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OZONE; ITS RELATIONS TO HEALTH AND DISEASE.

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THIS body, once unknown and long neglected, but now commanding the enthusiasm of all engaged in the investigation of its properties, is yet to form a most important chapter in every volume of medical literature. Emerging from the shades of an enshrouding obscurity, and rapidly becoming universally known, "*clarior e tenebris*" might not inaptly be cited as the brief but terse description of its previous history. When more patient and protracted analysis shall bring the sure reward of a still better comprehension, it will be prized as "the pillar of fire to give light" through the tedious wilderness of obscure and discouraging theory. But the nature of such a paper as the present forbids the indulgence of prediction, when the future alone can verify convictions which would induce the spirit of prophecy. With brevity and conciseness, therefore, we will, without preface, consider the subject contemplated.

It is now generally conceded that Van Marum was the first to call the attention of scientific men to the existence of some anomalous body, which farther investigations proved to be that of which we now write. This philosopher made his first experiments in 1785, but the results were too unsatisfactory to secure general attention. He had charge of the large electrical machine in Taylor's Museum, and with this he excited sparks in a tube filled with oxygen; after the disengagement of 5,000 sparks, the gas had acquired a very strong and characteristic odor. M. Schönbein, of Bâle, became interested in these experiments, and determined to fully investigate the subject. His researches were actively made and promptly given to the public. From this period the true history of the subject begins—that is, from 1842, two years after Schönbein's discovery.

To M. Schönbein really belongs the credit of having introduced

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this subject to the attention of the scientific in and out of the medical profession. A general interest was at once awakened, and we find monographs almost simultaneously published in different parts of Europe. Its composition, nature and properties formed subjects for excited controversies, and we find such distinguished men as Marignac, De la Rive, Arago, Becquerel, Liebig, Bergmann, Berzelius, Osann and others striving for the position of teachers and expounders of this novel agent. On account of its peculiar and strong odor it received from M. Schönbein the appropriate name it now bears, ozone, from the Greek verb, *οζω*, to yield an odor. Although this name reveals nothing of the composition of this body, and most investigators have attempted to make a more suggestive substitute, yet it has been retained, both for its appropriateness and as a merited tribute to him who gave it. Ozone was for a long time claimed as a binoxide, or peroxide of hydrogen; it was written in chemical abbreviation HO^2 , thus indicating the condition of the binoxide to be the most invariable. Schönbein regarded it as a regular constituent of the atmosphere, and the condition of the binoxide as that most uniformly manifested; this view was for a time doubted, but is now regarded as most generally correct. According to M. Schnepf, this fact was first promulgated in 1849, about seventeen years after its properties were generally investigated. After so many years of patient examination, it is at least most probable that this view is scientifically correct. Schönbein states that there is formed, from the same influences, a small proportion of nitric acid. The formation of nitric acid, as thus stated, was advanced by Cavendish as early as 1784, and fully proved after that time by Bergmann and others. Liebig investigated this fact in 1826, M. Boussingault in 1839, and M. Barral in 1852. Heller has attempted to prove the constant existence of nitric acid in the atmosphere, and, for this purpose, presented a memoir to the Academy of Sciences at Vienna. The report of the Academy was not entirely favorable, but he is sustained by many and prominent authorities, who not only differ with the Vienna Academy, but unanimously certify, in addition to this, that there is formed, at the same time, ozone and ammonia, &c., as claimed by M. Schönbein:—"Malgré l'autorité de cette société savante, il reste néanmoins acquis à la science, par suite des travaux de Cavendish, de Bergmann, de M. Liebig, de MM. Heller, Boussingault et Barral, que l'électricité contenue dans l'air atmosphérique, agit sur les deux éléments fondamentaux de ce fluide, pour donner naissance à l'ozone, et sans doute en même temps aussi, à une proportion très-faible d'acide nitrique et d'ammoniaque," &c. This claim, then, of Schönbein is fully admitted; for the testimony of the authorities quoted, whilst supporting the claim of M. Heller as to the constant existence of nitric acid in the atmosphere, fully proves that the same causes produce also ozone. The absolute and uniform composition of ozone has been, among chemists and philosophers, the subject of

repeated analysis, and, until recently, of constant controversy. Schönbein claimed it as a binoxide, or peroxide of hydrogen; Faraday denied this, and considered ozone as "oxygen in an isomeric state," or as a "simple modification of oxygen, in an allotropic condition of that body." Mr. Williamson, of the Royal Society of London, pronounced that according as ozone is produced by a galvanic battery, developed by the electric spark, or brought forth by the action of air on phosphorus, it is a hyperoxide of hydrogen and azotic acid, or a mixture of the two. Berzelius opposed this view, and contended to prove that Faraday was correct.

At this time a series of experiments were instituted, by MM. Marignac and De la Rive, two savans of Geneva, for the purpose of demonstrating the truth of what had been so frequently advanced—that ozone is only oxygen, in the peculiar state given to it by electricity. These experiments were commenced a short time after the publication, by MM. Frémy and Becquerel, of their original views, in their joint work "Electro-chemical Researches on the Properties of Electrified Bodies." It is to MM. Frémy and Becquerel that the scientific world is indebted for all that is original in this view—that ozone is but oxygen in the characteristic state induced by its subjection to electricity. This view, original with them, has been brought prominently before the public by MM. Marignac and De la Rive. It was apparently demonstrated, by MM. Frémy and Becquerel, that the "ozonoscopes" (or tests for ozone) would not be affected unless the oxygen be electrified. In the presence of oxygen, or electricity singly, they remained unchanged; but as soon as the oxygen was electrified, ozone, it appeared, was clearly manifested. This fact was proved, it was thought, by a few simple and ingenious experiments. Before alluding to experiments of any kind, however, it is proper to briefly explain the nature and composition of the "ozonoscope." This description will be general, as well as brief, and all the details and important suggestions connected with them will be postponed for that portion of the essay devoted to their consideration.

An ozonoscope is a slip of paper or cloth, on which has been spread a compound of gelatinized starch and the iodide of potassium. Ozone, playing the part of an acid, unites with the potassium, and, in forming potassa, liberates a certain proportion of free iodine; the iodine, thus liberated, unites with a portion of starch, forming the characteristic blue iodide of starch. The depth of this blue demonstrates the amount of ozone present, or, in the phraseology commonly used, chromatic intensity becomes the measure of ozonic quantity. It is not necessary to enter farther into the description of the ozonoscopes to insure a full understanding of the chemical changes taking place when they are experimentally used; farther details will therefore be postponed until they form the actual subject of consideration.

MM. Frémy and E. Becquerel, in their experiments, placed one of these ozonoscopes in a glass tube which was filled with oxygen and

then hermetically sealed. By means of metallic bulbs at each end of this tube, electric sparks were made to leap (from the point of an ordinary conductor) across this volume of oxygen. The ozonoscope was immediately made blue. It was now necessary to prove that this result was not caused by the decomposition of the iodide of potassium (on the ozonoscope) by means of the electricity used. The ozonoscope, for this purpose, was then placed in a similar tube, under similar precautions, and the tube, after being filled with hydrogen gas, was hermetically sealed. The same electrical agents were then applied to it. The ozonoscope remained unchanged. To succeed in this last experiment, the authors advise that only the purest hydrogen gas should be used, and that the ozonoscope shall be freed from the atmospheric air it contains. If the hydrogen is not absolutely pure and the ozonoscope thus prepared, the experiment fails; the least trace of oxygen, in the hydrogen or in the ozonoscope, will be sufficient to produce this failure. The oxygen, if thus present in the feeblest proportions, becomes electrified, and, reacting on the ozonoscope, generates the blue color which is the unanswerable indication of failure in this hydrogen experiment. These two experiments would apparently show that the ozonoscope, in the experiment with oxygen, is only made blue by the oxygen after being electrified, and that electricity, acting upon the iodide of potassium (on the ozonoscope) is not sufficient to produce its decomposition, and thus cause any change in the ozonoscope containing it.

Frémy and Becquerel proved that the ozonoscope, in the hermetically sealed tube containing oxygen, would be made blue when electricity was made to act upon the oxygen "by influence." This was done by dispensing with the metallic bulbs and by placing the tube between the branches of a conductor whose points touched the surface of the tube. The sparks, in passing from one point to the other, would (*in transitu*) lick the surface of the tube and thus affect the oxygen it contained; this oxygen would become electrified and the test paper rendered blue. This last experiment was, to all appearances, carefully made and really intended to remove all doubt and uncertainty; for among the many causes which are constantly and even inappreciably conspiring to vitiate these experiments, it is well known that the electric spark itself is frequently accompanied by foreign matter. This matter, it was thought, might produce some obscure but material change in the ozonoscope; and it was decided to fully guard against this source of error. The experimenters anticipated the possibility of such a charge, on the part of those ever ready to cavil against the position they had assumed, and wisely made such a charge impossible.

The next position established was, that the ozonoscope would remain unchanged in a volume of oxygen gas. An ozonoscope was, for proving this, carefully suspended in a receiver filled with this gas; after remaining ten days, it was entirely unchanged. To prove

that the gas was pure, it was electrified, and the paper immediately became blue. The same experiment demonstrated the careful preparation of the ozonoscope. The gas was electrified by the introduction of platinum wires, in connection with an electrical machine.

These experiments were all made (and apparently carefully made) by MM. Frémy and Becquerel.

M. Scoutetten next furnishes additional proof that electricity alone could not produce any change in the ozonoscope. He placed one in vacuo and subjected it to intensely electrical influences. It remained unchanged, but became blue when oxygen was introduced and then electrified. It was thus *apparently* proved that oxygen alone is not sufficient to produce a chromatic change in the ozonoscope; that electricity alone is also insufficient for the production of such a change; that electrified or pure hydrogen produces no change; but that oxygen, as soon as it is electrified, produces a sensible and distinct change.

One farther step, to commend these experiments to the approval of the scientific world, was now necessary. It being proved that oxygen did not affect the ozonoscope; that electricity, hydrogen alone and electrified hydrogen produced no change, but that electrified oxygen produced a marked blue color, it was essential to prove that the iodide of potassium was, in conjunction with starch, an efficient and reliable means of investigation; that an ozonoscope, thus prepared, would always manifest the presence of electrified oxygen, or, what was *claimed* to be the same agent, ozone. The ozonoscope, chemically considered, is the iodide of potassium, for this only is affected by ozone; the starch is added, that we may perceive the degree of change which ozone produces on the iodide of potassium; but the starch in no way contributes to the production of this change. *The iodide of potassium is the agent; the starch only indicates the extent of its action.* Hence it is necessary to show that the iodide of potassium will uniformly and efficiently act; that it will always manifest the presence of ozone. If it always acts in the presence of ozone, we, by the medium of starch, recognize the *fact and the extent of its action.* Is it uniformly and proportionally affected by ozone?

To prove this fact, eudiometrical glass tubes, filled with pure oxygen, were inverted over a solution of the iodide of potassium and distilled water—oil being poured over the surface of the water, to prevent the influences of the atmosphere. By means of platinum wires, the oxygen, in the tubes, is subjected to the action of an electric current and thus gradually electrified. Becoming electrified, it acts, as electrified oxygen, on the potassium contained in the solution of the iodide of potassium and water. This portion of potassium, so acted upon, becomes potassa, by its union with a portion of oxygen. The potassium, thus uniting with a portion of oxygen, liberates a corresponding quantity of iodine; and this iodine, becoming liberated from the potassium, unites with the water, forming in part

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the solution. Each volume of oxygen, thus electrified in the tube and uniting with the potassium in the solution, is replaced by a corresponding volume of the solution. As the experiment progresses, the solution becomes gradually tinged of a yellow color, from the iodine liberated, as portions of the oxygen unite with corresponding portions of the iodide of potassium. At the conclusion of the experiment, the gas has disappeared, having all united with the potassium in the solution; the solution, of a deep yellow color, fills the glasses; and the capacity of the glasses becomes the measure of depression, on the surface of the solution. The results are the same, whether the glasses are filled with ozone, or with oxygen and this oxygen then electrified. In either case, we have it demonstrated that the iodide of potassium is entirely decomposed; and by starch we are able to measure and to see the degree and the end of this decomposition. By the iodide of potassium, then, we are able to detect the existence of ozone, in consequence of its decomposition, in the presence of this agent; and by starch, we are enabled to measure the extent of this decomposition. When these are properly combined, we have a true ozonoscope.

Scoutetten has published (in 1856) quite an extensive work, taking his own experiments and those of the most distinguished observers, to prove the truth of the position first taken by MM. Frémy and E. Becquerel, and afterwards so ingeniously defended by MM. Marignac and De la Rive. Scoutetten's work is styled, "Ozone, or Researches Chemical, Meteorological, Physiological, and Medical, upon Electrified Oxygen:" so fully satisfied was he and the leading authorities of the world, that ozone was electrified oxygen. The experiments are only equalled in ingenuity, care and apparent scientific candor, by their great number; they are exceedingly interesting and plausible, and, in their results, *seem* to indicate the truth of this proposition, that ozone is electrified oxygen, and the converse of this. As the work published by Scoutetten, in 1856, attracted much attention, both in Europe and America, and as its author very deservedly was awarded much credit for his views and the ingenuity with which he sustained them, it is proper that I should give his opinion, as detailed in this work, on the composition of ozone. "I consider ozone as a body subject, like all chemical combinations, to conditions which favor its composition, or decomposition; possessing constant properties which serve to distinguish it from all other agents; a body producing varied and powerful effects, and which, from the multiplicity of the parts it performs in nature and the greatness of its results, deserves a distinct and exalted place. Although we still use the word given by M. Schönbein and now adopted, *we have no doubt of the chemical composition of ozone; it is electrified oxygen.*" This position has been fortified by hard labor and scientific research; and had to sustain it the names and deliberate testimony of the most prominent and careful authorities in Europe. One year since it was

accepted as the doctrine which all of the best investigators were ready to endorse and defend. Dr. Gregory, in his last and latest published opinions on this subject, thus writes:—"It was at one time supposed, that ozone contained hydrogen, and it has been described as an oxide of hydrogen, HO^2 . But even when formed in contact with water, there appears to be but one ozone. The recent researches of Andrews seem to establish this point beyond doubt, and it is certain, *that perfectly dry oxygen gas yields ozone when electric sparks are passed through it.*" This is quoted from the published opinions of Dr. William Gregory, F.R.S.E., Prof. of Chemistry in the University of Edinburgh. Dr. Andrews, to whom he alludes, published similar opinions in the Philosophical Transactions for 1856; and in the Journal of the Chemical Society of London, at a later period. At the same time, Dr. Andrews declared ozone to be an allotropic form of oxygen;—he is justly regarded as good authority on such subjects.

It is seldom the case in science, that error is long accepted as truth; under the caustic tests of constant analysis and experiment, every fallacy becomes inevitably exposed. Thus has it been in regard to the long cherished and ingeniously defended position in regard to ozone—that it was nothing more than electrified oxygen. It is a doctrine that must certainly take its long rest, among the exploded fallacies of the past. Griffin, in his recent publications, states that the conversion of pure dry oxygen entirely into ozone was accomplished only once, by MM. Frémy and Becquerel; "that it is rash to come to the conclusion that this object has been achieved from three experiments, of which two failed, and the best of which presents numerous reasons for doubt." The experiments of these gentlemen have always been cited as unanswerable proofs, in sustaining the position mentioned. Again, in opposition to the claim that pure dry oxygen can be electrified, we have the published statement that Baumert was totally unable to accomplish this, after the most patient and satisfactory trial. He found, "that when oxygen was electrified with an induction coil, at the rate of *five hundred thousand sparks in an hour, the product of that enormous exertion of power, continued for an hour, was only as much ozone as separated one milligramme of iodine from the solution of the iodide of potassium.*" These are already strong and convincing proofs against the truth of the theory claimed, as regards the chemical composition of ozone. But to add the last and more recent testimony, we will quote a brief extract from a paper read by Dr. Andrews, F.R.S., and Mr. Tait, M.A., F.C.P.S., before the Royal Society of London:—"The commonly received statements that the whole of a given quantity of oxygen gas (dry), contained alone in a hermetically-sealed glass tube, can be converted into ozone by the passage of electrical sparks, is erroneous." These gentlemen found "that not more than 1-100th part of the oxygen could thus be changed into ozone." Dr. Griffin says of this last statement, "it confirms, with experimental evidence, my double pro-

position, that oxygen alone cannot be converted into ozone, and that oxygen, in the presence of the iodide of potassium in aqueous solution, can be converted into ozone." It will be remembered that Dr. Andrews was the authority on which Dr. Gregory (Prof. of Chemistry in the Edinburgh University) chiefly, if not solely relied. But the most complete and satisfactory proof of the falsity of the theory, that ozone is but electrified oxygen, will be found in the fact, that whilst it is almost impossible to convert pure dry oxygen into ozone by electricity, it is one of the easiest experiments in the laboratory to thus convert the oxygen (by electricity) into ozone, *if water moisture or hydrogen be present*. Thus, when oxygen, in tubes over an aqueous solution of the iodide of potassium, is submitted to the electric current, ozone is generated with rapidity. Dr. Griffin explains this very naturally by saying, "that the vapor of water rises into the oxygen gas and affords the hydrogen which is required for the formation of ozone." Again, it is now demonstrated, that when hydrogen is present, ozone can always be easily prepared, either by chemical or electrical means; but when hydrogen is absent, it becomes almost impossible to thus generate ozone, even in the most feeble quantity. As is appropriately asked by Dr. Griffin, "Why is this so? If ozone is only oxygen (even in *any* state), why is the presence of hydrogen so helpful, if not indispensable, to its formation?"

[To be continued.]

IMPROPER TREATMENT OF WOUNDS IN SOME OF THE UNITED STATES HOSPITALS.

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MUCH can be said on this subject to pain the intelligent surgeon, and overwhelm him with astonishment at the apparent ignorance in certain cases of some of the most common, as well as most important fundamental principles of advanced surgical science. Really, it would be worse than absurd to associate surgical principles with the dogmatic empiricism which has located itself in some of the Government hospitals to dictate terms of recovery; those terms are a formula of two words—viz., *R. Cold water*. This panacea seems, in these cases, to have supplanted every known remedy of whatever reputation, and is so terribly exacting and jealous, vindictive and despotic, that if, when on any of its "beats" through the wards, it should discover an unhappy poultice, or simple dressings, or tinct. opii, or tinct. myrrh., or adhesive straps, or stimulating unguent, God help the "contract" surgeon who has ordered them! If he has any friends, let them come close to him, and stand by him; he will need them every one to condole and advise with him over the note received from the medical director of that department, advising him his "contract" had been annulled for "inefficiency."