEL-WURZEL.

**63. Cultivation of Mangel-wurzel.**—Clayey loams suit this plant best; and these must be well cultivated in autumn, and liberally manured. The seed should be soaked in water for two days before planting, and may be drilled in or sown broadcast at the rate of 6 lbs. per acre. The kind known as long red suits heavy land best; the red globe answers better for lighter soils; while the orange and the yellow globe are to be relied on for almost any kind of ground.

The young plants must be singled out so that they stand one foot apart; and the open spaces between the rows must be frequently hoed. In October, while the mangels are still unripe, and before they have been affected by frosts, they must be pulled up by hand, the tops twisted off, and the roots stored in heaps, which are covered, first with straw, and then with earth. During the next two or three months, as they lie in the heaps, a gentle heat will be produced, and the mangel roots will *ripen*, by which is meant that the sour juices of the plant are changed into sugar or gum. With care the mangels will keep good till midsummer; and they furnish a most valuable store of food during the winter months for dairy-cows, cattle, sheep, or pigs.

**64. Weight of the Mangel Crop.**—The weight of the mangel crop is not necessarily a true indication of its value to the farmer. By the plentiful use of nitrate of soda, for example, as a manure, crops of 40 or 45 tons per acre may be grown, consisting of roots of great size; yet there is much more real nutriment in a crop of mangels weighing from 30 to 35 tons per acre, composed of numerous moderately-sized roots, and manured with reduced super-phosphate of lime. A rough test of the feeding qualities of mangolds is to drop the roots into water; those which float contain but little nourishment.

FIG. 25.—STEM AND LEAVES OF PARSNIP.

**65. The Parsnip and the Carrot.**—The long tapering roots of these plants demand a deep sandy loam, deeply cultivated so that the roots may extend downwards without any hindrance. Only some 20,000 acres of carrots, and a less area of parsnips, are grown yearly, chiefly in England. The seeds must be mixed with sand so as to separate them from one another, otherwise the long hairs with which they are covered will cause them to adhere, and must then be sown in March at the rate of 6 lbs. per acre on well-manured land. The roots are raised and harvested in October, and form a rich and nutritious cattle-food.

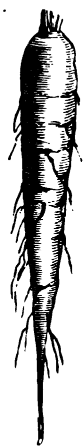

FIG. 26. LONG PARSNIP.

FIG. 27.—CARROT.

**66. Kohl-rabi.**—This plant belongs to the cabbage family, and is remarkable for the swelling of its stem, which takes place just above the ground, and which causes it to resemble the turnip. Like the turnip, too, kohl-rabi is a most useful food for sheep and cattle. It is cultivated in much the same manner as the turnip, being sown early in May, and fed off or stored in the autumn.

The area occupied by this crop lies chiefly in the midland and southern counties of England. It likes a mild climate and a clayey or peaty soil. The weight of the crop is about 20 tons per acre. There are two good points connected with kohl-

FIG. 28.—KOHL-RABI.

rabi which ought to strongly recommend it to the attention of farmers: the first of these is its freedom from blight and from the attacks of insects; the second, that it succeeds well on land which has become "turnip-sick."

**67. The Potato.**—We can hardly imagine a dinner without a dish of potatoes on the table, and yet only three centuries have elapsed since Sir Walter Raleigh brought this plant from Central America and introduced it into England; while its general cultivation as an article of food does not go back more than a century and a half. The area covered by this crop now includes 600,000 acres in Great Britain, and 850,000 acres in Ireland.

Botanically speaking, the potato is not a root, but a swollen portion of an underground stem. No land requires more manuring than that from which frequent crops of potatoes are taken; for since potatoes are used as human food, and not given to stock, and since they are mostly sold to go off the farm, the land *loses for ever* the nutritive matter contained in the potatoes. A potato contains three times as much nourishment as a turnip of the same weight.

Light soils, sandy loams, and peaty ground produce the largest and best crops of potatoes. Potatoes are not commonly raised from the seed (which will be found in the so-called potato "apples"); but the tubers are cut into parts or "sets," each set containing at least one bud or "eye." The land is rough ploughed in autumn, and is again ploughed in spring; the sets are then placed in every third furrow at about one foot apart. When the leaves wither and fall off the potatoes are ready for digging, and in good ground a yield of six tons per acre may be expected. The potato requires a large amount of potash during its growth, and for this reason the manure called *kainite*, which is rich

FIG. 29.—POTATO.

in potash, is of great service to the plant when liberally applied to the land.

The potato is a somewhat uncertain plant, suffering frequently from a disease called the "blight," which attacked the crop of 1846 so severely that it was almost a total failure: the result was a terrible famine in Ireland, where the people depend very largely on the potato crop as their chief food.

This "blight" is due to the attack of a very small kind of fungus, which burrows in the leaves and attacks every part of the plant. There is no certain cure for it; but change of seed, good culture, and the planting of early sorts are all useful ways of lessening the evil.

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FIG. 30.—TURNIP AFFECTED BY FINGER-AND-TOE DISEASE.
FIG. 31.—ANBURY DISEASE.

**68. Varieties of the Potato.**—A great number of varieties of the potato are grown in Britain. First, we may distinguish the field crops which are grown as food for cattle, pigs, etc., since, although very productive, they are not so delicate a food as the garden varieties. The principal field-potatoes are those known as "yams," "lumpers," and the "mangel-wurzel potato."

Potatoes grown for human food may be divided into the round and kidney varieties; and of each of these again there are "red" and "white" sorts.

Also, according to the time of ripening, we have the *early* potatoes, such as the "ashleaf" and "early rose;" and the *main-crop* sorts, as "magnum-bonum," "champion," "victoria," "schoolmaster," and many more.

**69. Diseases of Root Crops.**—Turnips suffer from a disease called "*anbury*," the outside of the root becoming covered with wart-like masses (see Fig. 31). Sometimes the turnip-root, instead of forming a neat globe, divides into "*fingers and toes*" (Fig. 30), and soon the whole root becomes woody, and then decays. The remedy for these diseases is thorough cultivation, including a proper supply of plant-food in the soil.

# PART II.

## *OUR CROPS: CAUSES OF THE VARIATIONS IN THEIR YIELD AND QUALITY.*

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### XI.—HOW CLIMATE AFFECTS FARMING.

**70. Climate and Weather—71. Weather Predictions—72. Distribution of Plants on the Earth's surface—73. Climate depends on Altitude as well as on Distance from the Equator—74. Other Circumstances affecting Climate—75. Climate as it affects Farming.**

**70. Climate and Weather.**—When we talk of the *weather*, we mean the state of the air at any particular moment. The weather may change from day to day, or indeed from hour to hour: in the morning the weather may be rainy and cold, while in the afternoon it may be fine and warm. But the term *climate* has a different meaning; by it we understand the *average* kind of weather which any country enjoys. Now to find this out we need to watch the weather for many years. Thus we may discover what kind of *weather* it is by simply looking out of the window; whereas to know what sort of a *climate* the place we are living in possesses, we ought to be able to examine the records of centuries.

**71. Weather Predictions.**—It is quite clear that it would be a great benefit to every person, and especially to those engaged in agriculture, if the state of the weather could be known beforehand—if we could tell, for example, whether to-morrow would be a wet or a dry day, a warm or a cold one. By careful observation of natural signs, such as the clouds, the direction of the wind, the behaviour of animals, etc., many persons, such as shepherds, sailors, and others, come to a pretty fair knowledge of the weather of the next hour or two; but by the use of such instruments as the barometer and thermometer, a still greater degree of certainty can be attained.

But to predict, or forecast, what the weather will be like, not for the next hour only but for the succeeding day, we require to know what are the indications of the barometer and the thermometer at places all around us to distances of several hundred miles. This can easily be ascertained by the electric telegraph, and it is from the information so obtained that a Government department, called the Meteorological Office, whose head-quarters are in London, is able to issue daily a "forecast" of the probable state of the weather over the British Isles for the succeeding twenty-four hours; and these forecasts, or predictions, are correct in four cases out of five. At hay-making time, when a knowledge of the coming weather is especially important to farmers, a forecast of the weather will be sent by telegraph from the Meteorological Office in Victoria Street, Westminster, to any farmer who applies for it, and these have already proved of great value; but much may be learned from the "Weather Forecasts" which are sent from the Meteorological Office to the daily papers, and which are usually illustrated by a map or chart.

**72. Distribution of Plants on the Earth's Surface.**—Other things being equal, the distribution of plants on the Earth's surface depends upon (1) heat, (2) light, and (3) moisture. Now, as a rule, all these three conditions are most intense near to the equator, and decrease as we approach the poles. Going from the equator towards either pole, and keeping in the low plains, it is possible to roughly map out the Earth's surface into belts or zones, characterized by distinct species of plants. In the northern hemisphere we can distinguish eight of these zones of vegetation, as follows:—

(1.) *Equatorial Zone*, where the thermometer indicates an average daily warmth of about 80°. Here vegetation is most luxuriant: grasses (bamboos, etc.) grow to the height of small trees; palms, bananas, and climbing plants of many kinds abound.

(2.) *Tropical Zone:* temperature 73°. Pine-apples, tree-ferns, figs, spices, cotton, coffee, tobacco, sugar-cane.

(3.) *Sub-Tropical Zone:* temperature 63°. Magnolia, laurel, fig, cactus, etc. Rice and maize grow well in this and the preceding zone.

(4.) *Warm Temperate Zone:* temperature 53°. Here we find the last evergreen trees growing, together with "deciduous" forest-trees, as the oak and chestnut, oranges, olives, the vine, etc. The countries of the south of Europe, including Spain, Italy, the south of France, and Turkey, are situated in this zone. Maize and wheat are the cereals cultivated in it.

(5.) *Cold Temperate Zone:* temperature not less than 43°. The British Isles lie entirely in this zone. It is characterized by all our ordinary forest-trees. Wheat finds here its northern limit; rye, buck-wheat, peas and beans also do well.

(6.) *Sub-Arctic Zone:* temperature not less than 39°. Coniferous trees (pine, larch, etc.) abound, with poplars, the beech, etc.; beans, barley, oats, and potatoes are grown. Norway and Sweden lie in this zone.

(7.) *Arctic Zone.* The small trees called dwarf birch, alder, and willow abound; in North America the rhododendron and azalea are natives of this zone.

(8.) *Polar Zone.* Lichens incrust the rocks, and mosses are common. No trees or bushes can grow, and it is impossible to cultivate plants for food.

**73. Climate depends on Altitude as well as on Distance from the Equator.**—In the hottest regions of the Earth we can pass through all the zones of vegetation in a few hours, and find ourselves in a polar climate if a mountain of 18,000 or 20,000 feet in height be ascended. On its sides we shall find growing, in regular succession, many of the plants named above, until at last we arrive at the bare and snow-clad summit. For every 300 feet that we ascend above the sea-level we may reckon that the climate becomes one degree colder.

**74. Other Circumstances affecting Climate.**—Besides distance from the equator and height above the sea-level, there are several other circumstances which

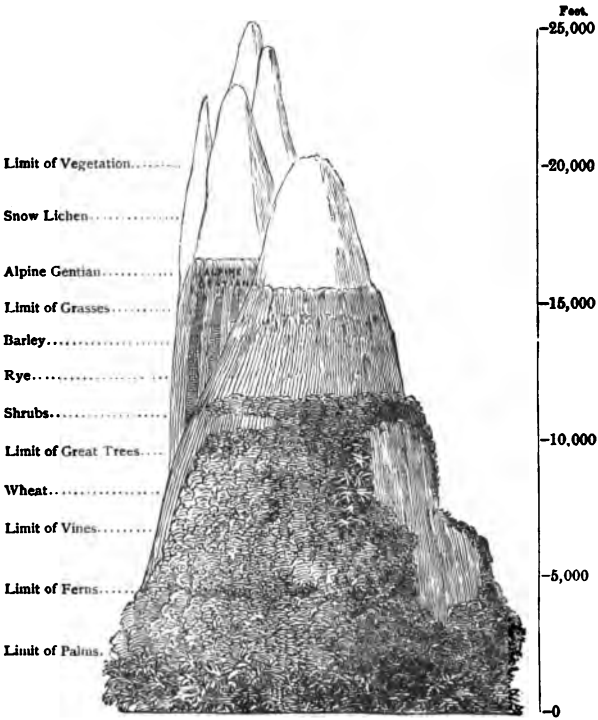


FIG. 32.—MOUNTAIN ZONES OF VEGETATION.

must be considered as affecting the climate of any district. One of the most important of these is its *distance from the sea.* The effect of a great mass of water, like the ocean, is to moderate the climate of a place, and to render it more equable. This is well seen by comparing the climate of Moscow in Russia with that of London: at Moscow the summer is one of burning heat, and the winter is cold enough to turn the rivers to a mass of ice. Now in London, as we all know, the difference between summer and winter is not nearly so great. The reason of this is that London is close to the great Atlantic Ocean, while Moscow is in the centre of a great extent of land.

The prevailing direction of the winds is important. The south-west winds, which blow so frequently over Britain, bring warmth and moisture with them. Marine currents, such as the Gulf Stream, have also their effect.

**75. Climate as it affects Farming.**—The farmer must closely consider the climate of the region in which his farm is situated before he lays his plans as to what crops he shall grow, or what system of farming he must adopt. Neglect of this consideration has led to great losses by young men who have learnt to farm in one county—perhaps in the east of England—and have then taken a farm in another county, or have perhaps emigrated to New Zealand or to America. We must always try to learn as much from local dwellers as possible: an old shepherd or farm-labourer can teach much to any new-comer, although the latter may have learnt at school and college all of the "science of agriculture" which can be taught in such places. But true science teaches us not to be proud of our knowledge, or to think it sufficient for everything, but to endeavour to gather as much as we can from those who have long had to do with the land, crops, or stock. The climate of the British Isles is an uncertain one. For example, the years from 1875 to 1885 proved much wetter than usual, and most of the rain fell at a period of the year—July to September—when fine hot weather is especially necessary to the ripening of the corn harvest. One consequence of this has been that the area devoted to corn crops has since been and is steadily diminishing, while the amount of permanent pasture is increasing.

## XII.—HOW CROPS ARE AFFECTED BY THE SOIL.

**76. Formation of the Soil—77. Kinds of Soils—78. Fertility of Soils—79. Effect of Population on Agriculture.**

**76. Formation of the Soil.**—All the soft earth, or sand, which we can dig so easily, once formed part of some hard rock. When rocks are exposed to the air, they wear away, or weather, or break up into small pieces. This breaking up is due to several causes. In the first place, the air contains two gases, which are known (1) as *oxygen* and (2) as *carbonic acid gas.* Now these gases will combine with certain of the substances of which the rocks are made, and will cause those substances to crumble to a powder. Thus if a clean, bright iron nail is exposed to moist air it will soon be covered with a red rust, composed of oxygen and iron, and known as oxide of iron. A great many rocks contain iron, and they are all acted on in this way when they are exposed to the atmosphere. The red colour of many clays and sandstones is due to oxide of iron; and if we dig deeply down we shall often find that these clays and sands are red only at the surface, where they have been in contact with the air, while lower down they are yellow or brown in colour.

Water acts powerfully in the breaking up of rocks. Where there are any little holes on the surface the water lodges in them, and if a frost should then take place, the water, in freezing, will expand, and consequently break up the sides of the hole in which it is lying, just as water will break a glass tumbler if it is caused to freeze within it. The beating of the rain on the rocks, the flowing of rivers, the dashing of waves against cliffs, the rubbing of ice, in glaciers, over the surface,—all these causes act together in breaking up rocks, and in reducing the pieces smaller and smaller, until at last they form the fine powder which constitutes a *soil.*

**77. Kinds of Soils.**—Some soils lie upon the rocks from which they were formed, and which they now protect from further wear. Other soils have been carried to a distance from their parent rocks by the currents of the sea, the tides, rivers, ice, etc. Often the soil made from one rock is mixed by these agents with the soil made out of another. Such soils, which do not now lie in the place where they were formed, are called transported soils. By the action of water the material derived from the breaking up of rocks is moreover *sorted out;* for the heavier substances—the stones—drop first to the bottom, forming a gravel; next comes the sand, dropped a little further on; while, finally, the very small particles which constitute the mud are carried to the greatest distance by the river, or by the sea, and are deposited together as clay.

Of course, the character of a soil will depend greatly on the rock from which it has been derived. Sandy soils mostly come from sandstone rocks; clays are derived from the rocks called slate and shale; a *loam* is a mixture of sand and clay; a *marly* soil is one which contains lime and clay. Besides these names, farmers apply many other terms to soils, according to the manner in which they behave while under cultivation. Thus a *hungry* soil is one continually requiring manure, of which it allows a large part to go to waste: many sandy soils are of this character. A *grateful* soil, on the contrary, repays well all the care and attention bestowed upon it. Clays are often called "tough" and "obstinate," because of the hard labour which their ploughing, etc., involves. When the crops grown look pale and unhealthy, owing to the absence of some necessary ingredient in the soil, it is called "sickly."

**78. Fertility of Soils.**—The fertility of a soil depends (1) on the presence of all the necessary mineral substances required by plants; (2) on their being in such a state that they can be readily dissolved by water.

For example, one of the mineral substances which plants require is soluble silica; wheat especially requires a considerable proportion of this substance. Now common sand consists of silica. Yet wheat would not grow in such sand, for it is not soluble—that is, it will not dissolve in water—and no solid substance can enter the rootlets of plants; everything must be first dissolved before it can pass through the delicate tissues of the roots and nourish the plant. Besides, sand consists almost entirely of this *one* substance—silica; and even if the wheat-plant could feed upon it in its insoluble form, there are some eight or nine other substances at least which are necessary to the healthy growth of plants.

By far the greater portion of an ordinary soil consists of matter useless as plant-food in its natural state, but yet useful as affording support to the roots of the plant, and so enabling it to fix itself in one place, and to erect its stem into the air. Yet this matter is capable of becoming useful as food to plants, after it has undergone certain changes in which the oxygen and carbonic acid gas of the air, together with water, play an important part. We may therefore regard it as a store of useful material laid up for future use, and so call it *dormant* plant-food. A soil which consisted of dormant plant-food only could grow no crops. But all soils contain a greater or less proportion of matter in a soluble state, which we may call *active* plant-food; and it is upon the presence and the amount of this active plant-food that the fertility of any soil depends.

**79. Effect of Population on Agriculture.**—In the neighbourhood of towns there is a constant demand for fresh butter, cheese, eggs, vegetables, etc. The consequence of this is, that we find a large amount of the land near such towns laid out as market-gardens or dairy-farms. Poultry, too, should be largely kept on farms in such situations.

## XIII.—ACTION OF ORGANIC MATTER IN SOILS: EFFECT OF DRAINAGE.

**80. Organic Matter in Soils—81. Organic Matter aids Capillary Action—82. Organic Matter aids in changing dormant into active Plant-food—83. Autumn Cultivation—84. Influence of Drainage on Crops.**

**80. Organic Matter in Soils.**—By organic matter we mean that which forms part of, or has lately formed part of, anything possessed of life. All fertile soils contain organic matter, usually the roots of plants which have previously grown in the soil. The amount of this organic matter may be ascertained by weighing a small quantity of the soil, then heating it strongly—which will burn away the organic matter present—and then weighing the soil again. Suppose we weigh out ten ounces of soil, and find that, after burning it, it weighs nine ounces, we know that one ounce, or ten per cent., of the soil consisted of organic matter.

Peat soils consist of little else than organic matter; but then they have been formed, not by the decay of rocks, but by the growth of mosses in damp places. Organic matter is very useful in a soil, and every farmer should try to maintain it there. In the first place, vegetable matter in a soil keeps a store of moisture, even although the soil may *look* quite dry. Such soils will show their valuable properties in dry, hot weather; for when the crops on soils from which vegetable matter is absent are parched up and withered, those growing on soils containing this useful storer-up of water will keep up a steady growth. Moreover, the organic matter in a soil has the power of absorbing moisture from the air; and along with this moisture it takes in those valuable gaseous plant-foods —ammonia, carbonic acid gas, oxygen, etc.—which exist in the atmosphere.

**81. Organic Matter aids Capillary Action.**—It is a well-known fact that water will rise up very narrow tubes to a height of two or three feet above its ordinary level. In any soil there are many narrow, irregular passages, which act like tubes, left between the particles of earth, and the water rises up these from the subsoil, so that at last it reaches the roots of the growing crop. Now the organic matter in any soil consists chiefly of the decaying roots and rootlets of plants which have previously grown in the soil, and these are spread out in every direction, but chiefly up and down. These decaying rootlets, and the passages which are left in the soil after they have totally decayed, form so many capillary tubes, and so the rise of the water is promoted.

**82. Organic Matter aids in changing dormant into active Plant-food.**—By the decay of organic matter carbonic acid gas is liberated; this gas unites with several of the "dormant" materials of the soil, changing them into "active" plant-food, and so increasing the store available for the growth of our crops. It is possible, however, to use up the organic matter in a soil very quickly by adding to the soil some substance which will eagerly combine with the carbonic acid gas in this way. If a soil is poor in organic matter, it is a bad plan to add quicklime to it as a manure; the lime will combine with the organic matter so quickly that the latter will be all used up, and the soil injured. Hence the old saying,—

> "The use of lime without manure
> Makes both the farm and farmer poor."

One of the best methods of increasing the amount of organic matter in the soil is to grow good crops of clover or grasses. The scientific farmer manures his clover liberally, and treats the crop well, because he knows that the matted roots of the clover, growing vigorously below the surface, will do him as much good, by the benefit they will afford to succeeding crops, as the leaves and stems of the clover will in furnishing food for his sheep.

**83. Autumn Cultivation.**—On good clay-land, rich in dormant plant-food, thorough autumn cultivation is of great importance. The use of the steam-plough is desirable; and the surface of the land should be left ridged-up, and as rough as possible. The winter frosts will break up the clods; while all the time those "farmer's friends"—the oxygen, carbonic acid gas, and ammonia, always present in the atmosphere—will be acting on the soil, and adding to the amount of active plant-food it contains.

**84. Influence of Drainage on Crops.**—In undrained land the whole of the soil up to the very surface, or within a short distance of the surface, may be saturated with standing water. In such a soil the plants which compose our farm crops cannot make a healthy growth. By drains, the level of the water is *lowered* to a depth of several feet from the surface; and, what is more important still, the steady passage of water through the soil is secured. It is the stagnant, or standing, water in the soil which injures our crops by keeping the land cold and preventing the entrance of air. All rain-water contains some air dissolved in it, and a little plant-food too. When the water stands in the ground it soon loses this air, and is then very harmful. But when water is led off by drains, it draws the air after it, and the passage of fresh air through the soil is a great benefit.

There is not much fear of "over-drainage," or making the ground too dry, for we have seen how water rises through the interstices of the soil, from a considerable depth, by capillary action. As it rises through well-drained ground, in these slender streams, the water meets air passing downwards, and is thereby improved, and made better able to nourish the plant.

*Irrigation*, or the supply of water to the fields by artificial means, is an excellent method for growing heavy crops of grass, and yet it seems at first sight opposed to the principles of drainage. But irrigation does good, because the water supplied is *kept moving* through the soil, and as it passes on it leaves behind valuable deposits of plant-food. But even in irrigation the land must not be kept constantly full of water; there must be frequent intervals during which the soil must be allowed to become dry, in order that air may enter and traverse thè ground, and perform its many tasks there.

## XIV.—THE SEED AND THE CROP.

85. Nature of a Seed—86. Requirements of a Seed—87. Sowing the Seed—88. Change of Seed.

**85. Nature of a Seed.**—A seed is a small portion of a plant, formed by it in order to continue its existence. Every seed consists of two main parts: —first, there is the *germ*, which can grow into a plant like that by which the seed was formed; and, secondly, there is a store of food laid up within or around the germ, in order to supply its needs until it is able to do so for itself. This food usually consists of a substance known as vegetable albumen, together with much starch. Both germ and albumen are surrounded by one or more coverings or coats, to protect them from injury.

Most seeds are *dry*, containing but a very little moisture. This is an important and useful fact, since it enables us to store our corn for months, or even years, until it is needed. If seeds were watery, they could not be kept long without decay.

**86. Requirements of a Seed.**—What a wonderful difference there is between the tiny round seed and the tall green plant which the seed can produce!

What does the seed require in order to enable it to change in this manner? For the first growth of a seed only three things are needed—*air*, *warmth*,

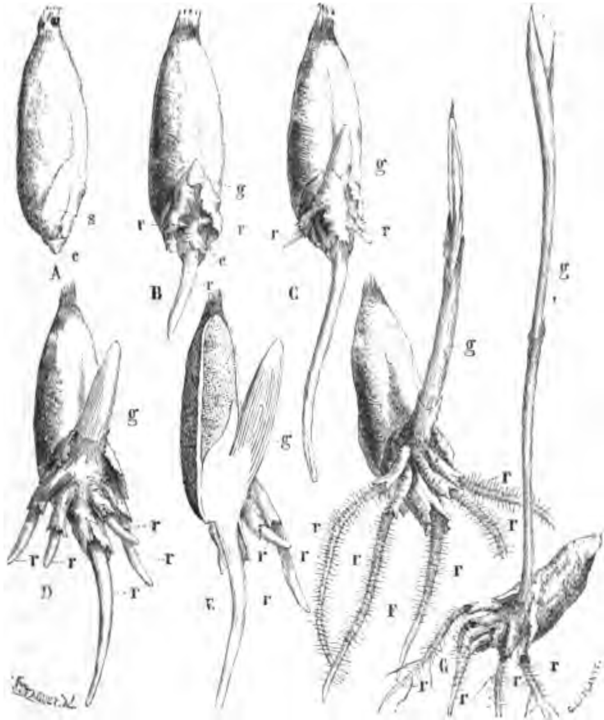

FIG. 33.—GERMINATION OF WHEAT.

A, Seed: *s*, point at which the stem will appear; *c*, appearance of the sheath which covers the root. B, *r*, rootlet; *r*, *r*, rootlets still enclosed in their sheaths; *g*, the stem. C, D, Showing the same parts as in B in more advanced stages. E, Section of D, showing the albumen. F, G, Lengthening of the stem, and appearance of the green leaf.

and *moisture;* and if these are supplied, the seed will make its first growth just as well on a piece of damp flannel in a warm room as if it were placed in the soil of a field.

Water does not simply soak into a seed. A careful examination of a seed with a microscope shows numerous *pores*, or little holes, on the skin or coating. Now these pores are the ends of very small tubes, through which water can pass to all parts of the seed. The presence of water is necessary, because the food of the germ—the albumen—must be dissolved before it can be of use to the germ. It is clear that seeds ought to be *clean*, and free from dust or dirt. Anything which stops up the pores prevents the entrance of water; so that dirty seeds will be much longer in sprouting, or germinating, than clean seeds. In sowing seeds for a crop, it is very important that they should all come up as nearly together as possible, so that the crop may grow evenly. But if water gains admittance to the interior of a seed, *air* will find its way with it, for all ordinary water contains air dissolved in it; air which enables fishes, for instance, to breathe as well as we can. It is the oxygen in the dissolved air which is especially useful to the growth of the seed; it combines with certain of the elements present in the seed, and the result is the formation of a small quantity of a nitrogenous substance called *diastase*. Now the effect of this new body—the diastase—is to change the starch in the seed into gum and sugar. Starch will not dissolve in water, so that it could not serve as food for the germ; but both gum and sugar are very soluble, and they are eagerly seized upon to enable the little germ to form its first stem, and leaves, and roots, after which it can find food for itself in the soil and in the air.

But none of these changes can take place in the seed without a certain amount of *warmth.* Frozen seeds could make no growth whatever; while it is found, in practice, that a temperature of about fifty degrees is that at which a seed will make the most healthy growth.

**87. Sowing the Seed.**—The farmer must always bear in mind the three requirements of the seed—air, warmth, and moisture. He must sow clean seeds at the proper time of the year, in autumn or in spring, when the ground is fairly warm; and he must not leave the seeds on the surface of the ground exposed to the cold, but must either harrow them in or press them in with the roller. The covering of earth which ought to lie above autumn-sown seeds will protect them from the frosts of winter; but if buried too deeply the seeds will be deprived of sufficient moisture and air. Each kind of seed has a certain depth at which it will grow best; and, as a rule, the smaller the seed the nearer it ought to lie to the surface. Grass seeds may lie within a quarter of an inch of the top, while beans, for example, will do better if placed at a depth of three inches.

The preparation of a good *seed-bed* is an important and difficult task, requiring much thought and experience on the part of the farmer, and a thorough acquaintance with the properties of the soil. On clay land, well broken up in autumn, and left exposed to the winter frosts, a beautiful fine tilth is formed, which it must be the farmer's aim to keep on the surface, and not bury by spring ploughing. Small seeds require a very fine soil, or they will sink down too deeply through the spaces between the clods.

**88. Change of Seed.**—As a rule, it will pay the farmer to purchase much of his seed. On the great seed-farms—such as those of the Messrs. Webb at Stourbridge, Sutton and Co. at Reading, and Carter and Co. in Essex—plants are grown solely for the sake of their seeds, and the produce is unequalled in purity and value. Good seed will very likely cost half as much again as poor or indifferent seed; but if it gives a larger and better crop, as it certainly will do, it repays its extra cost many times over. The *change of seed* is also an advantage. After a change of soil and climate, seeds usually grow more vigorously, and produce better crops, than seeds from plants which have been grown year after year on the same farm, in the same soil, and in the same climate.

## XV.—EXHAUSTION OF THE SOIL BY CROPS.

**89. The Food of Plants—90. Exhaustion of the Soil—91. Rotation of Crops—92. Use of Manures—93. Choice of a Manure—94. Continuous Growth of Corn.**

**89. The Food of Plants.**—Plants draw their food from three sources—(1) from the air, (2) from water, (3) from the soil. Now the supply of air and of water is unlimited; and we might think that as there is usually plenty of soil, the supply of earthy nourishment could never run short either. But we have learnt (see Vol. I., p. 68) that only a very small part of the soil is in an *active* state, ready to serve as plant-food. In the most fertile soils not more than one part in twenty is of immediate service to plants. In addition to this, we must bear in mind the fact that plants require *numerous* mineral substances to exist in the soil in a soluble condition, if they are to make good growth. A glance at the lists of mineral substances removed from the soil by our ordinary crops (see Vol. II., ch. vi.) will prove the truth of this. For the successful growth of any crop we require air, water, light, warmth, and also the presence in the soil of some eight or ten mineral substances in sufficient quantity and in a soluble condition. Moreover, the mineral substances are not required in like quantities by all plants. The wheat plant, for instance, needs a large supply of soluble silica; clover cares little for this *silica*, but demands much *lime;* turnips ask specially for *potash*, beans for *phosphates*, and so on.

**90. Exhaustion of the Soil.**—An ordinary crop removes from the soil, in one season, much more plant-food than can be added to it by natural means during the same time. The result of this must be, if we go on growing crops in the same soil, year after year, adding nothing to the soil, but taking much from it, that we shall gradually exhaust the land of its plant-food; our crops will become smaller and smaller, until at last they will not be worth the reaping.

**91. Rotation of Crops.**—One means of getting over this difficulty of the exhaustion of the land by crops will be to grow in successive years plants which demand *different* kinds of plant-food from the soil. On the Norfolk system of rotation a farmer first grows (say) turnips in a given field, and these turnips take a great deal of *potash* out of the soil; in the next year, the farmer sows barley in that field, barley being a shallow-rooted plant which chiefly desires *silica;* in the third year, a clover crop is taken, and now *lime* is especially drawn from the soil; lastly, the field is sown with wheat, a deep-rooted plant, which, like the barley, absorbs much *silica*, but draws it from a lower part of the soil; then, in the fifth year, the course is again begun with turnips. On this system of rotation of crops, the soil has several years in which to recover from the effect produced by the growing crop. If we grow turnips year after year, we shall soon exhaust the land of its potash; but if we grow turnips only once in four years, then in the three years between there will be time for much of the potash which is lying dormant, in a different state, to be changed into the active soluble potash of which alone the turnips can make use. Clayey soils are frequently so rich in soluble silica that we can grow two or more corn crops in succession upon them; and the Norfolk four-year system is then extended into a five-year or a six-year rotation. It is the same with every other crop. By growing crops in rotation, and by placing crops which make the same demands on the soil as far apart as possible in the rotation, we can *put off the evil day,* and delay the exhaustion of the land.

Other advantages which attend this system of the rotation of crops are—(1) that it spreads the work of the farm over the greater part of the year—some crops needing care at one time, and some at another; (2) it lessens the probability of a total failure of the crop, for while a rainy summer is unfavourable to the cereals, it produces good crops of clover, grass, and roots; (3) it enables the land to be cleared of weeds thoroughly and systematically. Cereals grow so thickly on the land that it is impossible to attack the weeds which spring up with them without injuring the corn; but root crops being sown in rows, with wide intervals between, allow of the weeds being continually hoed up and prevented from going to seed. So, by the alternation of root crops with corn crops, the land is kept clean and free from weeds. Weeds do much harm, for they take the plant-food from the crops, and prevent them from having as much light, air, and space in which to grow as they would otherwise have. Still, if a farmer depended entirely on this plan of cropping a field, first with one plant and then with another, it is certain (in England at all events) that his ruin would not be long delayed. The rich virgin soil of North America gave the early settlers good crops for fifteen or twenty years; but the time came when even that good ground was exhausted of its plant-food, and was unable to give a return for the labour expended upon it and the seed sown.

92. **Use of Manures.**—Although our crops draw mineral and other substances from the soil, and so tend to exhaust its store of active plant-food, yet it is a well-known fact that most of the land in the British Isles which is in the occupation of farmers *does* go on producing good crops year after year, and even century after century; indeed, we grow better crops and heavier crops than our fathers did, although we use the very same fields to grow them in. How has the exhaustion of the soil been prevented? It has been done by the wise use of *manures*. A manure is any substance which is added to the soil in order to increase its store of soluble plant-food. There are the *natural* manures, which seem always to have been in use in this country—the dung of animals, sewage, lime, etc.;

then we have the *artificial* or imported and manufactured manures, which have come so largely into use within the last thirty years, including guano, super-phosphate of lime, nitrate of soda, etc.

**93. Choice of a Manure.**—In applying a manure to his land the farmer must try to find out in what kinds of plant-food his soil is deficient, and he must then add such manures as will supply the deficiency. Farm-yard manure contains every kind of plant-food, and in addition supplies the soil with the organic matter which is so useful to it; hence farm-yard manure is a *general* manure, suitable for any or every crop. But if the soil is only deficient in one or two elements of plant-food, it will be cheaper to supply the deficiency by means of a *special* manure containing those elements only: thus, for old pasture-land, super-phosphate of lime is found to be a most excellent manure, because it returns to the soil the phosphate of lime of which the land has been deprived through the eating of the herbage by cows. This phosphate of lime helps to form the cow's milk, and is hence lost to the land.

It is remarkable that one substance cannot replace another as plant-food. If one ingredient only is lacking in the soil, we must not expect good crops; a double quantity of silica cannot make up for a short allowance of lime or potash, and *vice versa.* Hence the farmer must be careful to apply to the soil the right kind of manure. If he puts on a substance of which there is already sufficient in the soil, he is simply throwing his money away.

By the use of manures, combined with proper cultivation, a farmer is enabled to grow heavy crops, year after year, on the same soil, without exhausting it; but he also requires to do this so as to gain a profit. He must be careful that the cost of his manure, farm labour, machinery, buildings, rent, etc., does not exceed the amount for which he is able to sell the produce of his farm. In bad seasons it is very difficult to do this; but those who combine "science with practice" are most likely to be successful.

**94. Continuous Growth of Corn.**—A consideration of the action of manures will show that by their use we can set aside the system of rotation of crops and grow the same crop, season after season, if we take care to add to the land, by means of manures, at least as much plant-food as has been removed by each growing crop. In most cases, however, the cost of the manures required to do this would make the system an unprofitable one. On a few farms, however, such as that of Mr. Prout at Sawbridgeworth, corn crops are now being grown for the tenth or fifteenth season in succession, on the same soil, and with a good profit. Mr. Prout's success is owing—(1) to the good soil of his farm, a rich loamy clay; (2) to his thorough system of autumn cultivation by the steam-plough; (3) to the large amount of manure he adds to the soil yearly.

## XVI.—FEEDING QUALITIES OF CROPS: FUNCTIONS OF FOOD.

**95. Quantity and Quality—96. Nature of Food—97. Functions of Food—98. Foods which build up the Body, and keep it in Repair—99. Flesh-forming Foods—100. Warmth-producing Foods—101. Formation of Fat—102. Performance of Work—103. All the classes of Food are a daily Necessary.**

**95. Quantity and Quality.**—The mistake is too often made of estimating the value of a crop simply by its weight. In root crops especially the great endeavour has been to produce the greatest possible weight of roots per acre, without regard to the consideration as to how much of this weight was really of value to stock as food. It is obvious that a crop of twenty-five tons of mangolds per acre, containing five tons of nutritious matter, is better than a crop of forty tons per acre, containing only two tons of nutritious matter.

To understand what is meant by the feeding qualities of any crop, we must learn something about the way in which animals are nourished by food.

**96. Nature of Food.**—By "food" we here mean any substance which assists in the nourishment of the body of an animal. All the three kingdoms of nature—the animal, vegetable, and mineral—yield food to man; but the animals kept on our farms—

the cattle, sheep, and horses—eat mineral and vegetable food only.

**97. Functions of Food.**—The functions of food in the body are five in number. These are:—

(1.) To form or build up the body of the animal.

(2.) To keep the body in repair—that is, to prevent it from wasting away.

(3.) To maintain the heat of the body.

(4.) To form fat.

(5.) To enable the body to move about and do work.

We must not think that each kind of food is able to perform all these five functions. The first two functions go together: food which is able to build up the body is also able to keep it in repair. The last three functions are also performed by one and the same kind of food; so that we may say there are really two great classes of foods, when we consider them according to the work they perform in the body.

**98. Foods which build up the Body, and keep it in Repair.**—A young animal ought to be continually growing and increasing in weight. When the full growth has been obtained, food is still required to *keep up* the body. All animals, both young and old, lose part of their substance every day; and the reason why a young animal requires more flesh-forming food than an old one is that it requires this food for two purposes—first, to make its growth with, and, secondly, to repair the daily waste of its body. A fully-grown animal needs that food for the latter purpose only.

*Mineral Foods.*—The chief mineral food of our farm animals is *phosphate of lime*, which they need to form and harden their bones; *common salt* is also necessary, with a very little *iron*, and *salts of potash.* With the exception of common salt, these mineral foods are not eaten by themselves, but they enter the body as a part of some vegetable substance—the vegetable, of course, having previously obtained them from the soil. Thus all our green vegetables contain a little potash, while phosphate of lime is especially found in the seeds of cereals, as wheat, oats, etc.

99. **Flesh-forming Foods.**—By "flesh" we mean *muscle.* The best vegetable flesh-formers are the substances named *gluten*, *albumen*, *fibrin*, and *legumin.* They are each composed of the four elements carbon, hydrogen, oxygen, and nitrogen. As the last-named substance plays the most important part in these flesh-forming foods, they are often called "nitrogenous." Wheat contains gluten (8 lbs. in 100 lbs.); oats are rich in fibrin (14 in 100); while beans and pease contain a large proportion of legumin (23 in 100).

100. **Warmth-producing Foods.**—The bodies of all our farm animals are much warmer than the air which surrounds them. While the usual temperature of the air is not more than 50°, that of our cows, horses, etc., is about 100°. This bodily heat is produced and maintained by a class of foods called "heat-givers." They are composed of the three elements carbon, hydrogen, and oxygen; and since carbon is the most important of the three, they are often called "carbonaceous" foods. The vegetable

"heat-givers" include all kinds of starch, sugar, gum, and oil, substances contained in greater or less abundance in all our crops. When these foods are eaten, the carbon which they contain unites in the blood of the animal with the oxygen gas which the same animal has breathed in from the air, and the union of these two elements produces heat.

**101. Formation of Fat.**—After the maintenance of the heat of the body has been fully secured, then these carbonaceous foods are ready to set about the formation of *fat*. Fat is of use to the animal in protecting it from cold, and it forms a *store* of food within the body which can be drawn upon at any time when the supplies from outside fail. The more *shelter* we can afford our stock the more quickly they will fatten. When they are exposed to cold and wet, most of the carbonaceous food they eat will be required to keep up the heat of their bodies, and there will be little or none left to form fat.

**102. Performance of Work.**—Another task which the carbonaceous foods perform is to enable the body to do work. We know that animals which have to work very hard are seldom or never fat, especially if they do not get a good supply of food; and we now see the reason of this. Animals which it is desired to fatten quickly should therefore be kept in warm "boxes," or "byres," and not allowed to roam or gallop about the fields. Their bodies being then at rest, the carbonaceous food which would otherwise have been used up in supplying the force required to enable them to run about is devoted instead to the formation of fat.

**103. All the classes of Food are a daily Necessary.**— Since each class of food has its own work to do, and cannot perform the work of any other class, it is clear that a mixture of these foods ought to be taken daily by every animal. Now in many of our crops there is already contained in the material produced two or more of the classes of food—the bone-making, flesh-forming, and heat-giving; but as a rule the different foods are not combined in the right proportion. Some crops yield us little else than carbonaceous food, while in others there is an excess of nitrogenous matter. The farmer ought therefore to know the composition of crops, so far as their feeding powers are concerned, and he will then be able to supply his stock with a proper admixture of the different kinds of food required to keep their bodies healthy, and to fulfil the objects which he has in view.

## XVII.—FEEDING QUALITIES OF CROPS: CEREALS, ETC.

**104. The Cereals as Food—105. Composition of Cereals—106. Roots as Food—107. Grass and Hay.**

**104. The Cereals as Food.**—The corn-producing grasses furnish excellent food for both man and beast. They contain a great deal of starch—a heat-giving food—and also a fair proportion of such flesh-formers as gluten and fibrin. To show the presence of these two classes of food in wheat-flour, a table-spoonful of flour should be placed in a little muslin bag, which should then be repeatedly squeezed with the hand on the surface of some water contained in a basin. After a time the grains of starch will escape between the threads of the muslin, and will colour the water white, while the gluten will remain within the bag as a sticky yellowish mass.

FIG. 34.—Separation of Starch from Wheat-Flour.

**105. Composition of Cereals.**—Very many careful analyses of wheat, barley, oats, etc., have been made by experienced chemists, so that we know pretty well of what substances each of these grains is composed. Classifying these substances according to their function as food, we find the composition of 100 lbs. of each of the following cereals to be:—

| | WHEAT. | OATS. | BARLEY. | RYE. |
|---|---|---|---|---|
| Flesh-forming matter..... | 12¼ | 11½ | 9½ | 9 |
| Heat-giving matter........ | 68 | 63 | 65½ | 66 |
| Mineral matter............. | 1¾ | 3 | 2½ | 1 |
| Water ................ ........ | 15 | 13½ | 16 | 16 |
| Woody fibre................. | 3 | 9 | 6½ | 8 |
| | 100 | 100 | 100 | 100 |

This table shows that wheat and oats are in every respect superior as food to barley and rye; they contain more flesh-forming matter and less water. If we gave these seeds alone to our stock they would be too *dry*. Hence it is necessary and usual to add more succulent foods, such as roots; or to give oats, barley, etc., in the form of a warm mash—that is, boiled up in water. Wheat is as a rule too expensive a food to give to cattle, but the *bran*, which consists of the outer coating of the grains of wheat, is a very useful food for cattle and horses. It is rather indigestible, however, and should be scalded in boiling water before it is given to the animals.

**106. Roots as Food.**—The main characteristic of roots, considered as food, is the large amount of water which they contain. Now, although the presence of a certain and even of a large proportion of water is a useful property in roots, yet an excessive amount must be deemed a great evil. Water can be given as a food separately in the liquid form, and then costs little or nothing. But our root crops have cost much money, and if they are "nothing but water"—that is, if in 100 lbs. of roots we have perhaps 95 lbs. of water and three or four pounds of woody fibre (useless as food), then the pound or two of nutritious matter which remains is not sufficient to repay the farmer for his labour, nor indeed the animal for the trouble of eating such a poor food.

The *Mangold* is one of the most nutritious of our ordinary root-crops. 100 lbs. by weight contains 85 lbs. of water, 11 lbs. weight of heat-giving food (starch, gum, and sugar), 1 lb. of flesh-forming food, 1 lb. of mineral food, and 2 lbs. of woody fibre. It is estimated that 100 lbs. of mangolds are equal as food to 134 lbs. of turnips. Mangolds benefit greatly by being taken up early, while still unripe, and stored in that condition. As they lie in heaps during the late autumn and early winter months they heat, and some of their starchy matter is converted into sugar, decidedly improving them as food for stock. Sour, acid substances also exist in roots, just as they do in unripe apples, etc. As the roots ripen or mature these acid bodies also change into sugar. The change ought to be a slow and gradual one. Roots may be "ripened" in a few hours by a severe frost, but they are at the same time made rotten. Dairy cows fed on mangolds produce a larger quantity of milk than when fed upon turnips.

The *Swede* is a better food than the *Common Turnip*, because it has less water and more nutritious solid matter. When water is taken into the body of any animal it becomes at least as warm as the body of the animal, while much of it is evaporated from the skin and lungs. The heat required to do all this has of course to be furnished by the food, and if *all the food* of any animal is moist and very watery, it will certainly retard the fattening and injure the health of that animal.

Table showing the food substances contained in swedes and in common turnips:—

| | SWEDES. | TURNIPS. |
|---|---|---|
| Flesh-forming matter....... | 2 | 1 |
| Heat-giving matter.......... | 7 | 5 |
| Mineral matter .............. | 1 | 1 |
| Water .......................... | 89 | 92 |
| Woody fibre.................... | 1 | 1 |
| | 100 | 100 |

The *Potato* is the most nutritious of the plants usually classed as "roots." In 100 lbs. of potatoes we find 2 lbs. of flesh-formers, 20 lbs. of heat-givers, 1 lb. mineral matter, 75 lbs. of water, and 2 lbs. of woody fibre.

From the above examples we see that animals could not live on "roots" alone, because they contain an insufficient amount of flesh-forming food, with a great excess of water.

**107. Grass and Hay.**—We have already stated (page 20) that the chief difference between grass and good meadow hay is the much smaller proportion of water contained in the latter. The following table will show the comparative value of grass and of hay as food:—

| | GRASS. | MEADOW HAY. |
|---|---|---|
| Flesh-forming substances .... | 2 | 10 |
| Heat-giving substances ....... | 10 | 42 |
| Mineral substances ............ | 2 | 7 |
| Water ............................ | 74 | 15 |
| Woody fibre..................... | 12 | 26 |
| | 100 | 100 |

## XVIII.—ARTIFICIAL FOODS: OIL-CAKE; ENSILAGE.

**108. Use of artificial Food—109. Oil-cake—110. Ensilage—111. Conclusion.**

**108. Use of artificial Food.**—The natural food of the animals kept on any farm—the cattle, sheep, and horses—would be mainly grass and roots; and if these animals lived in the natural or wild condition, such food would be sufficient for them. But the farmer wants his horses to do hard work; he requires the dairy cows to produce many times as much milk as they would do in a state of nature; while store cattle, pigs, and sheep must grow and fatten far more rapidly than they would naturally do if they are to yield a profit to the farmer.

For these reasons artificial or manufactured foods have come largely into use of late years. They contain a large amount of flesh-forming and of heat-giving substances packed into a small space.

**109. Oil-cake.**—The seeds of such plants as flax, rape, and cotton contain a great deal of oil. To extract the oil the seeds are placed in a machine (the hydraulic press), which exerts upon them so great a pressure that about three-quarters of the oily matter contained in the seeds is pressed out. The remainder forms a compact, somewhat brittle cake, about half-an-inch in thickness, varying in colour and composition according to the seeds from which it is made.

*Linseed Cake* is of a reddish-brown colour, and costs about £10 per ton. In 100 lbs. of linseed cake of good quality there are 9 lbs. of water, 30 lbs. of flesh-formers, 11 lbs. of oil, and 36 lbs. of other heat-giving substances, 8 lbs. of woody fibre, and 6 lbs. of mineral matter.

*Rape Cake* costs about £8 per ton. Its taste is not so pleasant as that of linseed cake.

*Cotton-seed Cake*, with the husk on (undecorticated), is worth £7 per ton. If the hairy covering of the seeds has been removed by machinery, the "decorticated" cake is worth £9 to £10 per ton.

Oil-cake is not given alone as food for animals, but the stock should receive in addition a fair amount of other food, as roots, grass, hay, etc. About half a pound of oil-cake per day is sufficient for a sheep, and five pounds for a bullock.

110. **Ensilage.**—The system of ensilage consists in preserving green forage or fodder crops in a pit for winter use, without their turning mouldy or rotten. The word *ensilage* is derived from the two Spanish words *en*, in, and *silo*, a pit. Ensilage appears to have been practised for a long time on the Continent, but in 1877 the system was introduced into the United States, and it has proved so useful to the farmers there that many English farmers are also trying the system as an experiment.

First, a *silo*, or water-tight pit, about the size of a small room should be constructed. The sides and bottom may be of masonry, or better, of concrete.

The fodder crops intended to be stored in the silo should be cut when they are just coming into flower, as the stems will then be full of nutritious matter. When the crop—clover, lucerne, rye-grass, or whatever it may be—is cut, it is carried to the silo, and either at once thrown in, or first cut up in pieces about an inch long by a chaff-cutter and then placed in the silo. The green mass must then be trodden

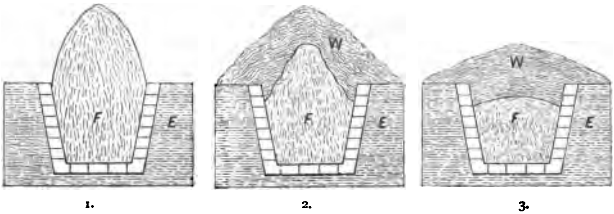


FIG. 35.—SYSTEM OF ENSILAGE.

1. A Silo just filled; 2. The same under pressure; 3. The Silo three months after filling. F, Fodder in the Silo; E, Soil in which the Silo is dug; W, Weights placed upon the fodder.

down, so as to lie as closely as possible, the great object being to exclude all air. The silo is filled high above the level of its top (see Fig. 35), and planks are then placed on the grass, and heavy weights on these—the heavier the better. In a few days the contents of the silo settle down (see Fig. 35, Nos. 2 and 3), and a foot or two of earth may then be placed on the top to prevent the entrance of air. The silo should not be opened till about three months after the time when it was filled. Fodder stored in this way is a most acceptable food to cattle, and is especially valuable for dairy cows during the winter and spring. The contents of the silo are cut into when required, just as if it were a rick of hay. The food is still green, and has a pleasant taste and smell, having heated and undergone a slight fermentation.

The uses of ensilage are—(1) that it enables crops to be stored in bad weather: the fodder can be put into the silo either wet or dry, while hay can only be made in fine weather; (2) it enables cattle to be kept in uniformly good condition throughout the winter; (3) the silo acts as a "save-all," into which all crops damaged by wet, or unsaleable for any reason, can go, forming excellent fodder.

**111. Conclusion.**—The more we consider the science of Agriculture, the more does it impress us with a sense of its importance. The success of our farmers in the cultivation of their soil is not only a matter of importance to themselves, to their landlords, and to their labourers, but it is a matter of the highest interest to the whole community, for we all depend on the farmer for our supplies of daily food. The area of cultivated land in these islands is but small in comparison with the large population, and it becomes every year more and more a matter of necessity that that small area shall be cultivated to the very best advantage. To do this we must educate not only our farmers, but their men. Landlords too must understand the necessity of improvements, for which they have to find the money. As we consider the question we shall perhaps agree more and more with that well-known potentate, the King of Brobdingnag, who long ago (see "Gulliver's Travels") gave it as his opinion "that whoever should make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."

# APPENDIX.

## QUESTIONS ON THE PRINCIPLES OF AGRICULTURE.

### I.

1. How should you measure land? How many square yards of land are there in the British Isles?

2. Why is not every square yard of land cultivated? How many acres of land in these islands are left uncultivated?

3. Name the principal classes of crops grown in the British Isles, and give an example of each.

4. Why do we import corn from other countries?

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### II.

5. What is the difference between a meadow and a pasture?

6. Whereabouts in the British Isles do the farms consist chiefly of pasture-land? Can you give any reason for this?

7. Name any good or "sweet" grasses with which you are acquainted. What other useful plants usually grow along with such grasses?

8. Can you tell the character of land from the weeds which grow upon it? How would you destroy weeds?

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### III.

9. What is the chief difference between grass and hay?

10. What kind of weather would you prefer for hay-making? What danger is a hay-rick specially exposed to, and how would you prevent it?

11. Describe exactly how to make grass into hay. How many days are usually required?

IV.

12. Explain the meaning of the words *arable*, *cereal*, and *pedigree*.

13. In what English counties is most wheat grown? Why is more wheat grown in the eastern than in the western counties of England?

14. When would you sow wheat? Name all the kinds of wheat you know.

15. How can you tell when wheat is ready for the sickle? How much wheat, under ordinary circumstances, would you expect to thresh out from a fifty-acre field?

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V.

16. What is the difference between barley and bere? Name the principal uses of barley.

17. How would you prepare the ground for a barley crop? From what part of the soil does the plant draw most of its nourishment?

18. What parts of the British Isles are most favourable to the growth of oats?

19. What cereal would you first sow on broken-up pasture-land?

20. Explain the reasons why oats are considered a valuable food for horses doing hard work.

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VI.

21. Explain the meaning of the word *legumin*, and name all the leguminous plants you know.

22. Describe the appearance of the flower of a bean or a pea. Of what service to the plants are the bright colours of these flowers?

23. When would you sow beans? What kind of soil do they prefer? How would you harvest beans?

24. Name any points in which the cultivation of pease *differs* from that of beans.

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VII.

25. Explain the words *fodder*, *crucifer*, *forage*, and *aftermath*.

26. Name all the plants which are usually grown as "green food" for stock.

27. Why is the clover crop considered to be of great importance and value by farmers?

28. Describe any common farming practices which are likely to *injure* a clover crop.

VIII.

29. How would you distinguish lucerne from tares?

30. What is a "catch crop"? What plants would you grow as catch crops, and for what reason?

31. Describe the cultivation of the cattle cabbage.

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IX.

32. Explain the words *fallow*, *soluble*, and *tuber*.

33. Point out the advantages of root-crops.

34. What do you know about the turnip? What soils are best suited for its cultivation?

35. What are "swedes"? How could you separate swedes of good feeding quality from others of fine appearance but containing little nutritious matter?

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X.

36. Explain the manner in which you think the wild beet-plant has become gradually changed to what we call "mangels." How could you again produce a plant like wild-beet from mangels?

37. Describe the plant called kohl-rabi. Why would a botanist say it was wrongly classed among the "root" crops?

38. How long have potatoes been known in England?

39. How would you plant potatoes, and what kind of soil does the plant prefer?

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XI.

40. Point out the difference between *climate* and *weather*.

41. In what way is it possible to foretell the weather of the next few hours?

42. Describe the distribution of plants over the surface of the Earth.

43. State the various conditions on which the climate of any place depends.

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XII.

44. By what agencies are hard rocks—such as granite—converted into a soft mass like the soil of our fields?

45. Classify the various kinds of soil you know.

46. What is meant by *plant-food?* Explain the word *dormant*.

XIII.

47. Explain the meaning of the words *organic* and *inorganic matter*; give three examples of each.

48. How does the presence of organic matter affect the fertility of a soil?

49. Point out the good which results from deep ploughing in autumn on clay lands.

50. Show how standing water, and how running water, affect the soil.

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XIV.

51. What does a seed require in order to make its first growth?

52. Explain the words *germinate* and *diastase.*

53. Why is a good seed-bed necessary?

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XV.

54. What are the three great sources from which plants derive their food? Which of the three can be most easily exhausted?

55. What is meant by the rotation of crops? Of what advantage to the farmer is a good rotation?

56. Why do we add manures to the soil?

57. Is it possible to grow heavy crops of corn year after year on the same soil? If this can be done, how is it that the soil does not become exhausted?

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XVI.

58. How do we ascertain the exact value, as a food, of any particular crop?

59. How would you classify foods?

60. What are the functions of food?

61. Can an animal subsist upon one class of food only? Give a reason for your answer.

62. Why do animals that are kept under shelter become fat more quickly than those which are allowed to roam the fields, although they each receive exactly the same quantity of food?

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XVII.

63. What classes of food are present in wheat?

64. What is the chief difference between roots and corn as food? Of

the various roots generally grown, which do you consider the most nutritious?

65. What changes take place in turnips, mangels, etc., after they have been stored for a few weeks? Should they be taken out of the ground before or after they are thoroughly ripe?

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XVIII.

66. Why do farmers give artificial food to their stock?
67. What is oil-cake? How is it prepared, and what does it cost?
68. Explain the meaning of the word *ensilage*.
69. Of what use is the system of ensilage to a farmer?

THE END.