Baldwin (J. F.)

—THE—

RELATION OF OZONE TO DISEASE.

PRIZE THESIS.

BY J. F. BALDWIN, M. D.,

PROF OF PHYSIOLOGY, COLUMBUS MEDICAL COLLEGE.

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THE RELATION OF OZONE TO DISEASE.

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INAUGURAL THESIS

OF

J. F. BALDWIN, M. D.,

COLUMBUS, O.

Professor of Physiology, Columbus Medical College.

PRESENTED TO THE FACULTY OF JEFFERSON MEDICAL COLLEGE, MARCH, 1874, AND BY THEM AWARDED THE HIGHEST PRIZE ($100).

The rise and progress of epidemics has always been a subject of great interest, and every theory advanced to solve the problems connected therewith has been favorably received and has not lacked able advocates. No sooner, therefore, had Schonbein announced the nature and properties of ozone, and suggested the hypothesis of its relation to disease, than it was enthusiastically seized upon as the long-sought *entity* by which could be explained the mysteries connected with all epidemics.

The well-known effects of artificial ozone as an irritant of the air passages, and as a deodorizer and disinfectant, suggested that its abundance in the air would lead to epidemics of certain inflammatory diseases;

while its absence would allow septic material to accumulate till an epidemic of some one of the zymotic diseases should either arise *de novo*, or be greatly augmented in extent and virulence.

In a recent monograph, I find the following statement, which may be regarded as the most ultra expression of the views advanced by those who adopt these theories:—

"The modern discovery of ozone furnishes us the key to unlock the mysteries of the causes of all fevers, of whatever nature or form or dimension, of either inflammatory, bilious, or typhoid; being all produced by the variation or want of this substance in the air inhaled. There were influences operating in producing different diseases of which we were ignorant: *ozone, and ozone alone, furnishes the key* to unlock and reveal the whole mystery."

In discussing the relation which ozone may sustain to disease, I shall consider it as, 1st, a cause; 2d, a remedy; and 3d, a preventive.

I. *Ozone as a Cause.*—The first crude tests that were made led observers to suppose that in pure air ozone existed to the extent of about one part in ten thousand. As more careful and accurate observations were made, this supposed quantity gradually diminished; till finally, as a result of the experiments of that most careful observer, M. Houzeau, he has determined that "the air of the country contains, *at most*, about one four hundred and fifty thousandth of its weight, or one seven hundred thousandth of its volume, of ozone." (*Am. Chemist*, Oct. 1873.) That his conclusion is correct and that this minute amount is really the maximum, is further shown by the fact that such men as Dumas, Thenard, Berigny, Cloez, Fremy, and others, doubt, or even deny, the existence of ozone in the atmosphere; and that in 1865 an attempt was made in the French Academy to overthrow the belief in atmospheric ozone.

At the very commencement then we must admit the existence of a strong presumption against the efficacy of an agent when so dilute; unless, indeed, we emulate Hahnemann, with his limitless faith in the "medicinal *aura*" of his thirtieth dilution. (*Organon*, p. 226.)

The peculiar odor which is sometimes observed during thunderstorms, and which we now know to be due to ozone, was noticed by the ancients, and was by them compared to that of sulphur. But although this odor is frequently mentioned, as by Homer, Lucanus, Persius, Pliny, and others, I do not find that any significance was attached to it as a cause of disease.

How highly charged an atmosphere must be to produce bronchitis or catarrh has never been determined. Certain it is that a lecturer and his students may remain for hours in a class-room where the odor is

quite strong, without experiencing the least discomfort or having the slightest symptom of disease. Bence Jones thinks that one part in two thousand is able to cause "dangerous engorgement of the lungs, and even smaller doses, long continued, cause bronchitis and pneumonia." (*Dublin Journ. Med. Sci.*, Feb. 1868.)

"We must confess that ozone in excess, as we produce it in the laboratory, induces certain symptoms of disease; but as yet, we know of no instance in which an excess sufficient to produce the same symptoms exists in nature. An air so charged with ozone as to produce these symptoms would require no chemical test to prove the presence of an injurious agent. It would be an irrespirable air, and it would affect, with varying intensity, all who breathed it." (Dr. Richardson, *Popular Science Rev.*, Jan. 1866.)

In the recent experiments of Mr. Dewar and Dr. McKendrick, reported to the Royal Society of Edinburgh, December 1, 1873, animals were allowed to remain in air, or oxygen, charged with about ten per cent. of ozone, till they perished. After death it was found that the blood throughout the system was venous, and that death by ozone was not due to irritation, but "resembled that caused by an atmosphere surcharged with carbonic acid." (*Nature*, Dec. 11, 1873.)

People living in the country are not more liable to epidemics of influenza and catarrh than those living in the town; while mountaineers, hunters, and sailors, though living almost constantly in a maximum of ozone, seem almost entirely exempt from these affections. Moreover, during the course of my experiments, I, on several occasions, remained all night in a small and close room, where ozone was being generated by the action of sulphuric acid upon permanganate of potassium, and though the odor was somewhat disagreeable, I experienced no further inconvenience, nor had I a single symptom of catarrh.

In truth, all *a priori* reasoning is most decidedly against the theory of the production of disease by atmospheric ozone, and the truth of this reasoning is shown by numerous observations, a few of which I will give.

Dr. Seitz, from observations made at Munich from 1853 to 1855, writes:—

"We found that months in which the ozone was abundant were not characterized by a predominance of catarrhal affections when compared with months in which less ozone was observed in the air. After days distinguished by a great excess of ozone we did not observe the occurrence of a greater number of cases of catarrh." (*Catarrh and Influenza*, 1865.)

From the observations of the Medical and Scientific Club of Konigs-

burg, Prussia, conducted during 1856, the conclusion was reached that there was no connection to be discovered at any time between a malady and the amount of ozone in the air. According to Dr. Hayes, of the Arctic Expedition, in the polar regions, where the ozone register is generally at 10 (the maximum), pulmonary and bronchial diseases are almost unknown. Capt. Pope, of the U. S. Army, makes a similar statement in regard to the table-lands of Texas and Mexico.

Dr. Ireland, of Bengal, reports that on one occasion "a sudden *decrease* in ozone was followed by a threefold increase of patients in the hospital, and by the prevalence of rheumatism and *influenza;*" when there came an increase of ozone the patients recovered. (*Edinburgh Med. Journ.* July 1862.)

The dust-storms of India are most highly charged with ozone, yet Ireland reports: "There is no influenza after dust-storms in India." (*Edin. Med. Journ.* July 1862.) The most delicate tests always fail to detect ozone in the air of hospital wards; yet in the Massachusetts General Hospital, during the epidemic of influenza in 1832, "nearly all the patients in the hospital were affected." (*Flint's Practice*, p. 216.) Nor is this an isolated case; for these epidemics visit, with equal severity, the alley and avenue, the city and the country, the mountain top and the mine.

Faber, Wunderlich, T. Boeckel, Houzeau, and many other eminent observers, do not believe in a causative influence of ozone upon bronchial affections or other diseases. The special cause of influenza is "independent of appreciable atmospheric changes." (Flint.) It is not due to "any recognizable physical changes in the surrounding air." (Da Costa.)

Mr. Fox, in his recent work on ozone (p. 158), thus concludes: "There is no evidence of any weight whatever in support of the views regarding an etiological connection between atmospheric ozone and certain diseases."

But I will not weary the reader with further quotations, which would be but tiresome repetitions of those already given.

The hypothesis, that a maximum of atmospheric ozone can cause disease, rendered exceedingly improbable by a knowledge of the minuteness of that maximum, and further weakened by the fact of the prevalence of these diseases in localities where, from its ready destructibility, we cannot imagine ozone to exist, has been, I think, completely demolished when put to the final test of observation, which has failed to establish or so much as render probable that ozone acts as even a *predisposing* cause of disease.

II. *Ozone as a Remedy.*—This can be dismissed very briefly. Ozone, artificially prepared, has been administered (?) in the form of the so-called "ozonized waters" and "ozonized oils," to which almost miraculous powers were *at first* attributed. The former, however, on careful analysis were found to contain no ozone.[1] In specimens examined by Boettger, a little nitrous acid was found (*Ph. Cent. Halle.*, 1871); by Kremer, a trace of the binoxide of hydrogen (*Ibid.*, 1872); by Behrens and Jacobsen, hypochlorous acid (*Scientific Am.*, Jan. 31, 1874); and by Ramelsberg, chlorine (*Ibid*).

Dr. Thompson, of London, in a paper read before the Royal Medical and Chirurgical Society, Feb. 26, 1861, asserted that ozonized oils, when administered in phthisis, reduced remarkably the frequency of the pulse. The real value of this agent may be inferred from the fact that "ozonized oil," and "oxidized oil," and "*rancid* oil," are strictly synonymous terms. (Rand.) Hence we are not at all surprised to learn that, when the experiments of Thompson were extended and repeated more carefully, ozonized oil was found to possess no peculiar virtues. [*Edin. Med. Journ.*, July, 1861.]

Patients affected with phthisis are sometimes sent with benefit into the pine forests. The benefit in these cases has, by some, been attributed to the ozone *supposed* to be produced by the terebinthinate exhalations. Mr. Burgess, the inventor of the method of making paper from wood, found that the introduction, into his bleaching room, of a few drops of turpentine, would not only prevent any further formation of ozone, but would even destroy that already existing.

The benefit derived by consumptives from a residence in Minnesota and other Western States, has been attributed to the abundance of ozone in these localities. The burden of proof, however, lies with the theorists, and they have not yet furnished the demonstration. In truth, the elements involved, in producing the effects due to "change of climate," are too numerous and complex to permit us to select any particular one, as the main or only cause, and we do not want the beneficial effects attributed to ozone unless the ozonometer is brought into play.

III. *Ozone as a Preventive.*—Ozone being found in the laboratory to possess deodorizing and disinfecting, or germicide, powers—of which my own experiments have assured me—was then, by inference, regarded as "nature's great disinfectant," which when present would destroy the floating germs of disease, and thus prevent or check an epidemic; while if it were absent the air would, in the words of

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1 All chemists agree in saying that ozone is insoluble in water.

a recent writer, "soon contain within itself the seeds of inevitable death," and "the wasting pestilence would stride on uncurbed."

This theory presupposes these germs to possess a greater degree of destructibility than is warranted by what we know, from the experiments of Wyman, Beale, and others, of other germs and ova floating in the air. The theory is, moreover, opposed by what is practically found necessary in order to accomplish complete disinfection. The *Oxford Disinfecting Minute* says: "No disinfection can be thorough if a man can live in a room whilst it is going on." J. M. Bryan thinks that "the only true disinfectants are those which produce an atmosphere or vapor in which neither we, nor any other life, can be sustained." [*Brit. Med. Journ.*, Dec. 13, 1873.] W. J. Cooper, in an essay before the Social Science Congress, says: "Before they could use enough iodine to have any effect upon germs it would produce the well-known iodine catarrh. Bromine would overpower the senses, with its suffocating stench, long before it could disinfect; and, if the air were to be overcharged with ozone, it would be productive of equally deleterious consequences." [*Scientific American*, Nov. 22, 1873.]

The general statement may, I think, be safely made, that fungi and infusorial germs require for their destruction an atmosphere so charged with noxious vapor as to be highly deleterious to, if not irrespirable by, human beings, and that there is no proof whatever that the invisible germs of disease are more easily destroyed.

Ozone is usually ranked with disinfectants, although, according to the report of General O'Neal, it [as permanganate of potassium] seems to be rather a deodorizer than a disinfectant. [*Annual Rep. Army Med. Dep't.*, vol. xiii.]

The conclusion of the Analytical Sanitary Commission on Disinfectants was that it did not possess any great advantage over less expensive and more convenient agents. [*Lancet*, July 26, 1874.] Dr. H. Day speaks of it as inferior to chlorine and bromine, and in many instances, not so applicable as iodine. In my experiments with ozone I found fungi to remain unaffected, unless the air in the bell-glass became perfectly saturated, as indicated by the rapid discoloration and bleaching of the test-papers, when they perished. If, then, ozone is not superior to the other disinfectants, and if none of them are germicide unless in suffocative amount—or even if a degree of saturation much less than this is sufficient—we must admit that the probabilities are very strong against the germicide powers of ozone when so dilute as one part in 700,000; which, it must be remembered, is not even its *average*, but is its *maximum*, amount.

This small quantity is found to be speedily destroyed in the presence of any decomposing matter. Thus it is a common observation that ozone can scarcely ever be detected in compactly built portions of a city, except in cold weather, when no decomposition is going on, or in elevated situations, as church steeples, where a feeble reaction may sometimes be detected. In Philadelphia, at my residence on Thirteenth Street, I tested for ozone in all kinds of weather; in the midst of fog, mist, rain, sleet, and snow; in hot weather and in cold; when the sky was clear, and when it was cloudy; but never —not even during a thunder-storm—was I able to detect the slightest trace of ozone. [1] We had all the "bracing and inspiring effect of clear, crisp, and sparkling mornings," but *no ozone*, notwithstanding the opposing theory of Dr. Beard. [*Popular Sci. Mo.*, Feb. 1874.] The general absence of ozone from cities is, indeed, a fact admitted by all observers. [As a specimen of the kind of logic, and of generalization, not infrequently indulged in by enthusiastic writers on ozone, I may quote the following, by one whose *observations* [?] were evidently made in the *country*: "The ozonoscope held before a half open door has a deep hue given to it. Every one knows the effect of such exposure, the ozonoscope defines the cause." [Dr. Royce, of Buffalo.]] In country towns ozone may generally be detected, though I am informed by Prof. Kemp, of Illinois, that such is not the case where impure coal, containing sulphur, is used for fuel. But though ozone can be detected in the air outside of country houses,[2] it can seldom be found within; for so easily and quickly is this body destroyed that I have never been able to detect it in the living-rooms of well-ventilated country residences.

The general fact being then established that ozone does not exist in compactly built cities, two conclusions necessarily follow: 1. A continued local absence of ozone cannot beget epidemics, else an epidemic should have arisen in Philadelphia. 2. The presence of ozone is not necessary for the destruction of the germs of disease, and the consequent limitation of an epidemic; for these diseases enter a city, run their course, and depart, without the presence of ozone being at any time manifest. That these epidemics rarely visit the small towns and rural districts must be accounted for by their isolation, rather than by

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[1] The tests used were prepared for me by an experienced chemist, and were the usual "starch-iodide" papers.

[2] Mr. Smyth, who conducted his tests by means of an aspirator—the only true method—advances the assertion that the amount of ozone in the atmosphere of the country is almost absolutely constant.—(*London Med. Times*, March 9, 1867.)

attributing their exemption to any agency of ozone ; for an epidemic, once introduced into a village, will not infrequently rage as fiercely and destructively as in the non-ozonized city. Numerous instances of this were furnished so lately as during the cholera epidemic of 1873.

Webster, in his work on *Epidemic and Pestilential Diseases*, 1799, after tabulating a vast number of epidemics, thus remarks: "It will not escape the most inattentive reader of the foregoing history, that all the violent and general plagues have been preceded or accompanied with remarkable phenomena in the physical world, as comets, earthquakes, explosions of volcanoes, and others of a subordinate kind." And another old writer says: "Mighty revolutions in the organism of the earth, of which we have creditable information, had preceded it. From China to the Atlantic, the foundations of the earth were shaken —throughout Asia and Europe the atmosphere was in commotion." [Hecker. *On the Black Death.*] Curiously enough, these very phenomena, although no longer regarded as associated in any way with the diseases in question, are, nevertheless, those which, by disturbing the electrical tension, are supposed to be instrumental in the production of ozone. Storms also produce ozone, yet Orton, in his work on *Cholera*, says it is an everyday occurrence in India for an epidemic to be ushered in by a storm. The same fact is noted by many other writers, but the following statement by MacCormack is especially pertinent: "The outbreak of cholera in the town of Sligo, where it raged with unparalleled severity, was preceded by a terrific storm of thunder and *lightning*, and this occurred also in several other districts throughout the country" [Ireland in 1832]. [*Cholera*, 1853.]

The oxygen given off by vegetation being in the form of ozone, forests have been regarded as largely instrumental in the production of this body in nature. Hence those living near, or in, forests should be specially free from the ravages of these diseases. That this is not true of the Indians of modern times, is well known ; that it was not true of them formerly is shown by the fact that during the years 1617, '18, and '19, a fearful plague, whose nature is unknown, prevailed among the tribes of New England: "They died in heaps as they lay in their houses. In the place where many inhabited there hath been but one left alive to tell what became of the rest, the living being, it seems, not able to bury their dead. And the bones and skulls made such a spectacle that as I travelled in that forest near the Massachusetts, it seemed to me a new found Golgotha." [Norton, *New England Canaan*, 1637.]

High hills generally, and elevated plateaus and mountains always,

furnish abundant ozonic reaction, and should hence be free from these epidemics. "The plague in 542, and in subsequent periods of the fifty years plague of Evagrius, ascended to the tops of the hills and mountains. Hildanus informs us that in the plague of Lausanne, in 1613, the huts of the peasants on the hills and mountains were not exempt, though detached and having no intercourse with the infected." "The same fact is recorded of the plague of 1720, which extended to the villages and mountains of Provence." (Webster. *op. cit.*) The citadel of Bellary, on a barren hill 500 feet high, with no marshes near, has had "permanent and unrelaxed severity" of cholera since 1818. (Prof. Peters, *N. Y. Med. Journ.*, Aug. 1871.) Of the epidemic of 1854–5, Dr. Terry states: "In both Venetia and Lombardy, the country suffered more than the cities, and the principal routes of the disease were along the high lands." (*N. Y. Med. Journ.*, 1866.) In the epidemic of 1849–50, nearly all the cities upon the elevated plateau of Mexico were affected. (*Ibid.*) "Cholera arises on the *tops of mountains*, and in the bowels of the earth; in hot climates, and in *cold climates;* wherever, in fact, man is, there may this disease be found." (Da Costa.) Islands, being constantly surrounded by an atmosphere highly charged with ozone, should sustain entire immunity from this class of diseases. But I think statistics show clearly that the poison spreads as rapidly, and proves as virulent, here as on the main land, and that the relative frequency of visitation, among various groups of islands, depends entirely upon their degree of isolation. Cholera shows itself "upon *lofty mountains*, in the midst of sandy deserts, and among the scattered inhabitants of thinly peopled agricultural districts. It crosses mountains, deserts, and *oceans*." (*Wood's Practice*, vol. 1, p. 811.) In support of this statement may be mentioned the striking fact, which even Pettenkofer, though holding the "ground origin" theory, was compelled to admit, that cholera has appeared occasionally on board ships at sea, under such circumstances that the occurrence could only be explained by supposing the germs to have been borne through the air from the far-distant land. (*Med. News and Library*, Oct. 1873.) Epidemics of *yellow fever* always originate in sea-port towns; and the specific poison of this disease "is sometimes generated in ships at sea." (*Flint's Practice*, p. 947.) Dr. Chauffard, of Paris, says of *typhus fever*, that on the high table-lands of Mexico, it is both endemic and frequent. (*Revue Scientifique*, 1873.)

If ozone can ever be detected in any part of a city, it will be in those parts which are most elevated, cleanest, and best ventilated; and those portions of a city should, according to the ozone theory, always be

most free from disease; especially when contrasted with those portions which are low and filthy. That the higher portions of a city are exempt from these epidemics is, as a rule, true. A single exception, however, will prove fatal to the view that this immunity is due to ozone. "In the *Traite de la Peste,* p. 29, it is asserted that in the melancholy plague at Lyons, in 1628, the filthiest houses, the crowded places, narrow streets and confined apartments, were places of the most safety; while the most airy situations, as houses on hills, were most exposed to the ravages of the disorder." "Malouin declares that the most populous and dirty places in Lyons and Marseilles were least affected with the plague." (Webster, *op. cit.*) In 1847, Constantinople was attacked by an epidemic of cholera. The upper portion, Bosphorus, clean, salubrious, and inhabited by wealthy families and retired merchants, escaped; while the lower portion, Stamboul, with its narrow streets and alleys, abounding in poverty and dirt, was devastated. But eighteen years afterward, clean Bosphorus was decimated, while filthy Stamboul escaped. According to Dr. Drake, the clean and dirty, and the high and low portions of Cincinnati, were alike affected in the epidemic of 1832. At Nashville, in the epidemic of 1849-50, it "singled out the very summit of College Hill for its onslaught;" and during the summer of 1873, "high places and low places were alike assailed." "It loved the high places and the clean places." (*Nashville Jour. Med. Surg.*, Aug. 1873.)

These examples, which I have selected from those met with here and there in my reading, show that neither the spread of a zymotic disease, nor its virulence, is influenced perceptibly in any way by the presence or absence of ozone. For we have epidemics attacking, with equal severity, the high and low, and the clean and filthy, portions of a city; spreading to the villages upon hills and mountains; depopulating the Indians in their native forests; decimating the inhabitants of sea-girt islands; and finally, even originating, or breaking out, on board ships at sea. Mountains and islands always furnish abundant ozonic reaction, while forests and seas are great manufactories of ozone.

But lest any should be so uncandid as to deny the conclusiveness of these facts, on the ground that no tests were actually made, and that therefore ozone *might have been absent* in these various cases, I have made "assurance doubly sure" by collecting instances where this proof is furnished. The properties of ozone being always the same, if it exists with, but does not destroy, the germs of disease to-day, it did not destroy them yesterday, and it will not destroy them on the morrow. Hence a single well-authenticated instance of the co-existence

of ozone and cholera, for example, would be sufficient, logically, to refute the theorists. But I will be more generous; I will give more than one, and will then assure them that the line might stretch out almost indefinitely:

Prof. Peters, of Lexington, Ky., informs me that he made ozonic observations during the epidemic of cholera in 1851, and arrived at the conclusion that there was no proof of any relation between the two. During the epidemic at Munich, in 1854, Seitz found "no relation." "In August, with a large amount of ozone, this disease increased from day to day; whilst in September, with a small amount of ozone, it decreased." (*Catarrh and Influenza.*) Of the same epidemic Dr. E. Bœckel, of Strasburg, writes: "The minimum of ozone does not coincide with a maximum of cholera, and this last does not diminish as the ozone augments." (*De l' Ozone*, 1856.) During the epidemic at Turin, in 1867, Father Denza made observations a half mile from the town, and found that "during the days in August and September, when the cholera was at about its height the amount of ozone present was variable, but considerable; perhaps about the average." (*Med. and Surg. Rep.*, May, 1868.) "Dr. Day, of Geelong, assures me that he suspended ozonoscopes around the houses of patients suffering from cholera in 1865, and noted an abundant reaction." (Fox, *op. cit.*, p. 131.) Dr. Macnamara, in his work on cholera, writes:

"With regard to the supposed influence of certain states of the atmosphere, having reference to the amount of electricity and ozone it may contain, in the generation of cholera in the human body, all such ideas are purely hypothetical. We have no evidence at all in favor of such views."

"A number of pamphlets have appeared, regarding the supposed relationship between cholera and ozone; at Munich, by Pettenkofer; at Konigsberg, by Schiefferdecker; at Vienna, Cracow, at Szegedin, in Hungary, at Senftenberg, in Bohemia, at Kremsmunster, etc. They are all unfavorable to the hypothesis that ozone descends below its summer minimum during an epidemic." (Fox, *op. cit.*, p. 135.)

Prof. Kemp, who made observations at Olivet, Mich., for three years, writes me: "I never could discover any relation between ozone and any special type of disease." Mr. Fox is my authority for the statement that during the epidemic in London, in 1854, Mr. Glaisher had ozonometric observations taken throughout the city, and was astonished to find that where there had been no ozone, there had been no deaths from cholera; and that where ozone had manifested itself, there the cholera had been most active.

Andrews says:

"It has been asserted, for example, as the result of observation, that

an outbreak of cholera is accompanied by a marked diminution of atmospheric ozone; but this statement has been disproved by later and more trustworthy observations. On the whole, it may be safely asserted that no connection has yet been proved to exist between the amount of ozone in the atmosphere and the occurrence of epidemic or other forms of disease." (*Nature*, March 12, 1874.)

My notes furnish many other similar results of observations on the *relation* between ozone and cholera, but those already given will suffice. As to other diseases, few observations of any kind whatever have been reported. At Nottingham, in 1848, E. J. Lowe observed ozone "to be in excess during months in which an epidemic of *small-pox* was most virulent." (Fox.) Dr. Grimshaw found "no correspondence" between the amount of ozone in the atmosphere and the prevalence of *typhus*. (*Med. and Surg. Rep.*, Aug. 11, 1866.) If ozone destroys *malaria*, as some have asserted, it seems a little curious that this miasm should exist in the country, where there is ozone, but should never enter the city, where there is no ozone. Prof. W. K. Kedzie, who made observations near Lansing, Michigan, for three years, in a decidedly malarious region, informs me that he never found ozone absent for more than two days at a time. "Ozone and malaria can coexist; of this my experiments have left no doubt." (W. W. Ireland, *Edin. Med. Journ.*, July, 1858.) Mr. Fox states that ozone passed through a solution of the organic matter of marsh air, does not decompose it; and quotes from Burdel to the effect that he frequently found as much ozone over marshes as in other situations. (*Recher. sur les Fievres Palud.* 1858.) And the same gentleman, after examining the subject very carefully, thus concludes: "There is no evidence to show that ozone destroys the marsh miasm, or is in any way related to malarious disease." (*Op. cit.*, p. 147.)

In considering the relation of ozone to disease, I have endeavored to devote to each division of the subject as much space, relatively, as its importance has seemed to demand. The remedial effects of ozone have attracted little attention and gained little credence. Comparatively few have advocated the theory of its acting as the exciting or predisposing cause of disease. But in the minds of many practitioners there exists an indefinite, half-formed idea that ozone destroys the specific poison of zymotic diseases; or, in other words, that the absence of ozone is the cause of the production or propagation of these diseases. Therefore I have devoted considerable space to the discussion of this part of the subject. The prevalence of this idea, and the extreme to which some have carried it, cannot be regarded, however, as proof of its truth. There exists in every mind a natural desire for some solu-

tion of the mysteries connected with epidemics: plausible hypotheses have always been readily received by the public, which ever, as Bacon says, "loves better to believe than to examine;" and it is notorious that when once the mind has become impressed by a new and strange object, it takes pleasure in ascribing to it properties which it does not possess, and which are often absurd. To get a more exact and full expression of opinion on this subject than I had been able to obtain by examining the various journals, I instituted a correspondence with a large number of scientific and professional gentlemen living in various parts of the country. As a result of this correspondence, I find that many of these gentlemen, especially those who have not made any observations, still hold the question *sub judice;* but that those who have tested the matter and have formed an opinion, with one exception only, hold that there is "no connection" between ozone and disease.

CONCLUSION.—When I commenced the study of this subject, I was biased in favor of the view that ozone could produce disease directly by its presence, and indirectly by its absence. But after a careful and candid investigation, I think this view entirely erroneous. Reasoning *a priori*, from the premises furnished by what I found known of ozone and of epidemics, did not result in a conclusion favorable to any such hypothesis; while a resort to recorded observation proved no more satisfactory. It is true that occasionally, in some circumscribed locality, the fluctuations of an epidemic have seemed to sustain a certain relationship to the fluctuations in the amount of ozone; but such an exception proves nothing. In truth, it would be strange if such a coincidence did not sometimes occur; for, by a well-known law, a parallelism must exist, now and then, between two independent and irregular curves.

In the relation of ozone to disease, that which accords perfectly with the known properties of ozone, which harmonizes with the results of all observations, and which at once challenges rational belief, seems to be simply this: *ozone influences the general health, only in so far as it purifies the air by destroying*—not the living germs of disease, but—*the products of decomposition.* Beyond this, all views concerning the action of ozone, as a cause, a remedy, or a preventive of disease, rest upon vague and unfounded hypotheses.

[The above thesis was published in the *American Journal of the Medical Sciences*, October, 1874, and is republished only at the request of numerous friends.

Since writing this thesis, I have watched the journals closely, but have found but little communicated bearing on this subject.

Some one has recently asserted that the development of ozone is the immediate cause of milk turning sour during thunder storms. As this brilliant discoverer does not give us the experiments on which he based his conclusion (indeed, seems to have made none), and as we know, *a priori*, that the ozone produced would be met, at the very instant of its entrance into the room containing the milk, and at once destroyed by the floating particles of organic matter, we must consider his explanation as a mere brain figment.

Dr. H. Cundell Juler, of Cincinnati, writes: "The air sometimes contains an excessive amount of vitalized oxygen or ozone, and when a person is brought suddenly from the impure air of the city into such an atmosphere, he may have a few fleeting symptoms [of urticaria] upon those portions of the wrists and neck uncovered by clothing. Once in my lifetime, while in transit from London to Aberdeen, I was attacked by the disease from this cause." (*Cin. Lancet and Observer*, Jan., 1878, p. 37.) This statement is so transparently inexact and unscientific as to require no comment whatever.

Prof. R. C. Kedzie, of the Agricultural College of Michigan, contributed a very valuable paper on the subject of ozone to the State Medical Society, in 1875, but he does not discuss its relation to disease.

At the present time, therefore, I can only reiterate the conclusions formed by me four years ago. B.]