A CENTURY OF MEDICINE AND CHEMISTRY: A LECTURE INTRODUCTORY TO THE COURSE OF LECTURES TO THE MEDICAL CLASS IN YALE COLLEGE. DELIVERED SEPTEMBER 14, 1871

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BY

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LECTURE.

A century has now nearly passed since on August 1st, 1774, Dr. Priestley first recognized the distinctive properties of oxygen gas which he called "dephlogisticated air." Lavoisier in the same year and shortly after the discovery of oxygen by Priestley, published a memoir in which he showed that in common combustion and in the calcining of metals it was not the whole of the air but only one part of it which was active in producing these changes. He at first called the active portion of the air "vital air," or "air eminently adapted for supporting combustion and respiration." Up to this time chemists had distinguished what we now call metallic oxides as the "*calx*" of metals. Lavoisier in preparing oxygen from what was then called "mercurial calx" (mercuric oxide, or "red precipitate *per se*",) as Priestley had done before him, took a most important step in advance of his English predecessor, and beyond his time, and proved that the "mercurial calx" was a compound of "vital air," or the new gas, with mercury, and hence he concluded, by analogy, that all metallic calxes must have a like constitution. Starting thus upon the legitimate, but until then untried path of inductive reasoning in chemistry, he advanced from the fact already made known some years before by the researches of Dr. Black of Edinburgh on "fixed air:" namely that metallic calxes when heated with charcoal were converted into the metallic state with escape of "fixed air," or carbonic acid;—the great French philosopher reached the important deduction that "fixed air" must itself be composed of charcoal (carbon) and "vital air" (oxygen). This latter conclusion he soon after established by a brilliant synthesis, by burning a diamond in "vital air" and proving that the sole product was "fixed air," which from that time was known as carbonic acid. The Florentine academicians in the days of Cosmo de Medici had indeed burned the diamond by means of a powerful burning glass, but these philosophers were so completely occupied by the phenomenon of the burning, physically considered, that they did not see in this remarkable experiment its chemical teachings, nor was the world then sufficiently advanced to comprehend the problem in its chemical relations. Thus, well advanced, in his course of chemical research, Lavoisier continued his investigations upon the constitution of acids by examining in 1777 the acid produced by the combustion of phosphorus. In this research he first demonstrated that the active agent of combustion constituted one fifth part of the air, thus adding the accuracy of quantitative determinations to phenomenal or qualitative observations. And finally in 1778, in a memoir in furtherance of the same line of research, he for the first time, in the literature of chemistry, distinguishes the "air eminently adapted for supporting combustion and respiration" by its present name of OXYGEN.

Prior to the discovery of oxygen, and with it the methods of reasoning and investigation peculiar to chemistry, there was no science of chemistry properly so called. The alchemists and the Iatro Chemists had indeed accumulated a great number of important data and had observed many interesting and valuable facts; but men's minds were then preöccupied by an hypothesis, which to a certain extent methodized facts, but completely misled the judgment and blinded the eyes of observers, when considering those chemical changes which accompany the phenomena of combustion. This was the so called *Phlogistic Theory* of Stahl. George Ernest Stahl was a German physician and chemist, (born in 1660, died 1734) of original power and whose medical theories were quite as prominent as his chemical. His phlogistic theory in chemistry was the first attempt at a systematic and philosophical arrangement of facts in the science, and held its ground for more than fifty years. Like all theoretical systems, which have had more than an ephemeral existence, there was in it a substantial element of truth, obscurely perceived it is true, but firmly held. Stahl's phlogiston was only another name for heat (φλογιστὸς, burnt) and so long as the material nature of heat was an article of scientific faith the phlogistic theory served to classify phenomena into generic groups and to furnish a plausible explanation for chemical changes. The fact that the loss of phlogiston, which by this theory was what happened whenever a body was burned (combustible bodies being such by reason of their holding phlogiston in combination;) that this loss was invariably accompanied by an increase of weight in the *calx* or body burned, appears to have offered no serious difficulties to those who had accepted the phlogistic theory. If pushed for an explanation of this undeniable fact, they found a ready refuge in the absurdity of assigning to this mysterious and unseen principle of phlogiston the quality of *specific levity!* Strange that men of such sagacity as Drs. Black and

Priestley should have been able to content themselves with a resort so completely unphilosophical! It was by the use of this weapon that Lavoisier attacked and destroyed the phlogistic theory, introducing for the first time in chemistry methods of experiment which admitted of rigorous exactness and demonstrating that in every case when, in the act of combustion, there was a gain of weight in the body burned, the increase was exactly equal to the loss sustained in a given volume of air concerned in the reäction. In fact the so called phlogiston was proved to be, not the principle of heat, but an element ever present in the air as one of its component parts and upon the presence of which all cases of common combustion depended. This element was *oxygen*, a name invented by Lavoisier to express what all chemists then believed to be true respecting the acidifying power of this wonderful agent.

It is well nigh impossible for us now from our present advanced position to recall the condition of chemical and medical science as it existed before the discovery of oxygen had rendered it possible to understand the most simple and frequently occurring phenomena of our daily experience, and before the nomenclature of the French Academy, propounded chiefly by Lavoisier, had supplied to us the forms of speech in which to clothe our notions of what takes place in even the simplest chemical changes. But we must not permit ourselves to look with disrespect upon the theoretical views which for nearly half a century held almost universal sway in the minds of chemists. The phlogistic theory of Stahl was the first great generalization of facts in chemistry. Led captive by the splendor of the phenomena which attend combustion, these chemical Fire-Worshipers lost sight of the fact that the change of weight in the body burned was quite as important, and demanded as satisfactory an explanation, as the light and heat sent out in the act of burning. The one set of phenomena are in fact just as important as the other and both must be explained before the philosophical mind can feel satisfied. The swing with which the chemical world moved away from the phlogistic theory to follow the new views set forth in the so called anti-phlogistic theory of Lavoiser was natural enough, but like all extreme movements became in its turn one-sided.

Viewed in the light of modern science the phlogistic theory is seen to involve, as before hinted, an important element of truth. Combustible bodies in burning do lose *something*; not an ideal phlogiston truly, but a *potential energy* which has a definite mechanical value and is capable in each case of an exact numerical statement in terms of work done or to be done. In a unit of carbon we recognize the equivalent of 8080 French units of heat evolved when the carbon burns in air to form carbonic acid; and we know that when the carbon has lost this something in the act of burning, which the older chemists called phlogiston, it can regain it only by the reverse process of *unburning*, which for its perfect accomplishment must borrow the same amount of power from some other source. Every body which is capable of burning may be likened to a force in a condition of unstable equilibrium, like a weight held at a height by a cord against the force of gravity, and which will reproduce by its fall the same amount of power which had been expended in raising it to its present position. What is the source of the power which we find in a mass of anthracite, or of wood when these substances burn? The answer is they exist in their present potential condition only by reason of the exercise at some former time of an amount of force equivalent, necessarily, to that which they in turn can now exercise in the act of burning. The sun has wrought out this problem with his silent power, unburning factors, which have, under his chemical agency, given up their carbon and hydrogen to form vegetable fibre and endow it with these reserves of force, which however great they may seem to us, are all precise equivalents of the energy employed in their production.

I sometimes think with how much satisfaction George Ernest Stahl would contemplate this view of his phlogistic theory, which assigns to it a definite philosophical basis, far more profound indeed than he could ever have dreamed of, and one which would have enabled him to meet his antagonists, had he been permitted to revisit the earth half a century after his death, and to have dealt them blows, which to say the least, would have been as well delivered as those which he had to receive. The triumph of a theory is its power to embrace and co-ordinate the greatest number and variety of facts. Now the theory of phlogiston was equally applicable to two opposite orders of phenomena and united them by a theoretical bond, but it failed while considering the phenomena of combustion and the calcination of metals to regard the part which the air bore in these changes, and precisely here was where it was successfully attacked by Lavosier, and brought to grief.

But let us consider more particularly a few points which are of more specific interest to us in view of what medicine has gained from the introduction of the