forms nearly the whole substance of the potatoe and about half the weight of oatmeal, Indian corn meal, wheaten flour and of the flou of other kinds of grain cultivated for food.

Gluten is a substance like bird lime, which exists along with starch in almost all plants. It may be obtained from wheaten flour by making it into a dough and washing the dough with water.

Oil or fat is found in all plants, though it is generally most abundant in their seeds or nuts, linseed, rape seed, hemp seed, poppy seed, castor oil bean, walnut &c.

The 1st of these four substances, woody fibre, is usually most abundant in the stems of plants, and starch in their seeds and roots as the potato and other similar roots.

Now the substances which chiefly compose the solid parts of animals are muscle, fat, bone and skin.

The muscle consists chiefly of blood and a white fibrous substance called fibrin. Now if you take a piece of meat and wash it in successive portions of water till it becomes more or less void of colour, it will show you the fibrin. Now, the fibrin is almost exactly the same thing as the gluten of wheat.

The fat of animals bears a very close relation to the fat of plants, the solid fat of olive oil for example is the same substance as the solid fat of the human body.

All natural fats or oils consist of a solid and a liquid part. Thus, solid animal fats, like lard or tallow, and vegetable fats, like palm oil, yield a liquid oil when submitted to pressure, and leave a solid fat behind; so olive oil when cooled down becomes partly solid, and if pressed in the cold state, yields fluid oil and a solid white fat. It is this solid white fat which is identical with the solid fat of the human body.

The organic part of bone and skin consists for the most part of gelatine or glue. When bones or skin are boiled long in water they give solutions which when cooled down solidify into a strong jelly or glue.

The most important difference thus between the organic part of plant and of animal is, that the plant contains a large percentage of starch and that of the animal contains none.

We are still treating of the organic substance, and let us now divide the organic substance of plants, animals and soils into elemetary and compound bodies. By the elementary I mean those which can be separated. The elementary bodies in plants, animals and soil are four in number and are carbon, hydrogen, oxygen and nitrogen, with minute quantities of sulphur and phosphorus. In 1000 lbs of dry clover the quantity of sulphur amounts to 4 or 5 lbs only and that of phosphorus to 2 lbs; in animal substances the proportions of sulphur and phosphorus are somewhat greater.

Carbon is a solid substance usually of black color which has no taste or smell and which burns more or less readily in fire: wood, charcoal, lamp-black, coke, black lead and the diamond are varieties of carbon.

Hydrogen is a kind of air or gas which burns in the air as coal, gas does, but in which a candle will not bur nor an animal live; when mixed with common air it will explode if brought near the flame of a candle. It is also the lightest of all known substances being 14½ times lighter than air.

Oxygen is also a kind of air or gas void of color or taste or smell, a candle burns in it with great brilliancy, animals also live too rapidly in it. It is 16 heavier than hydrogen gas and ⅛ part heavier than common air.

Nitrogen is also a kind of air differing from both the other two. *Like* hydrogen, a taper will not burn nor will an animal live in it, but unlike hydrogen it does not take fire when brought near the flame of a candle. It is a little lighter than the atmospheric air.

Sulphur is a yellow brittle substance which burns with a pale blue flame and with a strong pungent and peculiar odour.

Phosphorus is a yellowish, waxy sub-stance which smokes in the air, shines in the dark, has a peculiar smell, takes fire by mere rubbing and burns with a large bright flame and much white smoke. Five gallons of atmospheric air contains 1 gallon of oxygen and nearly 4 gallons of nitrogen.

Most vegetable and animal substances contain only three of these element, are bodies, carbon, hydrogen, and oxygen, such as starch, gum, sugar, oil, fat, whilst such as gluten of wheat, fibrin of flesh, curd of milk, white of egg, gelatine of bones contain all six. Wheat contains 455 parts of carbon, 430 of oxygen, 57 hydrogen, 35 nitrogen and 23 of ash or in organic matter.

To the agriculturist, therefore, an acquaintance with these constituent parts of all that lives and grows on the face of the globe is indispensable.

It then appears that three of the four elements which constitute the solid structures of animals and plants are, in their pure state, invisible gases, and the remaining one is identical with ordinary charcoal; yet into how great a variety of beautiful forms and valuable products are they transmitted by nature and how interesting and instructive must be the study of the ways in which these wonderful processes are effected! All plants require constant supplies of food in order that they may live and grow, and they obtain it partly from the air and partly from the soil. They take it in by their leaves from the air and by their roots from the soil. They require two kinds of food, organic to supply their organic part, and inorganic to support their inorganic part.

They take their organic food from the air chiefly in the form of carbonic acid gas, which is a kind of air without color, but has a peculiar smell and a slightly sour taste. Burning bodies are extinguished by it and animal die in it. It is one half heavier than common air, renders lime-water, milky and is taken up by its own bulk of cold water. This gas is the cause of the bubbling up of soda-water.

In 5000 gallons of air there are only two gallons of carbonic acid.

Plants drink in this gas in large quantities through all their leaves, which contain small mouths or openings on the under side of their surface. It is a fact that there are no less than 120,000 of these pores or mouths on a square inch of the leaf of the common lilac, or 60,000 on that of the white lilac. Now the leaves do not suck in the carbonic acid gas at all times, it is only during daylight; during the night they give off some of this gas. Six lbs. of carbon and 16 lbs. of oxyen form 22 lbs. of carbonic acid gas. The plant retains the carbon and gives off the oxygen into the air, and this is proved by putting a few green leaves under a large glassful of fresh spring water and setting them out in the sunshine when small bubbles of oxygen gas will be seen to rise from the leaves and to collect in the upper part of the glass.

Leaves also drink in watery vapour from the air, which serves to moisten the leaves and stems and fill their cells, and produce the substance of the plant itself.

Plants take in carbon from the soil by means of carbonic acid, gas humic acid and some other substances which exist in the black vegetable matter of the soil; a considerable portion of the nitrogen of plants enters them in form of ammonia and nitric acid.

Water consists of oxygen and hydrogen; 8 lbs. ox with 1 lb. of hy. make 9 lbs. of water. It is a peculiar thing that water which puts out all fire is formed of 2 gases one of which (hy) burns readily, while in the other, (ox) bodies burn with great rapidity.

The properties of water is important to vegetation, first in dissolving solid and other substances; second, in rising as vapor and falling as rain or dew, and third, in yielding oxygen and hydrogen to growing plants. The dissolving property of water is important to vegetation because it enables it to take up from the soil and convey into the roots and stems of plants the various kinds of food which plants derive from the soil. The rising in vapor benefits vegetation in enabling the winds to carry it every where over the surface of the land so as to refresh vegetation by rain or dew. In yielding oxygen and hydrogen it assists vegetation in enabling the growing plant more easily and quickly to form the various compounds substances of which its parts consist.

Amonia is a kind of gas which has a strong pungent peculiar smell is lighter than common air and possesses alkaline properties.

Water absorbs much ammonia, i. e., 6 or 7 hundred times its bulk of ammoniacal gas. The common hartshorn is only water impregnated with this gas which consists of nitrogen and hydrogen (14 nit. and 3 hyd. make 17 ammonia). Under certain circumstances Ammonia is known to be produced naturally in decaying animals and vegetable substances, in fermenting compost or manure heaps, and in fermenting urine, and it is the principal cause of smell perceived in hot stables. It is perceptible by mixing the substance with quick lime when if ammonia is present its smell will become perceptible. You can detect if ammonia be escaping from such substances by the smell, or by dipping a rod or feather in strong vinegar or in spirit of salt and holding it over them, when if ammonia be escaping into the air white fumes will become visible.

Nitric acid is a very sour, corrosive liquid, also called *aqua fortis* and consists of nitrogen and oxygen, only 14 nit. 40 ox. make 54 nitric acid. It is formed in compost heaps and in soils during the decay of organic matter and in the air wherever bodies are burned in it or lightning passes through it. These two substances, ammonia and nitro acid enter into plant by being dissolved by water in the soil, and are taken up in a very dilute state by their roots.

We have said that woody fibre, starch, gum, sugar are composed of carbon, hydrogen and oxygen; we may go further and say that they are composed of carbon and water because the hydrogen and oxygen they contain are always in the proportion to form water (1 to 8).

Now, the woody fibre, starch and gum contain 36 lbs of carbon and 45 lbs of water and are formed principally from carbonic acid and water which the leaves and roots take in from the air and from the soil, and this is done by the influence of light which causes the carbonic acid to give off its oxygen from the leaf while its carbon unites with the water of the sap to form starch, sugar &c.

Plants draw the greatest part of their carbonic acid from the air which is replenished with the carbonic acid from 3 sources principally from the breathing of animals, from the burning of of wood and coal, and from the natural decay of animals and vegetables. All animals throw off a small quantity of carbonic acid from their lungs every time they breath.

The decay of vegetables in the air, of roots in the ground, and of remains of animals, is only a slow kind of burning by which their carbon is *at last* converted into carbonic acid. Thus, animals produce carbonic acid upon which plants live, and from the carbonic acid and water together plants produce starch &c., upon which animals live. Humic acid is formed by the loss of a portion of their water in the woody fibre and starch of plants, and serves to feed plants and prepare and carry other kinds of food into thier roots.

The fat or oil of plants and animals consists of carbon, hydrogen and oxygen.

The fat of the animal is chiefly derived from the fat of its vegetable or other food (1); gluten and fibrin consist of carbon, oxygen and nitrogen with a little sulphur and phosphates, and the plant draws from the air by its leaves the carbon and oxygen; but the nitrogen, sulphur, and phosphorus which are to remain parts of gluten are taken in by the roots; hence the importance of adding these substances to the soil when they are either present in too small quantity or in a condition in which plants cannot take them up.

The animal does not form the fibrin of its muscles from the elementary bodies carbon, hydrogen, nitrogen, sulphur and phosphorus of which fibrin consist, but it obtains it ready formed from the gluten of the plant. The plant is the servant of the animal as you see, and it *prepares* in fat and gluten, what the animal afterwards *uses* or appropriates to form the parts of its body. The soil consists of two parts like the plant and the animal: that is, organic and inorganic.

The organic part is derived from the roots and stems of decayed plants, and from the dung and remains of animals. In peaty soils, the organic part forms about ⅔ of it, but in rich and fertile soils, the organic matter is from a twentieth to a tenth of the whole weight when dry; that is, a rich soil ought to contain about 5 % of organic matter

The organic matter increases or diminishes in the soil according to the way in which it is cultivated: it diminishes when the land is frequently ploughed and cropped or badly manured, and it increases when the land is planted with trees, when it is laid down to permanent pasture, or when large doses of farmyard manure or of peat compost are given it.

This organic matter supplies organic food which plants draw from the soil through their roots. Now the quantites they draw varies with the kind of plant, the kind of soil, and with the season or climate, but it is always necessary to the healthy growth of the plant. Thus, the soil will become gradually poorer and less produtive from the plants drawing the organic matter from the soil. Then how can you keep up the supply? By ploughing in green crops, by growing clovers and other plants which leave long roots in the soil, by restoring all the hay and straw to the land in the form of manure, by laying down to pasture, by planting with trees, &c.

The inorganic part of the soil is derived from the crumbling down of

(1) And from the *Carbo hydrates* too; the starch; sugar, &c.—Ed.