slightly so in water, and produced during the decomposition of vegetable matters by the action of acids or alkalies. It has, however, received various names according to the different external characters and chemical properties which it presents. Thus, *ulmin*, *humic acid*, *coal of humus*, and *humin*, are names applied to modifications of *humus*. They are obtained by treating peat, woody fibre, soot, or brown coal with alkalies; by decomposing sugar, starch, or sugar of milk by means of acids; or by exposing alkaline solutions of tannic and gallic acids to the action of the air.

Vegetable physiologists have, without any apparent reason, imputed the known properties of the *humus* and *humic acids* of chemists to that constituent of mould which has received the same name, and in this way have been led to their theoretical notions respecting the functions of the latter substance in vegetation.

The opinion that the substance called *humus* is extracted from the soil by the roots of plants, and that the carbon entering into its composition serves in some form, or other to nourish their tissues, is considered by many as so firmly established that any new argument in its favour has been deemed unnecessary; the obvious difference in the growth of plants according to the known abundance or scarcity of *humus* in the soil, seemed to afford incontestable proof of its correctness.

Yet, this position, when submitted to a strict examination, is found to be untenable, and it becomes evident from most conclusive proofs that *humus* in the form in which it exists in the soil, does not yield the smallest nourishment to plants.

Humic acid, when first precipitated, is a flocculent substance, is soluble in 2500 times its weight of water, and combines with alkalies, lime and magnesia, forming compounds of the same degree of solubility. (Sprengel.)

Vegetable physiologists agree in the supposition that by the aid of water *humus* is rendered capable of being absorbed by the roots of plants. But according to the observation of chemists, humic acid is soluble only when newly precipitated, and becomes completely insoluble when dried in the air, or when exposed in the moist state to the freezing temperature. (Sprengel.)

Let us now calculate the quantity of humic acid which plants can receive under the most favourable circumstances, viz., through the agency of rain-water.

The quantity of rain which falls at Erfurt, one of the most fertile districts of Germany, during the months of April, May, June, and July, is stated by Schubler to be 19.3 lbs. over every square foot of surface; 1 Hessian acre, or 26,910 square feet, consequently receive 771,000 lbs. of rain-water.

If, now, we suppose that the whole quantity of this rain is taken up by the roots of a summer plant, which ripens four months after it is planted, so that not a pound of this water evaporates except from the leaves of the plant; and if we further assume that the water thus absorbed is saturated with humate of lime (the most soluble of the humates, and that which contains the largest proportion of humic acid;) then the plants thus nourished would not receive more than 330 lbs. of humic acid, since one part of humate of lime requires 2500 parts of water for solution.

But the extent of land which we have mentioned produces 2843 lbs. of corn (in grain and straw, the roots not included,) or 22,000 lbs. of beet-root (without the leaves and small radicle fibres.) It is quite evident that the 330 lbs. of humic acid, supposed to be absorbed, cannot account for the quantity of carbon contained in the roots and leaves alone, even if the supposition were correct, that the whole of the rain-water was absorbed by the plants. But since it is known that only a small portion of the rain-water which falls upon the surface of the earth evaporates through plants, the quantity of carbon which can be conveyed into them in any conceivable manner by means of humic acid must be extremely trifling, in comparison with that actually produced in vegetation.

Other considerations of a higher nature confute the common view respecting the nutritive office of humic acid, in a manner so clear and conclusive that it is difficult to conceive how it could have been so generally adopted.

Fertile land produces carbon in the form of wood, hay, grain, and other kinds of growth, the masses of which differ in a remarkable degree.

2920 lbs. of firs, pines, beeches, &c. grow as wood upon one Hessian acre of forest-land with an average soil. The same superficies yields 2755 lbs. of hay.

A similar surface of corn-land gives from 19,000 to 22,000 lbs. of beet root, or 881 lbs. of rye, and 1961 lbs. of straw, 160 sheaves of 15.4 lbs. each,—in all, 2843 lbs.

One hundred parts of dry fir-wood contain 38 parts of carbon; therefore, 2920 lbs. contain 1109 lbs. of carbon.

One hundred parts of hay*, dried in air, contain 44 31 parts carbon. Accordingly, 2755 lbs. of hay contain 1111 lbs. of carbon.

Beet-roots contain from 89 to 89.5 parts water, and from 10.5 to 11 parts solid matter, which consists of from 8 to 9 per cent. sugar, and from 2 to 2½ per cent. cellular tissue. Sugar contains 42 4 per cent.; cellular tissue, 47 per cent. of carbon.

22,000 lbs. of beet-root, therefore, if they contain 9 per cent. of sugar, and 2 per cent. of cellular tissue, would yield 1032 lbs. of carbon, of which 833 lbs. would be due to the sugar, and 198 lbs. to the cellular tissue; the carbon of the leaves and small roots not being included in the calculation.

One hundred parts of straw, dried in air, contain 38 per cent. of carbon; therefore 1961 lbs. of straw contain 745 lbs. of carbon. One hundred parts of corn contain 43 parts of carbon; 882 lbs. must therefore contain 379 lbs—in all, 1124 lbs. of carbon.

26, 910 square feet of wood and meadow land produce, consequently, 1109 lbs. of carbon; while the same extent of arable land yields in beet-root, without leaves, 1032 lbs., or in corn, 1124 lbs.

It must be concluded from these incontestable facts that equal surfaces of cultivated land of an average fertility produce equal quantities of carbon; yet, how unlike have been the different conditions of the growth of the plants from which this has been deduced!

Let us now inquire whence the grass in a meadow, or the wood in a forest, receives its carbon, since there no manure—no carbon—has been given to it as nourishment? and how it happens, that the soil, thus exhausted, instead of becoming poorer, becomes every year richer in this element?

A certain quantity of carbon is taken every year from the forest or meadow, in the form of wood or hay, and, in spite of this, the quantity of carbon in the soil augments; it becomes richer in humus.

It is said that in fields and orchards all the carbon which may have been taken away as herbs, as straw, as seeds, or as fruit, is replaced by means of manure; and yet this soil produces no more carbon than that of the forest or meadow, where it is never replaced. It cannot be conceived that the laws for the nutrition of plants are changed by culture,—that the sources of carbon for fruit or grain, and for grass or trees, are different.

It is not denied that manure exercises an influence upon the development of plants; but it may be affirmed with positive certainty, that it neither serves for the production of the carbon, nor has any influence upon it, because we find that the quantity of carbon produced by manured lands is not greater than that yielded by lands which are manured. The discussion as to the manner in which manure acts has nothing to do with the present question, which is, the origin of the carbon. The carbon must be derived from other sources; and as the soil does not yield it, it can only be extracted from the atmosphere.

In attempting to explain the origin of carbon in plants, it has never been considered that the question is intimately connected with that of the origin of humus. It is universally admitted that humus arises from the decay of plants. No primitive humus, therefore, can have existed—for plants must have preceded the humus.

Now, whence did the first vegetables derive their carbon? and in what form is the carbon contained in the atmosphere?

These two questions involve the consideration of two most remarkable natural phenomena, which by their reciprocal and uninterrupted influence maintain the life of the individual animals and vegetables, and the continued existence of both kingdoms of organic nature.

One of these questions is connected with the invariable condition of the air with respect to oxygen. One hundred volumes of air have been found, at every period and in every climate, to contain 21 volumes of oxygen, with such small deviations that they must be ascribed to errors of observation.

Although the absolute quantity of oxygen contained in the atmosphere appears very great when represented by numbers

* 100 parts of hay dried at 100° C. (212° F.) and burned with oxide of copper in a stream of oxygen gas, yielded 51.93 water, 165.6 carbonic acid, and 6.82 of ashes. This gives 45.87 carbon, 5.76 hydrogen, 31.55 oxygen, and 6.82 ashes. Hay, dried in the air, loses 11 2 p. c. water at 100° C. (212 F.)—(Dr. Wil.)