CLASSICS OF SCIENCE: Carbon in Plants

Physics—Chemistry

Liebig gives the following experiment to prove that plants absorb carbon dioxide and give off oxygen: "The leaves and other green parts of a plant absorb carbonic acid, and emit an equal volume of oxygen. They possess this property quite independently of the plant; for if, after being separated from the stem, they are placed in water containing carbonic acid, and exposed in that condition to the sun's light, the carbonic acid is, after a time, found to have disappeared entirely from the water. If the experiment is conducted under a glass receiver filled with water, the oxygen emitted from the plant may be collected and examined. When no more oxygen gas is evolved, it is a sign that all the dissolved carbonic acid is decomposed; but the operation recommences if a new portion of it is added. Plants do not emit gas when placed in water which either is free from carbonic acid, or contains an alkali that protects it from assimilation."

ORGANIC CHEMISTRY in its Applications to Agriculture and Physiology. (1840) By Justus Liebig, M.D., Ph.D., F.R.S., M.R.I.A., &c., Edited from the manuscript of the author by Lyon Playfair, Ph.D. First American Edition, with an introduction, notes, and appendix, by John W. Webster, M.D. Cambridge (Mass.) 1841.

JUSTUS VON LIEBIG

Carbon in Soil Increases

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 not 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 twenty-one 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, yet it is not inexhaustible. One man consumes by respiration 45 Hessian cubic feet of oxygen in 24 hours; 10 centners of charcoal consume 58,112 cubic feet of oxygen during its combustion; and a small town like Giessen (with about 7000 inhabitants) extracts yearly from the air, by the wood employed as fuel, more than 1000 millions of cubic feet of this gas.

When we consider facts such as these, our former statement, that the quantity of oxygen in the atmosphere does not diminish in the course of ages,—that the air at the present day, for example, does not contain less oxygen than that found in jars buried for 1800 years in Pompeii,—appears quite incomprehensible, unless some source exists whence the oxygen abstracted is replaced. How does it happen, then, that the proportion of oxygen in the atmosphere is thus invariable?

The answer to this question depends upon another; (*Turn to next page*)

New Fossil Footprints

Paleontology

New finds of fossil footprints in the rocks of the Grand Canyon of Arizona, but this time on the north rim, fourteen miles from the site of previous discoveries on the south rim, are reported by Dr. Charles W. Gilmore of the U. S. National Museum and Glenn E. Sturdevant, government naturalist of Grand Canyon National Park.

Slabs bearing the foot imprints of small reptiles or salamander-like amphibians were found at two levels, one in the Coconino and one in the Supai formation. These correspond with two of the three formations on the other side of the Canyon in which tracks have been found during the past few years, but further exploration and examination of specimens will have to be carried on before it can be determined whether the levels match up exactly and whether the tracks represent the same kinds of feet.

The fossil footprints from the south side of the Canyon thus far discovered represent 36 species, distributed among 28 genera.

Science News-Letter, March 3, 1928

Do You Know That—

A new lock for the North Sea Canal will be larger than any on the Panama Canal.

Plate glass is rolled from a soft hot mass, like pie crust, with steel rollers.

Almost every important nation in the world manufactures oceanographic and topographic charts.

In order to lift the average adult, a balloon must have about 4,000 cubic feet of gas.

A city of bungalows, offices, and stores entirely for airmen is being built in Wisconsin.

Telephones are being used to communicate between the head and rear ends of long freight trains.

A new refrigerator invented by Swedish engineers keeps cool with heat, burning about three cubic feet of gas per hour.

Liebig—*Continued*

namely, what becomes of the carbonic acid, which is produced during the respiration of animals, and by the process of combustion? A cubic foot of oxygen gas, by uniting with carbon so as to form carbonic acid, does not change its volume. The billions of cubic feet of oxygen extracted from the atmosphere, produce the same number of billions of cubic feet of carbonic acid, which immediately supply its place.

Carbonic Acid in Air Constant

The most exact and most recent experiments of *De Saussure,* made in every season, for a space of three years, have shown, that the air contains on an average 0.000415 of its own volume of carbonic acid gas; so that, allowing for the inaccuracies of the experiments, which must diminish the quantity obtained, the proportion of carbonic acid in the atmosphere may be regarded as nearly equal to 1-1000 part of its weight. The quantity varies according to the seasons; but the yearly average remains continually the same.

We have no reason to believe that this proportion was less in past ages; and nevertheless, the immense masses of carbonic acid, which annually flow into the atmosphere from so many causes, ought perceptibly to increase its quantity from year to year. But we find, that all earlier observers describe its volume as from one half to ten times greater than that which it has at the present time; so that we can hence at most conclude, that it has diminished.

It is quite evident, that the quantities of carbonic acid and oxygen in the atmosphere, which remain unchanged by lapse of time, must stand in some fixed relation to one another; a cause must exist which prevents the increase of carbonic acid, by removing that which is constantly forming; and there must be some means of replacing the oxygen, which is removed from the air by the processes of combustion and putrefaction, as well as by the respiration of animals.

Both these causes are united in the process of vegetable life.

The facts which we have stated in the preceding pages prove, that the carbon of plants must be derived exclusively from the atmosphere. Now, carbon exists in the atmosphere only in the form of carbonic acid; and, therefore, in a state of combination with oxygen.

It has been already mentioned likewise, that carbon and the elements of water form the principal constituents of vegetables; the quantity of the substances which do not possess this composition being in very small proportion. Now, the relative quantity of oxygen in the whole mass is less than in carbonic acid. It is therefore certain, that plants must possess the power of decomposing carbonic acid, since they appropriate its carbon for their own use. The formation of their principal component substances must necessarily be attended with the separation of the carbon of the carbonic acid from the oxygen, which must be returned to the atmosphere, whilst the carbon enters into combination with water or its elements. The atmosphere must thus receive a volume of oxygen for every volume of carbonic acid which has been decomposed. . . .

The presence of a rich and luxuriant vegetation may be conceived without the concurrence of animal life, but the existance of animals is undoubtedly dependent upon the life and development of plants.

Plants not only afford the means of nutrition for the growth and continuance of animal organization, but they likewise furnish that which is essential for the support of the important vital process of respiration; for besides separating all noxious matters from the atmosphere, they are an inexhaustible source of pure oxygen, which supplies the loss which the air is constantly sustaining. Animals, on the other hand, expire carbon, which plants inspire; and thus the composition of the medium in which both exist, namely, the atmosphere, is maintained constantly unchanged.

Justus von Liebig was born in Darmstadt, Germany, May 4 or 12, 1803, and died in Munich April 10, 1873. His interest in chemistry was intense by the time he was fifteen. With a Ph.D. from Erlangen University, he went to Paris at nineteen, lamenting that he had wasted so much time trying to learn chemistry in the then poorly equipped schools of Germany. He completed important investigations of the fulminates of silver and mercury in Gay-Lussac's laboratory in 1824, and in the same year was appointed extraordinary professor of chemistry at Giessen. There he had adequate equipment for experiment installed, and his classes became the most famous center of chemical research in the world. In 1832 Liebig and Wöhler worked out the composition of oil of bitter almonds, and discovered the series of benzoyl compounds. The two researchers remained friends for the rest of their lives. About 1838 the study of the chemistry and physiology of plants and animals claimed Liebig's attention, and he worked in that field for the next thirty-five years. From 1845 to 1850 he tried out his theories of soil chemistry and artificial fertilizers by experimental farming. In 1852 Liebig went to Munich as professor of chemistry, occupying that position until his death.