solid rocks which consist more or less of hardened sandstones, limestones and clays either alone or mixed. All soils consist principally of sand, and clay lime. A mixture of sand and clay with a little lime would be called a loam, if much lime was present it would be a calcareous loam. Light land is one containing a large proportion of sand or gravel, heavy land is one containing much clay, a light soil is more easily cultivated and is better fitted for barley, maize and turnips and other green crops, while stiffer soils do better for wheat and beans.

It is better to plough deep, because then the roots of plants are able to descend deeper in search of food. There are occasions when it is better to plough less deep, when the under soil contains substance hurtful to plants, &c., and in such soils it is better to subsoil-plough, which enables the air and rain to descend into the subsoil and so change it as to make it fit to be brought to the surface. Heavy clay lands retain water most and should be drained, and so ought light soils, because the deeper you make it dry the deeper the roots go in search of food. The roots of grain-crops, clover and flax will go down 3 ft. and even turnips in an open soil will go down upwards of 2 feet.

Now, draining serves another purpose besides that of carrying off the water: it perfects the work of the subsoil-plough, it lets the air into the subsoil and allows rain-water to sink down at once and wash out of it anything which may be hurtful to roots of plants. Here is another reason why draining improves the soil; if the rain sinks where it falls, it does not wash the manure out of the soil, and if it contains anything valuable to plants, this is filtered out of it before it gets down to the drain. It is considered in England that the cost of draining land is paid back in from 3 to 5 years. The inorganic part of the soil serves two purposes: 1st it serves as a medium in which roots can fix themselves so as to keep the plant in an upright position, and 2d it supplies the plant with inorganic food.

The inorganic part of the soil contain several other substances as does the inorganic part of plants such as soda, potash, &c., and every fertile soil must contain them all because the plant requires them. If the soil is destitute of any of these substances, good crops will not grow upon it. If the land contained little lime it might grow a good crop of rye grass and yet might not be able to grow a good crop of clover or lucerne; a soil naturally fertile will become barren by continued cropping with the same kind of plant without a proper addition of manure. If you continue same field in wheat, oats or other grain, or with hay, it will become unable to grow any of them because the crop draws certain substances from the soil in great abundance, and after a number of years, the soil cannot furnish these substances in sufficient quantity to growing crops. The grain crops especially draw from the soil phosphoric acid, potash and magnesia. The roots of turnips, and potatoes chiefly exhaust it of potash, soda, lime, and phosphoric acid and thus you ought to return to the soil these substances.

Hay is the most exhausting crop, it carries off 130 to 210 lbs of mineral matter to every ton besides the organic substance.

Every crop takes away from the soil a certain quantity of those substances which all plants require. If you are always taking out of a purse it will at last become empty.

Manure means anything that furnishes food to plants and is of three kinds, vegetable, mineral, and animal.

The cultivated grain and roots chiefly consist of starch, gluten and oil or fat. As we have seen 100 lbs of wheat or barley flour contain 55 lbs of starch, 10 lbs of gluten and 2 or 3 of oil; 100 lbs. of oats contain 40 starch, 10 gluten and 4 oil. Indian corn 60 lbs of starch 10 gluten, and 5 fat, beans 45 lbs starch 24 gluten and 2 fat, clover, 40 starch, 8 gluten and 4 fat, potatoes 75 water and nearly 25 nutritive matter, 15 to 20 starch and 2 gluten.

Oats and Indian corn and oily seeds contain most fat, beans and peas, most gluten, and least oil, and oily seeds most gluten and oil together.

The dry substance of cabbage contain, more gluten than any crops.

The wheat of warm climates is said to contain more gluten, the potatoes and barley grown upon light or well drained soil, more starch.

Vegetables are intended to serve for the food of animals. The animal must derive from its food, in order that it may be maintained in a healthy condition, starch, gluten, oil or fat, and saline or inorganic matter.

The starch as we have seen consists of carbon and water and the animal requires it to supply the carbon which it throws off from its lungs during respiration. A man throws off 6 to 8 ounces of carbon in a day and must therefore eat nearly 1 lb. starch per day. 10 ounces of starch contains 4½ of carbon; it is given off from animals as carbonic acid gas, and the purpose for which the starch is reconverted into carbonic acid is to keep the animal warm. The carbonic acid is diffused into the air and fed to the plant to form starch.

The gluten serves to build up the muscles or lean part of the body.

A full grown animal requires gluten for the purpose of repairing the daily waste of the muscles of its body. Nearly all the parts of the body suffer certain waste every day. It is believed that all the parts of the body of a well fed man are removed or renewed once in the course of every thirty or forty days and yet the old scars on the body remain. The more exercise a man takes or bodily labour he performs the faster is his body wasted, and if he has food enough, renewed.

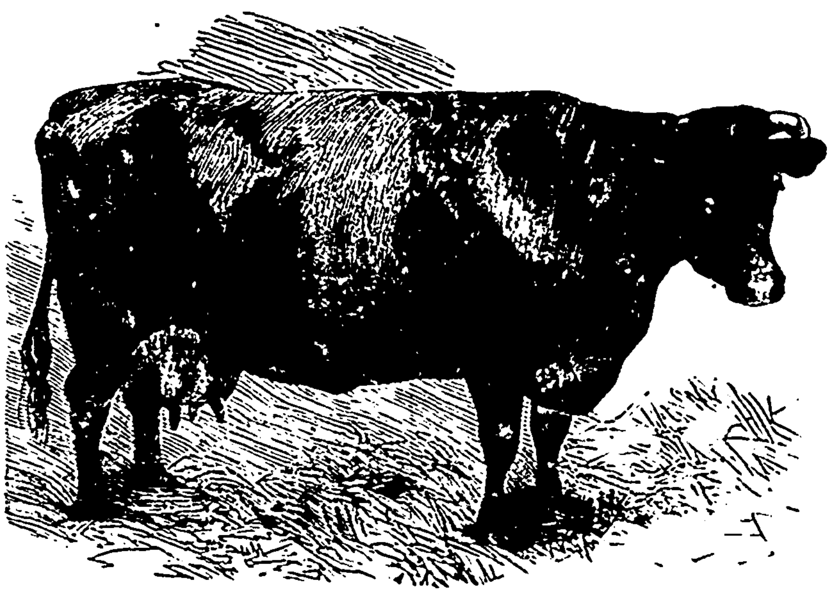
The part that thus wastes away is carried off through the body and forms part of the dung and urine of the animal.

The gluten of plant is almost the same thing as the muscles of the animal, and thus the foods which contain most gluten such as beans, peas, linseed cake, cabbage, build up and increase the muscles or muscular strength.

The animal requires oil or fat to supply the loss of oil or fat and to increase the fat.

Thus, the food containing most oil fatten quickest. The inorganic matter of plants is intended to serve in feeding animals to supply the mineral matter to the body as the soil supplies them to the plant, and a certain daily portion is necessary to the animal at all stages of its growth to supply the daily waste of the bone, of the salts in the blood, and the muscles &c., &c. Phosphate of lime is the kind of mineral matter, which is principally required by the bones. Gluten, fat and saline matter serve in growing animals by adding to the weight of its body. To sustain an animal, if not hard worked, requires about $\frac{1}{60}$ part of its weight of good; hay to increase or fatten it or enable it to give milk, about $\frac{1}{30}$ part.

If the same food be given to a full grown animal and to a growing animal the dung of the full grown animal, will be the richer, because the growing animal extract and retains more of the substance of the food.



CHAMPION MILKING SHORTHORN COW RED CHERRY.

THE DETERMINATION OF THE AVAILABLE PLANT FOOD IN SOILS.

I

MR. R. WARRINGTON, F. R. S., contributes an important article to *Science Progress* for May, which, with permission we propose to reprint in instalments —:

The chemical analysis of a soil, if carried out with completeness and read accuracy, is a work demanding much labour and skill. It has been frequently regarded as a thankless task. Agricultural chemists of high standing have proclaimed that such analyses were unreliable, because it was improbable that the very small quantity of soil investigated by the chemist could fairly represent the enormous quantity contained in a field. They further pointed out that the results afforded no information unpon the most important questions. There was frequently no thing to show why one field was fertile and another not. The quantities of plant food shown by the analysis were generally, when calculated on an acre of soil, extremely large; yet experience had probably taught the farmer that the application of a small quantity of soluble phosphate, of a potassium salt, or of a nitrate, had the effect of considerably increasing the crop. Some analysts, like Prof. Hilgard, have continued patiently at work, notwithstanding hostile criticism, and by the accumulation of experience have become able to interpret soil analyses with considerable success, especially if relating to a district already investigated. In such cases the agricultural meaning of the analysis did not lie on its surface, but was elucidated by bringing the analytical results into connection with other previously ascertained facts.

The main object of a chemical analysis is clearly to show *what is the* quantity of plant food existing in the soil. Physiologists are aware that the plant food in a soil occurs in two distinct forms. A plant can, in the first place, feed upon substances which are in solution. The water in a soil contains a more or less considerable amount of carbonic acid, and in this weak solution of carbonic acid certain of the ingredients of the soil are soluble. Soil water generally contains a good deal of calcium and magnesium carbonate; it contains nitrates, chlorides and sulphates, with soluble silicic acid. It generally contains no phosphates and only traces of potassium salts; sodium salts may, however, be present. If therefore, the *plant were entirely dependent on the* soil solution for its nourishment, it would be starved, as two essential constituents of plant food, phosphates and potash, are not supplied by this medium.

The second mode in which a plant feeds by the solvent action of its roots. This extremely important function of the roots has been far too little investigated. *Sachs* was the first to show that the root hairs of certain plants had the power of eroding polished plates of marble, dolomite, and osteolite, by virtue of the acid sap which they contained. *Zöller*, more than thirty years ago, ascertained at Liebig's suggestion that calcium phosphate, ammonium-magnesium phosphate, and the potash of a freshly-manured soil were dissolved when placed on a membrane the other side of which was in contact with a weak solution of hydro chloric acetic acid. It is generally, and *probably correctly, held that this solvent action of the roots is especially* effective towards the phosporic acid, potash and other substances which have been previously absorbed by the *soil from solution, and which are thus* held on the surface of the soil particles. As to the nature or amount of the free acid present in root sap little is definitely known. A. Mayer lays most stress on the presence of oxalic acid, which he found in several instances.

The importance of this solvent action of the roots can hardly be over-rated. Most of the phosphoric acid in soil exists as a basic ferric phosphate, in soluble in water and in carbonic or acetic acid, and but for the existence of this solvent power in roots would remain useless to vegetation. The potash, and we may add the ammonia, of soils is held in almost equally insoluble combinations; but analytical chemists are aware that the whole of the ammonia, and more or less of the potash, becomes soluble as soon as the soil is placed in a weak solution of hydrochloric or nitric acid. The acid sap of the roots is thus equally required *to bring about the solution of* this important soil constituents.

THE LEAF AND ITS FUNCTIONS.

The leaves of a tree are the most important organs of growth. More than nine-tenths of all the organic matter in tree comes from the air by means of the assimilation of carbon, from the deoxidation of carbonic acid,