Wallian. (S.S.)

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AS A REMEDIAL AGENT

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the Author.

ON OXYGEN

AS A REMEDIAL AGENT

BY

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PREFATORY NOTE.

THE trend of modern medical thought is toward the solution of the scientific problem:

How are we to more fully avail ourselves of the evidently potent, perhaps wholly competent, influence of normal elements and natural agencies, in the removal of morbid conditions called diseases, and the amelioration of human suffering?

There is a growing and rational distrust of, and revolt against, what may be appropriately styled abnormal and artificial, as well as far-fetched and heroic, agencies in the treatment of disease.

"If they threw physic to the dogs only, we might commiserate the unfortunate brutes; but when we think of the human, everywhere, down whose unsuspecting throats the vandal dose must go, we may well shrink aghast at the unrecorded mischief done."[1]

A prominent professor in one of our leading medical schools says: "There is in every science a mythological part, which is handed down from generation to generation, whose disbelievers formerly were crucified, now are ostracized. Shall I tell you where the mythology of medicine is stored up? In the handbooks of materia medica, allopathic as well as homœopathic."

Among the natural agencies oxygen easily and unquestionably stands at the head of the list. All organized beings must have a constant supply of it, inspire it with every breath, drink it with every draught, move in it at every step, and live immersed in it as a perpetual bath, or perish.

[1] Welch. MEDICAL RECORD, vol. xxv., p. 663.

The ancients recognized but three ordeals of purification—*air*, *water*, and *fire*. In each of these the potent and only active element is oxygen. Without this there could be neither air, nor fire, nor water. The first food of the infant at birth, and the last gasped for by the dying patriarch is diluted oxygen. We may abstain from ordinary and grosser means of physical sustenance for days and weeks with impunity; robbed of oxygen we do not survive so many minutes. Tanner prolonged his fast from meat and bread, even to the duration of the original deluge, without serious discomfort; but he constantly required and really subsisted on air and water—oxygen.

Every vital process, construction, maintenance, repair, disintegration, is accomplished directly or indirectly through the same all-pervading and potent agency. Priestley would have been justified in naming it *zoögen*, since without it animal existence would have been an impossibility.

It is quite time we should practically realize, for we already theoretically admit, that this omnipresent, almost omnipotent, and yet thoroughly commonplace element, cannot be replaced, scarcely supplemented; that there is no known alterative, eliminator, or disinfectant comparable with it; that disease-propagating germs cannot withstand a free supply of it, but are soon robbed of their virulence or destroyed in its presence; and that *the original, normal, and only unobjectionable and universally efficient antiseptic is pure oxygen.*

Yet with these facts daily and hourly staring us in the face, no other necessity of life is so parsimoniously dispensed, so universally adulterated, or so little appreciated. Robbed of a due proportion of it all along the devious path, from the cradle to the grave, it is little wonder that,

> "however we brave it out,
> We men are a little breed."

And little wonder that anæmia, and scrofula, and tuberculosis are the rule, robust health the exception.

As a therapeutic agent oxygen is not yet popular, not yet the fashion; although for years enterprising quacks

have been gathering a generous harvest, from honest dupes who have sickened of cruder quackery, by broadcast heralding of the magic virtues of some impossible "compound" of it.

Is it not high time that its intelligent use should be undertaken at the hands of legitimate and competent physicians, who have no secret wares to hawk about the country, in competition with other cheap and nasty nostrums?

BLOOMINGDALE, N. Y., September 15, 1884.

ON OXYGEN

AS A REMEDIAL AGENT.

PRIESTLEY, who divides the honor of its discovery with Scheele, was the earliest experimenter with oxygen as a physiological agent. He demonstrated that birds, dogs, rabbits, and other animals immersed in an atmosphere of this gas became more lively, active, and brilliant; that dogs trained for the chase could endure greater hardships, and for a longer period, when allowed to breathe the gas for a short time previous to the start, than similar animals not thus prepared; and that animals asphyxiated by being compelled to inhale carbon dioxide or other noxious gases were speedily resuscitated if treated immediately with pure oxygen.

Lavoisier confirmed these results, and further demonstrated that the muscles of animals repeatedly subjected to the influence of the gas became very firm, decidedly interfering with their tenderness if speedily designed for the shambles!

These results attracted some attention, and were followed by considerable experimentation on the part of pathologists and physiologists.

Among these early investigators, Dr. Beddoes—not "Eddoes" as quoted in the London *Lancet*—was the first medical man of repute who gave the subject any serious attention. He was assisted by some of the most eminent scientists of his day, including Sir Humphry Davy. These original experimenters labored under se-

rious disadvantages, particularly that of evolving the gas in suitable quantities and of sufficiently pure quality for medical use. After many trials and numerous failures, with not a few accidents, Beddoes declared himself beaten, not by his own loss of faith in the potency of the new remedy, but "by the difficulty of making it available." He did not escape the usual storm of ridicule which invariably greets an innovation, especially if the latter falls short of an immediate and pronounced success. However, his partial success inspired other efforts in the same direction, and he was followed by Drs. Hill, Thornton, Cavallo, and others. Over-sensitive to unkind professional criticism, the latter conducted their experiments in comparative seclusion.

In 1820 Dr. Hill published a brochure reporting the results of these efforts, which, although full of instructive facts and suggestions, attracted little attention, and members of the profession at the present day would be surprised to know that experiments so conclusive were so long since attempted, or that a work of such unusual professional candor was ever issued.

Thornton, Cavallo, and McCormack followed, somewhat later, with still more searching and extensive trials of the gas, and each unequivocally asserted that it would eventually be found a potent and valuable therapeutic agent. They failed to awaken much interest in the subject, and met with the customary storm of ridicule and unreasoning opposition.

Within the last quarter of a century, although little has been said on the subject, various men of note in the profession, including Goolden, Birch, Alexander, Erichsen, Richardson, Demarquay, and others, have more or less investigated, occasionally used, and without exception admitted the potency of oxygen in the treatment of disease.

In this country but casual attention has been given to the subject, and beyond an occasional exhibition in some extreme case in hospital practice, little has been reported, the opinion still obtaining with those who have considered the subject at all, that the use of non-atmo-

spheric oxygen in the treatment of disease is of doubtful utility, if not positively dangerous.

Literature on the subject is meagre and unsatisfactory. Little has appeared in this country, and, as yet, no American publisher has ventured the reproduction of such fragmentary foreign works as have occasionally appeared.

In an article ("Super-Oxygenation as a Therapeutic Measure") in the *Chicago Medical Journal*, vol. xxvi. (1869), pp. 116–120 and 139–152, I gave the results of some of my earlier experience with various super-oxidizing agents.

As a rule, the medical press, both at home and abroad, has shown very little interest in the subject, evidently acquiescing in the prevailing verdict—the only marked exceptions being the London *Lancet* and the *British and Foreign Medico-Chirurgical Review*, in both of which interesting articles have occasionally appeared.

Demarquay's reports to the Academy of Medicine (Paris, 1866)[1] were considered conclusive and satisfactory as far as the subject was covered by his experiments, but have never been reproduced for American readers.

In 1856 appeared in London a small volume under the extremely classical title of "Pneuma-Therapeia." Its author, who was presumed to be McCormack, withheld his name, probably for prudential reasons, since its arguments and reports of cases were addressed more to the public than to the profession; and in an appendix, the Medical Pneumatic Apparatus Company, with the address "46 Regent Circus, Piccadilly, London," advertised to supply both oxygen and the necessary apparatus for manufacturing and administering it.

This little anonymous volume repeated some of Hill's reports of cases treated, including *scrofula*, *dyspepsia*, *chronic dysentery*, *asthma*, *dyspnœa*, and *asphyxia*; also referring to the experiments of Beddoes, Davy, Weeks, Cavendish, Coleman, Goodwin, Menzies, Liebig, and others.

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[1] See also Gazette Médicale, Paris, 1866.

Dr. S. B. Birch, of the Manchester Medical School, issued a monograph on the subject of oxygen as a curative agent ("On Oxygen," London, 1857), but it met with very ungenerous criticism and did not find its way to this side. A second edition (London, 1858) was the first contribution to the literature of the subject which commanded any degree of attention.

Ten years later, already investigating the subject of oxygen compounds, I procured a copy of Birch, and am indebted to him for valuable suggestions.

This author says (*op. cit.*, p. 148):

"It (oxygen artificially prepared) is a powerful, really scientific, and agreeable curative agent; is capable of far more extensive range in its application to the rational treatment of chronic disease than, perhaps, any other remedy—*is pre-eminently Nature's own therapeutic*, affording assistance in her own way without opposing the intentions of her ever-present *vis medicatrix*, and is entitled to the position of a *curative* in a variety of intractable diseases, otherwise incurable by any other known means, or tacitly acknowledged to be so; . . . . is occasionally *the* remedy, and then the only one worthy of the name, in certain contingencies where life must be (and frequently is) sacrificed by neglecting a fair trial of it."

He adds: "It may with safety be predicted that, sooner or later, non-atmospheric oxygen will be universally admitted as one of our most valued remedial agents" (*op. cit.*, p. 149).

The verification of this rather sanguine prediction has not yet transpired. Whether on account of the serious and hitherto insuperable difficulties of making the treatment generally available in private practice, or from lack of professional enterprise and ingenuity, remains to be investigated.

With the general profession a sort of chronic impression prevails, based on neither science nor experience, that the therapeutic use of non-atmospheric oxygen has been tried and failed.

Professor Da Costa says: "Of all the gases oxygen is

now being most tried, particularly for the relief of dyspnœa and in low fevers, or during convalescence from low fevers, and in chlorosis. We must await these new trials, for the former experiments were unsatisfactory. But excellent results have quite lately been claimed for oxygen inhalations by Demarquay—who is at present investigating the subject—not only in the conditions named, but in diabetes, in senile gangrene, and in prolonged suppuration" ("On Inhalations," Philadelphia, 1867).

In this country, very little has been heard from these later investigations, except in connection with the subject of antisepsis. In fact, the past decade, in the history of medicine, may not inaptly be termed *the age of the germ-craze*. The microscope has monopolized the laboratory, and well-nigh superseded the inductive method. Morbid products have been accorded more prominent attention than vital processes; results studied with the most elaborate minuteness, to the exclusion or ignoring of their underlying causes.

There is no doubt, however, that the shortcomings of impure and carelessly manufactured gas have done more than all else to bring the use of oxygen and its congeners into disregard, if not discredit, and to prevent its timely use by the profession at large.

Again, the usual methods of generating it in a sufficiently pure form for medical use are a conspicuous drawback to its general use by even those who are aware of its value and anxious to avail themselves of it. Some apparatus is required, and careful chemical manipulation, which in time, no doubt, will be delegated to the pharmacist and manufacturing chemist.

At present the process by means of chlorate of potassium and manganese dioxide is the most practical and economical for ordinary purposes. The apparatus required is neither complicated nor expensive. Some care is requisite, but the gas afforded can be secured in a state of almost absolute purity. Various inventors and manufacturers of surgical instruments have, from time to time, brought out unique and ingenious contrivances for evolving and administering the gases, of which might be men-

tioned one by Dr. Biegel, and that of Galante, of Paris. The Pneumatic Medicine Company, and also Barth, of London, condensed the gas in iron flasks, and added devices for its convenient dispensation.

Fleitmann proposed a process for the rapid liberation of oxygen in a tolerable state of purity (which in a medical sense is nothing short of *in*tolerable) by means of calcium chloride and monoxide of cobalt. Since it required that the chloride should be in a state of saturated solution previous to the addition of the cobalt, it was unwieldy and never became popular.

Improving on this suggestion the Messrs. Robbins & Co., of London, succeeded in combining the two substances in the form of dry powder, which is ready for instant use on the addition of simple boiling water, and, it is said, may be preserved indefinitely without deterioration. The process of combining the two substances is reserved by this firm as a manufacturing secret.

An intimate ally of oxygen, therapeutically speaking, is found in *nitrogen monoxide*, N_2O—the "nitrous oxide" of the old nomenclature. It is almost as potent an oxidizing agent as oxygen itself. It supports combustion nearly as well; its specific gravity is greater, and it is distinguished from oxygen by its much greater solubility in water. Doubtless, from this cause, it is much more rapidly and extensively absorbed into the system when inhaled.

It is best known through its general use as a dental anæsthetic. When perfectly pure—a rarer circumstance than need be—it may be inhaled for some time with impunity; in fact it may be safely assumed that the rational use of the pure gas is practically, if not absolutely, free from danger, since out of the millions of instances of its exhibition to patients of all ages and conditions, the very few fatal cases reported were quite probably attributable to impure gas, irrational or ill-timed administration, or accidental causes.

The anæsthesia induced by its free inhalation, quite unlike that from chloroform, ether, ethy-bromide, and other anæsthetics, is transient, pleasurable, unaccom-

panied by a stage of excitation, and is not followed by depression or other unpleasant after-effects.

Under a pressure of fifty atmospheres, it becomes liquid, and at —120° F., Faraday succeeded in reducing it to a solid. In the latter form, applied to the skin, it produces a painful, burn-like blister (Fownes).

That it is an oxidizing agent in a marked degree, and that its therapeutic value is not limited to its use as an anæsthetic, is evident from its chemical and physical characteristics. At the same time it combines properties so different from those of oxygen, that the two are by no means therapeutically identical.

Several small volumes have been devoted to this gas, all but one of them, so far as I am informed, limited to a study of its claims as an anæsthetic.

In 1860 Dr. George J. Ziegler, of Philadelphia, issued a little volume, now out of print, in which he claimed much for this gas in the treatment of several forms of chronic disease. Experimenting somewhat extensively, his success led him to assert emphatically that, if properly exhibited in suitable cases, it would be found not only a *materia medica* but also a valuable *materia alimentaria.* Classing its anæsthetic and antispasmodic properties as secondary, he insisted that it served as a *direct source of supply to the blood and tissues.*

Later, some enterprising but unscrupulous pretenders "discovered" in this gas the so-called "oxygenized air," which a dozen years ago was extensively advertised as a cure-all. "Rights" to manufacture and administer it (!) were sold to gullables for a round sum, the process of generating it being bunglingly disguised by the addition of ferric carbonate or other inert coloring material to the ammonium nitrate used. Even to this day a firm in Philadelphia is still harping on the miraculous alchemy of "compound oxygen." What their office remedy may be I do not know, but the trash they send to their mail correspondents, calling it "home treatment," is a barefaced swindle and utterly worthless, being nothing more than a weak solution of the nitrates of lead and ammonium, or of ammonium muriate and St. Croix rum.

The process for evolving nitrogen monoxide is simple and well known to every tyro in chemistry. The gas should be washed through not less than four waters (wash-bottles)—half a dozen would be still better—before it is fit for inhalation.

The *peroxide of hydrogen*, H_2O_2, was discovered by Thenard in 1818, but has not until quite recently attracted any attention as a physiological agent. Assmuth and Schmidt made some unsatisfactory experiments with it in 1864. Richardson soon after used a solution of it in water, and approved it for internal administration. Its very unstable nature and disagreeable flavor, however, prevented any degree of popularity, and not until 1878 were any satisfactory experiments conducted. In that year Gutmann and Schwerin demonstrated that it underwent decomposition in the tissues, liberating free oxygen in quantity sufficient, when pushed, to induce gaseous pulmonary embolisms, with arrested capillary circulation, and finally fatal results.

About the same sime Stöhr, experimenting with it as a disinfectant, employed it extensively in cases of phagedænic and syphilitic ulcers and diphtheria. According to this author the pus from venereal ulcers lost its virus after two hours' contact with a concentrated solution of peroxide of hydrogen. The discharge from ulcers treated with it quickly assumed a more benign character, healthy granulations appeared and losses of substance were rapidly repaired.

More recently MM. Péan and Baldy have given this agent quite extended trial in the surgical wards of the Hôpital St. Louis (Paris), as a substitute for carbolic acid in antiseptic dressings. Under its use the general sanitary condition of the wards notably improved, cases of traumatic fever and erisipelas became less frequent, and it was found especially desirable as an application in dressing flaps, after amputations, union by first intention being decidedly encouraged by it. As compared with carbolic acid and other antiseptics it possessed the manifest advantage of being devoid of both unpleasant odor

and toxic influence, while its application was painless, if not even agreeable.

Following in the wake of these promising and suggestive tests, Dr. Landolt found its use in ophthalmic surgery to be a great advance over that of any known antiseptic, since it can be used of a strength sufficient to effectually destroy all forms of microzoa without injury to the delicate structures to which it is applied in ocular surgery, which is not true of carbolic acid, alcohol, salicylic acid, etc. He also found it to be possessed of very remarkable detergent properties, promptly cleansing suppurating surfaces, arresting septic fermentation, and rapidly checking suppuration in even neglected cases of gonorrhœal ophthalmia.

For more extended details of Dr. Landolt's interesting experience, see the London *Medical Record*, for March, 1883.

At this point, some inquiry as to the *modus operandi* of super-oxidizing agents and the final disposition of the quantity of oxygen daily consumed or *appropriated* in the human system will not be out of place.

A healthy adult, at active exercise in the open air, inspires daily one thousand gallons of oxygen, diluted with four thousand gallons of nitrogen.

Regnault and Rieset have shown that the decarbonization of the blood is one of the minor offices of the oxygen inspired. Of the one thousand gallons daily required, from ten to twenty-five per cent.—one hundred to two hundred and fifty gallons—*is absorbed, directly and in a free state, into the blood* (Magnus).

The marked affinity of the blood for oxygen is indicated by the physical fact that the former readily absorbs two and one-half times as much of the latter as water at the same temperature.

Nor is it true that the carbon dioxide exhaled during animal respiration is wholly formed in the lungs. It already exists in the venous blood before it reaches the lungs, while both carbon dioxide and free oxygen exist in arterial blood (Dalton).

Magnus found the proportion of free oxygen to car-

bonic acid by volume in arterial blood was as 10 to 25; in venous blood as 10 to 40.

Thus in the pulmonary circulation carbon dioxide is given off and oxygen absorbed, while in the general circulation the oxygen gradually disappears, and is replaced in the venous blood by carbon dioxide. The free oxygen in the general circulation exists there in the form of a simple solution. It is finally absorbed from the blood of the capillary vessels, and *becomes fixed in the substance of the vascular tissues.* The blood is therefore a circulating fluid destined to transport oxygen from the lungs to the tissues, *for it is the tissues themselves which finally appropriate the oxygen and fix it in their substance* (Dalton).

Burdon-Sanderson has further shown that the red blood-cells are the main carriers of oxygen, and that the condition of inflammation, in its earlier stages, essentially consists in a sluggish and finally immobile condition of the white blood-cells, from want of a due and regular supply of oxygen; and that the activity of the white blood-cells is in exact proportion to the amount of oxygen present. This would seem effectually to refute the prevailing impression that an over-supply of oxygen to any part necessarily induces an inflammatory condition.

The principal source of the carbon dioxide of the blood is the decomposition of the tissues, an essential part of their constant metamorphosis. The experiments of Marchand prove that *even here it is not a process of direct union of oxygen with the carbon of the tissues, but in some other and more indirect mode.*

Further evidence that oxygen and its congeners are important elements in every stage of the process of tissue-building, that oxygen itself is an element *in quo multum alimenti est*, is scarcely necessary. It is evident, however, contrary to the generally accepted ideas, that oxygen should be classed as a *restorative* rather than a *destructive*, and as *contributing directly toward constructive rather than destructive metamorphosis.*

Instead of constantly breaking down tissue by true chemical oxidation, as is almost universally taught and

unthinkingly accepted, it really replenishes wasted tissue, both by supplying in itself an essential element toward such repair, and by stimulating and correcting, at every step, the assimilative process.

On the other hand, admitting that the stereotyped assumptions in physiology are true, the rate of metamorphosis is held to be the gauge of vitality. Imperfect or impeded metamorphosis is disease, arrested metamorphosis is death.

In many of our therapeutic efforts of late are we not too eager to hasten *con*structive transformation, almost forgetting that this process must in all cases be both preceded and accompanied by *de*structive action? And do we not ignore the glaring fact that *no molecule of matter, whether of nerve or muscle-fibre, bone element, or blood-plasma, can be made to assume its position in the animal economy except through its direct association with this vital and inevitable element—oxygen!*

Throughout the organic world oxygen in some of its protean forms is the universal basic element; the addition or elimination of a single equivalent often sufficing to transmute the blandest article of food into the most virulent poison, and *vice versa*.

It is an every-day fact in chemistry that substances identical in ultimate composition, as far as our yet imperfect art can discover, are strikingly different in a physiologic or therapeutic sense. Whether this difference consists in varying modes of atomic and molecular arrangement, or in different, but as yet indistinguishable, states of the oxygen base, is yet beyond our scientific ken.

Hence it does not follow that oxygen as found in common air, and the same element in doubtless a nascent and hyper-active state, as artificially generated—liberated would be a more accurate term—are either physiologically or therapeutically identical.

Again, the *physiological* relations of oxygen are definite and limited, while *its nature and potency as a therapeutic agent are, as yet, not generally understood, entirely unlimited, and as different from the former as though it were in reality another element.*

While all physio-chemists assert that it is an active eliminator, depurant, disintegrant, resolvent, and perhaps sorbefacient, and alterative, very few have taken the pains to investigate it in the light of a *materia alimentaria*, and hence a direct invigorator and renewer of the whole vital organism. Nor do we yet practically realize the evidently demonstrable fact that *there is no antiseptic known of equal potency with pure oxygen;* or that there is no known antiseptic compound which does not contain this vital element. It may yet transpire that all antiseptics depend for their special properties, directly or indirectly, on the free or feebly combined oxygen they contain. Should this presumption prove to be well founded it devolves on this micro-chemic age to devise methods for the convenient and successful use of the real and safe factor, to the exclusion of the noxious, carbonized elements at present so largely composing antiseptic mixtures, and thus forever do away with carbolic, salicylic, and all other "antiseptic" septæmia!

Thus, Pasteur has demonstrated that by cultivating the disease-germ of chicken cholera for several generations in fluids having free access to the oxygen of the air it is gradually robbed of its virulence and eventually becomes inert; and Buchner succeeded in transforming the dreaded *bacillus anthracis* into the harmless *bacillus subtilis*—the hay bacillus—and *vice versa*, by repeated cultures in fluids freely supplied with oxygen, or wholly deprived of the same, according to the results desired.

Prof. Law's[1] experiments with the virus of hog cholera fully confirm the foregoing results. The virus attains its maximum of virulence after cultivation in fluids occluded from free contact with the oxygen of the air, and is gradually, but surely, robbed of all malignancy by culture in fluids freely supplied with that element.

The same principle holds with regard to the propagation of yellow fever, typhoid fever, Asiatic cholera, diphtheria, croup, and the pleuro-pneumonia or lung-plague of cattle.

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[1] Malignancy of Disease Germs Mitigated by Oxygen. THE MEDICAL RECORD, vol. xix., p. 673.

Another idea, not quite foreign to the subject, suggests itself: Has any chemical or physiological investigator queried whether the fundamental difference in the toxic tendencies of the two anæsthetics, ether and chloroform, is to be found by a comparison of their chemical composition? $CHCl_3$=chloroform; $C_4H_{10}O$=sulphuric ether. In the latter one equivalent of oxygen does duty, while in the former none of the elementary constituents would sustain animal life for a moment.

The question of ventilation in crowded cities, public buildings, and even in private dwellings, will eventually resolve itself into improved methods for supplying and distributing, in suitable quantities, artificial oxygen, and *if the bacillus tuberculosis prove to be a veritable entity —the essential factor in the induction and propagation of phthisis—then must we find in pure oxygen, by one mode or another of administration, its one efficient germicide and antidote!*

If Koch be right, then is mountain air and the air of new countries, in phthisis, but a removal from germ-fostering to germ-discouraging atmospheres. And whether he be right or wrong, bad air is the culture-fluid of all zymotic and germ-engendered diseases the world over.

The field of profitable investigation suggested is fairly exhaustless, but space forbids its further exploration in this connection.

Recurring to the practical side of the subject, I have personally used oxygen in only its simple gaseous form, and exclusively by inhalation. As to proportions and combinations, I have exhibited the gas, first, pure or undiluted; second, diluted with common air; and, third, admixed with nitrogen monoxide in various proportions.

In asphyxia from drowning or the inhalation of noxious gases, in threatened fatal syncope, suspended animation, and some other emergencies, as uræmic coma, chloroform or ether narcosis, opium-poisoning, etc., the first form of administration is indicated. For general use in chronic diseases the undiluted gas is seldom appropriate; but is to be modified by proper dilution, or associated with ni-

trogen monoxide in various proportions, according to the exigencies of each case.

MODUS AND METHODS.

In attempting to formulate rules for its indication and exhibition the most difficult part of my task remains, since in no other form of therapeutic effort is more careful discrimination necessary, and in none are we confronted by a greater dearth of precedent. Ordinarily the diagnosis furnishes the indication, and the age, condition, and temperament of the patient are accredited as safe guides to the proper dosage.

The agents now under consideration are potent for good or evil in a superlative sense, and cannot be so exhibited. Nor have we in our libraries half a century's accumulations of literature on the subject, to which, as in ordinary cases, we can refer for aid in case of a dilemma.

One of the first misconceptions, or misapprehensions, to be thoroughly uprooted—for it is always necessary to unlearn errors before we can comprehend facts—is the inference or impression that since these agents are principally used by inhalation they are, on this account, particularly adapted, if not practically limited, to the treatment of pulmonary complaints. Nothing could be farther from the truth, as will appear from the general tenor of arguments used and facts presented throughout this series of papers. Oxygen may be now, or may in time become our chief reliance in combating the strumous and tubercular, as well as other diatheses; but it is not and will not be because it is taken directly into the lungs, the apparent principal seat of tubercular manifestations.

Its specific action is by and through its absorption into the blood and its direct and rapid distribution to every tissue throughout the entire system. It thus becomes, as already set forth with sufficient emphasis, an important source of supply to the blood, *an element of repair and nutrition*, already prepared for direct and immediate assimilation, requiring neither gastric solution nor intestinal

modification in order to become an integral part of the vital organism. Its effects, therefore, must not be compared with those which follow a dose of "medicine" in the ordinary acceptation of that term. Hence, while certain immediate or acute morbid conditions are quickly removed by its timely exhibition, it cannot be ranked as a drug to be divided into definite doses and exhibited promiscuously in all acute and chronic diseases at stated intervals, as is the case with the ordinary articles of the Pharmacopœia.

If, therefore, I were to be asked whether the oxygen treatment will "cure" this or that particular malady or disease by name, as phthisis, carcinoma, rheumatism, epilepsy, I should promptly answer, No, it will "cure" no disease whatever. If, on the other hand, a professional brother should inquire, In what diseased conditions do you consider it particularly indicated? I should as promptly respond, *In every chronic morbid condition of which it is possible to form a conception.*

This may seem an extravagant estimate, but it really is not, since the question is like asking in what conditions of the system is it proper to administer nourishment? It is merely recognizing the view now coming to the front in medical philosophy, that, in the language of Ordroneaux, "We are to treat it [disease] not as a personal devil entirely, to be exorcised by philters and mummery, but rather as *the perversion of a natural state struggling to regain its equilibrium.*"[1]

Another stereotyped error in connection with the use of oxygen as a remedy must be eradicated from the average medical mind. It is assumed, on the basis of an ancient chemical dogma, that this element is pre-eminently a *destroyer;* that it is the principal, or even sole office of the oxygen inspired to break down used tissues, to eliminate refuse material, to "burn up" waste products; and that more oxygen means simply and necessarily more extensive waste, more rapid destruction—a hotter fire! This is another of the superannuated myths

[1] Journal of Insanity, vol. xxix., p. 333.

of science. It is true that living is synonymous with wasting, disintegration—*burning*, if you insist on the misnomer—but to cease to waste, to interrupt disintegration, to *put out the "fire,"* even for a moment, is to cease to live; it is irrevocable death. Nor can reparation, or even primary assimilation, proceed without its twin process—destruction. Admitting all this as abundantly established by both analogy and observation, there is still every corroboratory assurance, in both chemistry and physiology, that the element under consideration is less a *de*structive than a *con*structive agent, less a detergent than an aliment, less a *burner* than a *builder*.

Again, the underlying idea in all rational therapeutic endeavors, aside from surgical conservation of structure and the temporary palliation of excessive pain, is to hasten metamorphosis, both destructive and constructive, since it is universally recognized that destructive action —elimination, depuration—is but one and a very essential part of constructive change. It is the thrusting aside of obstacles which impede or bar the progress of true repair and rebuilding.

On the part of those who have been in the habit of thinking, teaching, and acting in the old rut—for rut it certainly is—it will take some time to fully comprehend, and will require a considerable effort to frankly admit this; for the rut has long been revered as the regular way; in it we have always had, and still have, plenty of company, and that of eminence the most unquestioned. Nor is it any novelty, or in the slightest degree an innovation, to assert this. Acknowledged authorities in physio-chemistry have all along taught it. It will be a surprise to even well-read and experienced members of the profession to refer freshly, in the face of this assertion, to standard works on physiology, and see how strong and positive is the evidence to this effect—evidence which most of us have all along blundered over, ignored, or but half comprehended.

"To describe fully the physiological action of oxygen would involve a description of the processes of respira-

tion, sanguification, nutrition, and tissue-change, for to all these, and to life itself, it is essential." [1]

"Preyer showed that a greater saturation from oxygen inhalation is, *a priori*, probable, . . . and Demarquay proved it by showing that suppurating, indolent, or unhealthy wounds on the extremities of animals became quickly florid and hyperæmic when pure oxygen was inhaled. . . . Allen and Pepys, and later Limousin, showed that by inhaling an equal quantity of atmospheric air at one time and oxygen at another, double the amount of carbonic acid was expired, and this increase continued for fifteen minutes after the inhalations had finished."

"Other observers have reported that the elimination of uric acid during a course of oxygen inhalation is markedly lessened, *i.e.*, that more complete combustion occurs within the system (Schmidt's Jahrb., t. 1, s. 28, 1865)." [2]

Kollman found that the quantity of uric acid in an equal amount of urine was reduced nearly fifty per cent. by free oxygen inhalation. In one experiment the amount of acid fell from one hundred and thirty-four to twenty-five milligrammes.

Gubler's experiments proved that active inspiration of pure oxygen gas slowed the pulse and respiratory movements, produced a general sense of comfort, did not cause dyspnœa, and that the pause between inspiration and expiration could be prolonged from the ordinary limit of thirty to as much as ninety or one hundred seconds after breathing oxygen ; and as a result of his observations, he asserts that the blood receives the gas in proportion to its physical capacity for it, rather than in proportion merely to the vital necessity of hæmatosis. The globules absorb what they need, while any excess circulates free and enters into combination only as the hæmoglobin loses oxygen in passing through the capillaries.

Quinquaud, by certain chemical tests, which, to make them reliable, need corroboration, estimated that the

[1] Phillips: Mater. Med. and Therapeutics, vol. i., p. 2, ed. Wood's Library. 1882.
[2] Phillips, op. cit., p. 5.

capacity of the blood for oxygen in healthy subjects was quite uniformly two hundred and forty cubic centimetres of oxygen to every one thousand grammes of hæmoglobin.

The experiments of Buckheim, Klebs, Husemann, Naoumoff, Beliaieff, Savory, Richardson, Ewald, Hering, and others, have not given us much additional light on the subject. They were chiefly of that crude, forced, and unnatural character, too common in physiological experiments, which add so little to our practical knowledge of the "action" of any remedy when properly exhibited. For example, what would it profit the pathologist to learn, by cruel experiment on the lower animals, or perhaps on some helpless, hospital-stranded human wretch, that an exclusive diet of absolute alcohol produced a train of untoward symptoms and speedy death? Would we therefore proscribe all the alcoholic mixtures—brandy, gin, wine, whiskey, etc., etc.?

Nature does not suggest the use of oxygen in a "pure and nascent state," as used by these experimenters, and I do not consider such use of the agent, unmixed and undiluted, permissible, much less advisable, except in a few emergencies, and then only to cover the exigencies of the particular cases as presented. Hence I have little interest in the class of experiments referred to. *Tests of the gas as a therapeutic agent must be based on conditions which do not do violence to well-known and well-proved natural laws.* The safe guides in this, as in all therapeutic investigations, are common-sense, the recognition of known facts, and the simple rules of analogy. Above all, we must "take a hint from nature."

Among the acute or immediate conditions which oxygen and its congeners can be made to promptly, safely, and surely relieve, may be cited *asphyxia*, from drowning, hanging, or from inhaling carbon dioxide or other noxious gases; *suspended animation*, from syncope and from opium or chloroform narcosis; *poisoning*, from various toxic agents; *spasmodic asthma* (the paroxysm); *obstructed respiration*, as in diphtheritis and membranous croup; and in *cyanosis*, from whatever cause.

Of the many chronic conditions which may be confidently attacked, I may specifically mention *anæmia* (Birch, Demarquay, Da Costa, Dujardin-Beaumetz, *et als.*); *chlorosis* (iidem); the *cachexiæ* and *dyscrasiæ* in general; all the *indigestions* and dependent disorders (Hill, Beddoes, Birch, Goolden, *et als.*); *struma* and *tuberculosis* (omnes cit.); *empyæmia;* chronic *glandular enlargements; intra-thoracic* and *intra-pelvic abscesses* and *degenerations*; *epilepsy; emphysema* (palliative); *asthma* (curative); the *typhoid state; zymosis, septicæmia,* and *malarial poisoning; neurasthenia,* and nearly all forms of *neuralgia.*

From this imperfect generalization, it will not be difficult for the observant medical mind to discern the special indications and contra-indications for treatment in any given case.

It may be asserted, in general, on rational as well as experimental grounds, in connection with this treatment, that those chronic cases show most marked and striking results which are selected from the great army of house-prisoners, "delicate" people who, from necessity, habit, preoccupation, or negligence, have been long deprived of wholesome air and everything like active out-door life; or who have long suffered from miasmatic location, sedentary occupations, or unsanitary surroundings; or from those who have been too tenderly reared—over-coddled (and this virtually includes every close resident of a populous city). To these may be added the phlegmatic, the "lymph-albuminous," and the lazy—of whom every community shows numerous examples—patients with sluggish circulation, small respiratory apparatus, torpid or enlarged livers, fatty heart or kidneys, and with habitually retarded excretory functions generally.

As far as individual experience with oxygen goes—my first cases were treated sixteen years ago—I have found thoroughly satisfactory, and in some instances very remarkable, results in cases of inveterate asthma. As a palliative of the immediate attack, a mixture of oxygen and nitrogen monoxide has invariably given instant and happy relief; and the continued use of the two, variously mod-

ified, has never failed, in my hands, to effect a, to all appearances, complete and perfect "cure." If more extended trial proves equally successful, the treatment might very properly be termed a "specific" in the treatment of this distressing malady, which so often resists all ordinary as well as extraordinary measures.

In the severer forms of the indigestions the results have been scarcely less brilliant. Scanty or suppressed secretions are gradually restored, absorption and assimilation resume normal activity, and the functions of depuration and defecation, long deranged, obstructed, or interrupted, are surely, normally, and, in a medical sense, permanently restored.

Hill's first experiments with oxygen (1820) covered cases of hydrocephalus, epilepsy, chronic arthritis (gouty?), paralysis, and morbus coxarius. In each of these he reported flatteringly encouraging results.

Another, by no means unimportant, but as yet almost wholly ignored use for oxygen, is in connection with the administration of anæsthetics. On purely rational grounds, as well as from some years of practical experimentation, I am thoroughly convinced that the dangers heretofore presumed to be inseparable from the use of ether, chloroform and other anæsthetics, can be reduced to a minimum, if not rendered altogether nil, by the timely, previous, and perhaps occasionally subsequent exhibition of oxygen. A few inspirations of the gas, slightly diluted, taken just before inhaling chloroform or other anæsthetic, while it does not interfere with the degree of anæsthesia produced, effectually prevents the usual untoward symptoms—nausea, headache, delirium, etc. And while not materially abbreviating the stage of complete anæsthesia, it shortens the recovery stage and effectually forestalls the symptoms of imminent danger which so frequently alarm the operator and jeopardize the life of the patient.

In the use of nitrogen monoxide as an anæsthetic in short surgical operations, dentistry, etc., the effects are much more desirable when a certain percentage of pure oxygen is added.

On this point I would quote a summary of results arrived at by Dr. Klikowitsch after a series of experiments in Prof. Botkin's laboratory, at St. Petersburg (*Virchow's Archiv*):

1. Anæsthesia induced by it [nitrogen monoxide] is closely associated with insufficient oxidation of the blood, and hence not absolutely free from danger.

2. The association with it of twenty per cent. of pure oxygen completely removes all possibility of asphyxia, without interfering with the completeness of the anæsthesia.

3. By the use of this mixture the heart-pulsations of healthy subjects are increased, the pulse-wave diminished, respiration increased in depth but decreased in frequency; these effects lasting from three to five minutes.

4. In four cases of weak heart-action, the exhibition of this mixture produced no unfavorable symptoms. On the other hand, the pulse increased in strength and decreased in frequency; these effects lasting from one to two hours.

5. In cases of disturbed respiratory innervation, the mixture rapidly removed the symptoms of deficient blood-oxidation and regulated the respiratory rhythm.

6. This mixture quickly relieves suffering in angina pectoris, and when pushed, produces very perfect transient anæsthesia.

7. It is preferable to chloroform as an anæsthetic in labor.

8. Vomiting and cough of reflex origin are arrested by a few inhalations of these mixed gases.

The various methods of exhibition of this agent may be briefly adverted to:

1. *Direct inhalation* will probably always stand at the head of all methods.

2. *Cutaneous absorption* has been resorted to in Europe, and may be found advantageous in certain cases.

3. *Oxygenated water* is a feasible and pleasant medium for stomachal administration. It is prepared by saturating steam with the gas, at high pressure, and afterward condensing the steam.

4. *Oxygenated bread* has been used to some extent in England, and there is no reason why the "aërated bread" of our cities should not be easily transformed into *oxygenated* bread at will.

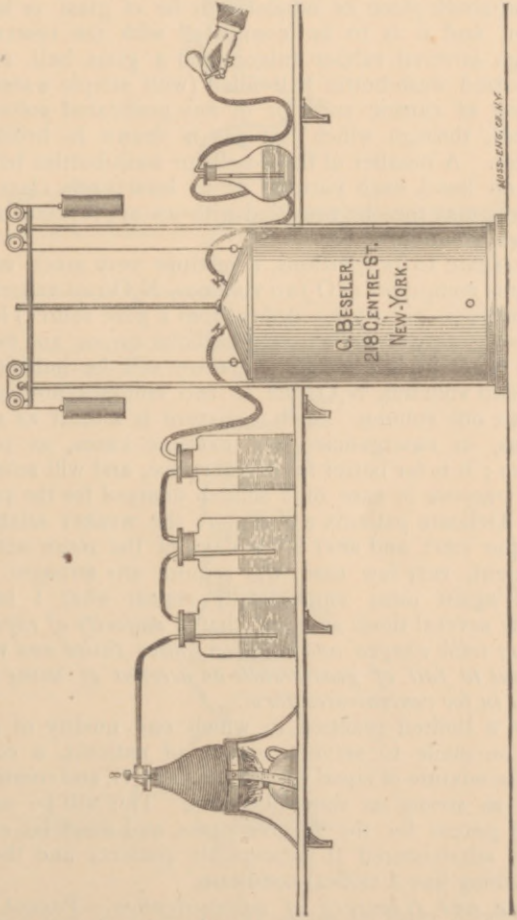
Of this bread Dr. Birch (*op. cit.*, p. 18 *et seq.*) says: "Its relative effect on the appetite is singular. Thus on the one hand (as might be expected) it stimulates the appetite when absent or capricious, while, on the other hand, it tends to produce such a feeling of epigastric fulness, when sufficient food has been taken, as to effectually suspend (if not satisfy) some morbidly craving appetites. . . .

"*In some cases* it will be found advantageously to supersede artificial pepsin, pancreatin, and even quinine and the mineral acids. . . . It is particularly indicated in cases of delicate children with continually recurring ascarides, functional derangement of the stomach and bowels, and mesenteric weakness."

In the matter of proportions and combinations, and as respects the quantity to be exhibited in a given case, there is as wide latitude for the exercise of professional discretion as in the compounding and selection of ordinary drugs.

Appliances for clinical exhibition.—As will be inferred, the use of these agents, although not necessarily restricted to these, is more especially adapted to office and hospital practice. For a complete office equipment in every considerable practice there should be at least three separate reservoirs. One should contain, at all times, pure oxygen, ready for instant use in cases of emergency; a second may contain pure nitrogen monoxide, and a third such modified admixture as is found best adapted to the class of cases under treatment. One or more additional reservoirs will at all times be found a matter of convenience, and in undertaking the treatment of a variety of cases in an extensive hospital or general office practice, quite essential. A receiver containing condensed air will make the armamentarium still more complete and comprehensive, and will frequently prove of great value. These should

be arranged so as to be readily connected when desired. They may be placed in a suitable hall, closet, or private



Apparatus for making and administering pure Oxygen Gas.

room adjoining the office, and connected with the latter either by ordinary gas-pipe or by rubber tubing. The

latter may be neatly covered, as a matter of taste, with rep or other suitable material.

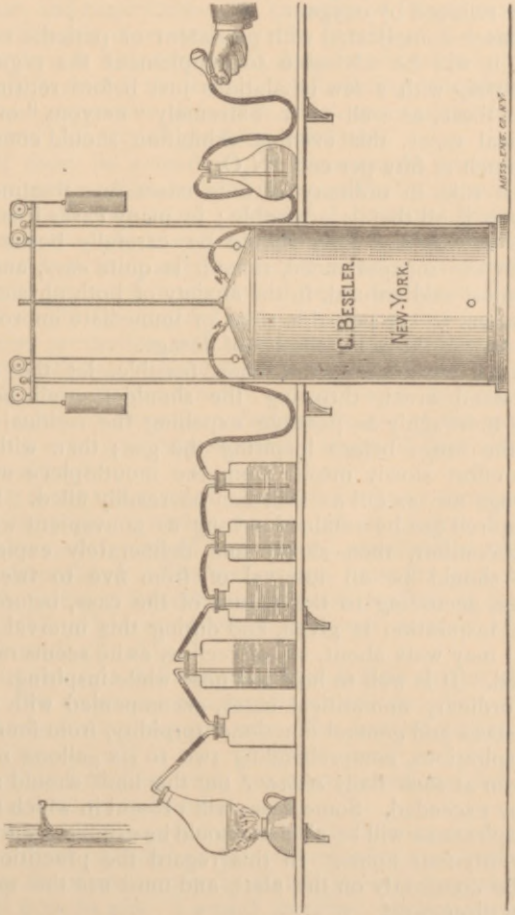
The mouth-piece or inhaler may be of glass or hard rubber, and it is to be connected with the reservoir through covered rubber tubing and a glass bell, or a small-sized wash-bottle half filled (with simple water, a solution of caustic soda, or of any medicated solution desired), through which the gas is drawn in brilliant bubbles. A number of these bells or wash-bottles being kept on hand, each patient, or at least each class of patients, may thus be provided with an appropriate and separate solution.

In regard to proportions, a mixture very much used by me is composed of O two volumes, N_2O two volumes, and common air (to be drawn from a pure source) four volumes. In cases of extreme vascular torpor and functional inactivity a stronger mixture will be indicated, as O two volumes, N_2O one to two volumes, and common air one volume. Such a mixture is almost as efficacious, in emergencies and extreme cases, as pure oxygen; it is far better for ordinary use, and will answer every purpose in case of a sudden demand for the pure gas. Delicate patients will require the weaker mixture from the start, and after a few days of the more active treatment, very few cases will require any stronger. I would again most emphatically repeat what I have already several times asserted, that *a majority of experimenters with oxygen and congeners have failed and will continue to fail of good results on account of using the agents in too concentrated form.*

For a limited practice, in which one quality of gas must be made to serve a variety of patients, a compromise mixture of equal volumes of O, N_2O, and common air is as strong as should be used. This will be sufficiently potent for the severer cases, and must be cautiously administered to susceptible patients and those in anything like a critical condition.

Time and frequency of administration.—Except in emergencies, the treatment should not be given either on an empty stomach or after a prolonged fast. In a

majority of cases the mid-meal hours between breakfast and dinner are most favorable. It is well to avoid



Apparatus for making and administering pure Nitrous Oxide.

giving any active treatment within an hour of any principal meal, or at any time when there is present an

unusual degree of fatigue. Mere weakness or nervous prostration do not, however, contra-indicate, but are usually relieved by oxygen.

In cases complicated with persistent or periodic neuralgia, it will be advisable to supplement the regular daily sitting with a few inhalations just before retiring; and in these, as well as in extremely "nervous" or in hysterical cases, this evening exhibition should consist of as much as fifty per cent. N_2O.

As a rule, in ordinary chronic cases one treatment per diem is all that is advisable; in many cases it is all that is *allowable*. This should be carefully borne in mind by the inexperienced, since it is quite easy, and I had almost said natural, in the anxiety of both physician and patient to see palpable signs of immediate improvement, to overdo in the matter of dosage.

Dosage and intervals.—When feasible, let the patient stand erect, throwing the shoulders well back and as thoroughly as possible expelling the residual air from the lungs before inspiring the gas; then with a steady effort slowly inspire from the mouth-piece until the lungs are as full as they can be readily filled. Let the inspired gas be retained as long as convenient without discomfort, then slowly and deliberately expired. There should be an interval of from five to twenty minutes, according to the nature of the case, before a second inspiration is given, and during this interval the patient may walk about, sit, or recline, as he seems most inclined. It is well to hold the nose while inspiring.

In ordinary non-critical cases, accompanied with venous stasis and general functional torpidity, from four to ten inspirations, comprehending two to six gallons, may be given at each daily *séance*; but this limit should seldom be exceeded. Some cases will present in which two full inspirations will be all that should be exhibited during the twenty-four hours. In this regard the practitioner must be constantly on the alert, and must use the most careful discretion.

A systematic record should be kept of each case treated, beginning with a summarized history, a thorough

physical examination, an examination of the urine, noting pulse- and respiration-rates, capacity of lungs, etc. The quantity per diem and specific gravity of the urine, as observed at stated intervals, daily in critical or important cases, and at least weekly in all, during treatment, will furnish suggestive data from which to regulate the quality and quantity of gas to be exhibited.

If there be a tendency to hæmoptysis, oxygen is not necessarily contra-indicated, but evidently should be administered with more caution. I have not hesitated to advise the treatment in these cases, if not otherwise contra-indicated, and have never witnessed any untoward results; but the lungs should never be forcibly inflated, nor should the inspired gas be so long retained. As a further precaution, which, however, I am inclined to think is superfluous, it should be much diluted at the outset and gradually increased in strength with the progress of the case. I have even thought the use of the gas, with due precautions, has eventually lessened the liability to hemorrhage.

In acute cases, as of asphyxia from any cause, alarming dyspnœa, cyanosis, suspended animation, narcosis, severe paroxysms of asthma, etc., no definite rules can be formulated. The indications must be gathered in each instance from the nature and progress of the case, and the judgment of the practitioner must in all cases supersede all rules.

In cyanosis and asphyxia there is little danger of pushing the treatment too rapidly or too far, short of positively relieving the patient. The immediate demand is for *oxygen*, and it may be given, freely and constantly, until the imminent crisis has been passed and the urgent symptoms are relieved.

A practical suggestion.—In its incipiency every "new" treatment is called on to perform miracles, since at first only the most inveterate and apparently incurable cases will seek its aid. I would therefore utter this warning, and suggest that no such cases be received except with the express stipulation that the treatment shall be punctiliously followed for a definite period of, say, not less than

two, three, or four months. It will be worse than throwing away time, or than placing pearls before swine, to permit the grand army of physical vacillators to spasmodically attempt the treatment, foolishly expecting that it will accomplish greater wonders than the touch of Midas' wand, and fully believing for a day that it is the latest "wonderful discovery" among patent nostrums. These will follow it for a few days or weeks, and will insist upon giving it up long before it has accomplished any definite or permanent good. They will be only a block of stumbling to its success with others, and will give you no end of annoyance by their irrational and short-sighted criticisms. Better decline to treat not only hopeless incurables, but all who will not stipulate to give the treatment a fair and thorough opportunity to accomplish tangible and permanent results. I would insist on this, even though it might appear to savor of the methods of the advertising charlatan. Thus, it would be a stroke of business prudence to charge each patient a maximum fee by the month for the first month, and minimum or perhaps graduated fees for subsequent months of treatment, since this will encourage perseverance on his part, and since the first month covers the period requiring most watchful care and intelligent adjustment of all the conditions.

Adjuvants.—As regards concurrent treatment by means of drugs, this must be left to the discretion of each practitioner, guided by the exigencies of each particular case. It must not be omitted whenever it rationally appears to be either synergistic or complementary. To reject any source of aid in treating maladies is to raise (or lower) any method of treatment to the questionable rank of a hobby.

Theoretically, iron is an oxygen carrier, and in some instances it may be given with advantage during an oxygen course; but if the patient's diet be sufficiently varied so that it shall contain the earthy salts in due proportion, there will be little need for increasing the chalybeate element.

To this end, even though it may seem pedantic, I would distinctly urge, in connection with an oxygen

course, the daily use of those cereal and other preparations known to be rich in phosphates and other needed elements, as oatmeal (coarse), white wheat (crushed or cracked), whole wheat flour, some of the principal elements of which are wanting in a majority of modern dietaries.

In connection with the use of oxygen the question of alimentation is of far more than usual significance. In all cases the diet should be thoroughly sustaining, and in some it should be abundant, even to the extent of forced feeding. Bearing this well in mind, no specific rules need be suggested. The necessity for an intelligently selected variety in diet suggests itself when we reflect that the subtle and powerful agent to which we are subjecting our patients rapidly permeates every molecule of matter in even the remotest tissues of the body. It accelerates at once the process of liberating worn material with retained and septic excretions, as well as that of rebuilding or repairing weakened structures. For all this work—destruction and reconstruction—liberal supplies of fresh material are in constant demand, and must be supplied with the food.

In all cases complicated by chronic gastric catarrh or torpid states of any of the viscera, the somewhat overdone fashion of hot-water drinking, to the extent of two or three pints per day, an hour before meals, will be found a valuable adjunct. If simple hot water be voted flat, hot lemonade or hot soda-water may be substituted, as indicated. The washing away of morbid products set free by the treatment is also quite an essential factor; hence, in addition to the hot-water drinking, the warm full bath, or a course of systematic bathing with massage, with also frequent local lavements, hot douches, etc., should not be omitted. These are invaluable adjuvants to any treatment.

The regulation of the general sanitary and hygienic surroundings of each patient need not be adverted to. The judgment of all intelligent practitioners will suggest this. One exception may be remarked in connection with this treatment: Deprivation in the matter of out

door air and physical exercise, whether from negligence, necessity, or indifference, will not be so serious a drawback as in case of ordinary treatment, since super-oxygenation to some extent supplies the lack. But blind faith in the treatment should not be allowed to exclude such aids as may be derived from any and all adjuvants.

That the use of oxygen in medical practice requires considerable time and care in its manipulation, and the exercise of much judgment and discrimination in its exhibition, and that impatient, over-sanguine, or careless practitioners will fail of satisfactory results in attempting it, is very true; but it may be made to add so largely to our therapeutic resources, is a desideratum in so many contingencies, and *the necessity for it increases so exactly in proportion to the increase of artificialness in the social and physical habits of modern society*, that the conscientious and painstaking physician of the future will undoubtedly avail himself of its aid in all appropriate conditions and emergencies.

The following cases, selected from those treated during a number of years past, represent the *range of adaptability* rather than any special features of the treatment, and are inserted, hoping that other experimenters in this promising field may be prompted to give to the general profession the results of their efforts, and that in due time we shall not be, as now, literally without a literature on the subject. It will be noted in all of them that prompt and permanent aid to digestion and assimilation is a decidedly prominent if not the principal result.

Case I.—Mrs. J. S——, aged thirty-nine, married, two children, the youngest several years old. By profession a singer and teacher of music. Family history includes phthisis, of which she lives in great fear. Each winter has severe bronchial and laryngeal troubles, with persistent cough. Anæmic, extremities habitually cold; pulse, 102 to 108; constant subclavicular pain; dyspnœa and fatigue on slight exertion; weak digestion, with bowels habitually constipated. She expectorates rather copiously; sputa muco-purulent; and there is circumscribed dulness over the apex of the left lung. She is very

despondent, and has no faith that any treatment will avail.

March 25th.—She presents for treatment and is placed on daily inhalations for thirty minutes at a sitting—℞. Oxygen, one volume; nitrogen monoxide, two volumes; common air, one volume. At a forced effort she can inspire 150 cubic inches of the mixture.

April 10th.—Improvement has been manifest from the first. The nitrogen monoxide acts as a wonderful calmative to the nervous system. She is no longer despondent; appetite much improved, coughs less, sputa reduced in quantity and less purulent. *Constipation effectually relieved.* Lung capacity, 190 cubic inches.

April 25th.—Resumed her music classes soon after last record. Improvement has been rapid and constant. Says she is "better than for many years;" eats, works, and sings with gusto. Considers herself "well," and treatment suspended.

(Observed this patient eight months later, no untoward symptoms reappearing.)

Case II.—Mrs. C. L. W——, aged twenty-nine, married, one child aged five. Family history says father died of cancer of stomach; mother of cardiac disease. She has "weak lungs," and lives in perpetual dread of "consumption." Sense of constriction in left lung; circumscribed "sore spot" under the left clavicle; severe cough for several years past, and there is now some dulness on percussion over the left apex. Has been treated by eminent physicians without appreciable benefit; very anæmic; voice weak; no appetite; amenorrhœic for three years past; menstrual discharge, when present at all, is either profuse, acrid, and colorless, or greenish in color, scanty, and offensive. Has been subject to repeated attacks of severe nephralgia. Urine not examined.

May 23d.—This patient was placed on a mixture of—℞. Oxygen, nitrogen monoxide, āā 2 volumes; common air, 1 volume, of which she inhales, twice daily, three gallons at a sitting. Shows a lung capacity of 130 cubic inches.

June 1st.—Improvement already manifest. Feels

"rested;" eats better; says the "soreness" has nearly left her. Can now inspire 165 cubic inches at an effort. Treatment continued twice daily.

June 15th.—Acute nephritis suddenly developed, or at least the chronic condition of those organs assumes a subacute form. Temperature, 102°; pulse, 122. Urine scanty, specific gravity 1.030; some albumen and casts. Oxygen suspended and hot hip-baths ordered, with demulcent drinks, to be followed by hot fomentations over the region of the kidneys.

June 25th.—The acute symptoms, which were somewhat alarming at last record, soon subsided, and general improvement is very evident. Lung capacity, 200 cubic inches. Oxygen was resumed 20th.

July 1st.—Improvement continues. Menses appear naturally and without unusual disturbance. Appetite excellent; walks two miles a day without fatigue, sleeps well, and gains flesh rapidly.

July 10th.—Patient continues to improve. Treatment reduced one-half and conjoined with chalybeates. Lung capacity increased to 225 cubic inches.

July 25th.—Treatment suspended. Patient returns to her friends very much rejoiced at her progress.

(Two years later this patient reported no return of former symptoms.)

Case III.—Miss A. B——, nineteen years of age. Family history good, except that mother died young. Father, Judge B——, quite robust at sixty-eight. She has suffered from spasmodic asthma since childhood, the paroxysms occurring daily and on the slightest exposure. She is very delicate, anæmic, and fatigued on slight exertion. Has constant dyspnœa and marked cyanotic appearance. Appetite weak and capricious.

May 25th.—Placed patient on—℞. Oxygen, 1 volume; nitrogen monoxide, 4 volumes, of which she inhales five gallons, once daily, with the result of immediately relieving the dyspnœa. Her lung capacity is but 75 cubic inches.

June 4th.—Improvement has been steady. No more cyanosis; does not suffer from paroxysms; appetite

fairly good. She inflates her lungs much better than at first; capacity, 100 cubic inches.

June 20th.—Proportion of oxygen increased to forty per cent. No return of paroxysms. General health greatly improved.

July 1st.—General improvement continues. From being caught in a storm has had one mild asthmatic paroxysm.

July 10th.—Patient can now endure active exercise without fatigue. Treatment continued every other day. Inspires 140 cubic inches.

July 25th.—Treatment has been irregular since last record, but patient's general health continues to improve; breathes, sleeps, and eats well. Exposes herself to changes of weather and temperature with impunity.

August 10th.—There has been no recurrence of the asthma, although patient asserts that she has repeatedly exposed herself to the same influences which invariably induced paroxysms previous to treatment. She is advised to continue the treatment at intervals, but as the family are about to remove from the city no further observations are practicable.

(November 30th.—This patient writes that she continues to enjoy excellent health, and has had but one asthmatic paroxysm since leaving the city—this from being drenched to the skin in a sudden rain-storm.)

Case IV.—Miss E. L. C——, sixteen years of age. For three years past subject to epileptic convulsions. Family history shows the malady to be hereditary. Patient tall, slender, with stooping, awkward gait, languid attitude, flabby muscles, sallow complexion, feeble pulse, morbid appetite, and poor digestion. Complains of constant cephalalgia, and, in short, is decidedly chlorotic. Has never menstruated, and her mother associates her malady with this fact.

August 13th.—Patient placed on—℞. Oxygen, 1 volume; atmospheric air, 2 volumes; four gallons at each daily sitting. Inhales but 60 cubic inches at an inspiration.

August 20th.—Mother reports that she sleeps better

and does not have her nightly "fit." Can inspire 90 cubic inches at an effort. Ordered chalybeates and nutritious diet, for the latter of which she begins to show a natural desire.

August 30th.—Still no return of the paroxysms. Cephalalgia has disappeared; appetite, digestion, and general health much improved. Lung capacity, 100 cubic inches.

September 14th.—Proportion of free oxygen increased to fifty per cent.; five gallons each sitting every other day. Patient resumes her classes in school, walking several miles daily without fatigue. Inspires 105 cubic inches.

October 10th.—Slight convulsion after severe exposure, attending an evening political demonstration. Daily treatment resumed; same formula as at last record. Lung capacity increased to 115 cubic inches.

November 1st.—Improvement has been constant; appetite fairly insatiable; digestion excellent, and is one of the most boisterous of her class on the playground.

November 10th.—Treatment continued every other day. Catamenia appear, naturally and without disturbance.

November 25th.—Patient decidedly robust, and apparently, as she asserts herself, "perfectly well." Treatment suspended.

(Six months later there had been no return of the epilepsy; general health of the patient continuing excellent.)

Case V.—A. S.——, aged fifty-one, married, several grown-up children; by occupation, commission merchant. Has been twenty years an invalid; a confirmed dyspeptic, and suffers from constant and extreme nervous irritability and prostration (neurasthenia?). Constant frontal headache and frequently recurring paroxysms of a dull, benumbing pain referred to the medulla and base of the brain. Appetite wanting; constipation habitual, alternating occasionally with diarrhœa; extremities cold, is very despondent, and has suffered for years from a masked or "dumb" ague. Liver and spleen somewhat

enlarged; urine turbid, specific gravity 1.030, abounds in alkaline phosphates, but deficient in urea and uric acid.

September 20th.—Daily treatment instituted, using—℞. Oxygen, nitrogen monoxide, āā four gallons at each sitting. Lung capacity, 160 cubic inches.

September 29th.—The evidence of retention of urea in the system corroborated, and the value of oxygen as an eliminator well illustrated. Crowding the treatment from day to day, patient last night inhaled eight gallons of the mixed gases. Urine now loaded with urea; specific gravity, 1.035. Treatment continued, the dosage diminished.

October 11th.—The disturbances noted after first week of treatment have nearly subsided. Urine nearly normal as to quantity, but still shows excess of urea; specific gravity, 1.028.

Mixture changed to—℞. Oxygen, 1 volume; nitrogen monoxide, 2 volumes; eight gallons at each daily sitting. Lung capacity increased to 200 cubic inches. Patient is less irritable, sleeps better, and feels greatly encouraged.

October 18th.—Improvement has been gradual but constant since last record. Cephalalgia is becoming a much less frequent symptom, and when present is less severe. Specific gravity of urine, 1.025.

November 11th.—Has steadily improved since last record, in spite of the drawback of constant business worry and overwork. Urine normal; lung capacity, 220 cubic inches.

November 20th.—Digestion good; sleeps well; no longer despondent or irritable; no headache; extremities in a comfortable glow; all his functions well performed. Treatment discontinued.

(Four months later this patient reported himself in active business and feeling strong and well.)

Case VI.—Miss E. A. W——, aged thirty-one; superintendent of a fur manufactory, the confinement and dust of which is very irritating. Strumous habit, but family history negative. Is anæmic, despondent, and complains of a constant cough; areas of dulness over

right lung, with persistent bronchial irritation and bronchial catarrh.

April 20th.—Placed this patient on a mixture of equal volumes of O, N_2O, and common air. Lung capacity but 130 cubic inches, although a woman of more than average stature and weight. Advised daily exercise in the open air and nutritious diet.

April 30th.—No apparent improvement; cough rather worse; expectoration very profuse, and sputa containing fetid cheesy (tubercular?) matter. Treatment continued.

May 10th.—Appetite rather better, and sleeps more regularly; otherwise no visible improvement. Cannot secure out-door exercise to any extent. Treatment changed to O two volumes, N_2O and atmospheric air, āā one volume. Lung capacity 150 cubic inches.

May 20th.—Lung begins to clear up, but no outward signs of improvement. Patient much discouraged, and only consents to continue the treatment on my positive assurance that she has made some progress. Lung capacity 160 cubic inches.

May 30th.—Now reports her general health as very decidedly improved; cough perceptibly better; her former sallow ("bilious") complexion has cleared up, and is now fairly ruddy. Eats and sleeps well, and enjoys a buoyancy of spirits unknown for years.

June 10th.—Reports herself "cured," and is loud in her praise of the treatment. Says she had no faith in it in the start. Her cough is almost entirely gone; respiratory murmur audible all over both lungs, and *has gained twenty pounds in flesh.* Lung capacity 195 cubic inches. Treatment discontinued, patient going to the country for a vacation.

August 8th.—She returns for additional treatment. Took a severe "cold" *en route* from the country, and her bronchial trouble returned. Severe passive congestion of both lungs, annoying cough with muco-purulent expectoration. Pulse, 94. At the first sitting she inhales two full inspirations of O one volume, N_2O one volume, and common air two volumes. Within five

minutes her pulse falls to 84, and the immediate dyspnœa is decidedly relieved.

August 20th.—Some cough yet, but great general improvement is evident. Severe bronchial irritation persists, and, continuing the oxygen treatment, a local spray is added. ℞. Potas. chlor. ʒ j. ad aqua ℥ iv.; alternating every other day with ℞. Fl. ext. hyosc. ʒ ss. ad aqua ℥ viij. per steam atomizer. Complains of pectoral and intercostal myalgia, for which ordered a stimulating lotion and tonic regimen.

August 29th. — Notable improvement is evident. Bronchial difficulty is much relieved; myalgia gone, and not much cough left. Treatment interrupted.

September 20th.—Treatment resumed every other day, improvement having continued since last record.

October 10th.—This patient now considers herself well, but is advised to leave the factory and live more out of doors, if possible.

Saw this patient six months later, and although she has not left the unwholesome factory she continues well.

Case VII.—L. P. N——, aged twenty-five; theological student; nervous temperament; family history good, but is a confirmed dyspeptic, and has spermatorrhœa of several years' standing, nocturnal emissions occurring almost every night. Over the latter he is despondent, even to desperation. Fears he is going into a "decline." Studies hard far into the night, preaches, becomes very excitable; after which he suffers from protracted insomnia. Has consulted a number of physicians here and elsewhere, but without benefit. Is now trying movement-cure, but thinks it weakens rather than strengthens him.

April 13th.—Begins the use of a mixture composed of O one volume, N_2O two volumes, and common air two volumes. Lung capacity 160 cubic inches; countenance expressing haggardness and hopelessness; urine loaded with oxalates.

April 20th.—Already reports a marked change in his appetite and digestion. Says his food no longer distresses him.

April 30th.—Nocturnal emissions have entirely ceased. He sleeps and eats well, and does not give way to excitement as formerly. Lung capacity increased to 190 cubic inches. Feels greatly encouraged.

May 10th.—Improvement has been constant and rapid since last report. Appetite and digestion excellent. Has gained in flesh, feels fresh and buoyant, and no return of emissions. In short, this patient is quite himself, and attributes the change wholly to the oxygen treatment. Lung capacity 200 cubic inches. No further treatment deemed necessary, and patient passed from observation.

Case VIII.—E. W——, aged forty-nine; insurance agent—one of the toughest of his kind! Could talk a graven image into taking a policy, if he had time. Mixes his family history so much with Farr's tables and the "actuaries' experience" that I cannot make much of it. Is suffering from a chronic "cold on his lungs," which I diagnose as bronchitis—subacute, with some pulmonary congestion. Has a very harassing cough, is quite dyspeptic, constipated bowels, harsh, dry skin, haggard appearance.

April 8th.—Placed him on the use, daily, of the standard admixture of equal volumes of O, N_2O, and common air. Lung capacity 150 cubic inches. Urine heavy with chlorides, etc.

April 16th.—Decidedly relieved; coughs less, raises more easily, sleeps and eats better. Treatment continued, increasing the proportion of O. Lung capacity 180 cubic inches.

April 25th.—Patient says he is pretty much "cured," and that the treatment has benefited his general health more than all the tonics, bitters, and "blood renewers" he has ever taken. Has a more natural appetite than for twenty years, and *is quite relieved of his habitual constipation.*

May 8th.—Reports himself "well;" no cough, respiration free and natural, all his bodily functions well performed.

Saw this patient six months later; no relapse.

Case IX.—Mrs. L. F. L——, aged forty-seven, married; one child, aged twenty. Family history shows rheumatism in her mother (arthritis, both subacute, and deformans), who is still living. Father dead. Brothers and sisters enjoy very fair health. Some twelve years ago had a miscarriage at three months, from which she made a poor recovery. Her account would indicate that the secundines were retained for several weeks, and finally expelled, with a spasmodic effort, and in a very fetid condition; pelvic cellulitis supervening and eventuating in chronic abscess (intra-pelvic), which four years ago found exit through a tortuous sinus and reached the surface in the right labia majora. Free incision was made, and the immediate or superficial abscess cavity was syringed repeatedly with tincture of iodine, carbolic acid, and glycerine. It healed, but soon filled again, and a careful exploration with flexible probe proved its origin to be as above stated, the seat of the original abscess being, apparently, in the vicinity of the right ovary.

During the past three years patient has suffered from lumbo-sacral neuralgia and wandering arthritic pains. Six months since her neuralgia culminated in a painful and disabling sciatica of the left side. After exhausting all the domestic remedies to be had or heard of, trying salicylates, manaca, lotions, and anodynes without limit, she came to me in sheer desperation. I found her anæmic, suffering paroxysms of excruciating pain, which extended from the hip to the ankle; bowels constipated and moved only by enemas, dysuria a frequent symptom, appetite wanting, and much gastric distress accompanying the process of digestion. Tonics, iron, stimulants, counter-irritation, the deep injection of chloroform, and in some of the worst paroxysms, of morphia and atropia, as also the constant current, were all thoroughly tried, and afforded some temporary relief. However, these remedies severely aggravated her stomach troubles, inducing intense cephalalgia and almost unendurable nausea; and on omitting them the paroxysms returned with even greater severity.

As a last resort I advised a persistent trial of the oxygen treatment; and for the purpose of making the test a thorough one, took the patient into my own family. Her complexion is quite sallow, and skin, especially on her hands, covered with patches of "salt rheum," which has persisted for thirty years. She suffers from periodic attacks of rheumatic headache, and her countenance is a petrified epitome of seriousness and distress.

February 1st.—Prepared a mixture of O two volumes, N_2O two volumes, and diluted this with twenty per cent. of common air. Of this, four full inspirations to be taken at 10 A.M. and the same on retiring. Lung capacity 100 cubic inches. The first few doses of the mixture produced such complete muscular relaxation and semi-insensibility that she sank helplessly to the floor unless supported; no unpleasant sensations or effects supervening.

February 10th.—Sciatica still recurs, but less frequently and with less severity.

February 20th.—Appetite improves; complexion a little clearer; no dysuria except after the use of anodynes; discharge from the abscess less profuse and less fetid. Patient very impatient, and not at all encouraged.

February 28th.—No further discharge from the abscess; digestion constantly improving; sciatica decidedly modified. Lung capacity 140 cubic inches.

March 5th.—Headaches less frequent and less severe; lameness almost wholly overcome; complexion rapidly improving. Patient eats, sleeps, and walks better, and shows a buoyancy of spirits unknown for years. Lung capacity 150 cubic inches. The treatment is continued with some interruptions, changing the proportions by adding twenty per cent. of common air and increasing to five full inspirations at each sitting, twice per diem.

March 12th.—Improvement steadily continues in all directions.

March 20th.—Is gaining flesh quite perceptibly, but *it is as much a gain of quality as quantity.* Paroxysms of

headache rare and light; sciatica persists, but is mild. "*Salt rheum*" *gone; skin smooth as a child's.*

April 1st.—She declares she is ready to "certify" to any kind of statement I may ask as to the efficacy of the oxygen treatment. Avers that it has made her "a new woman," etc. Wants to go home. I express my conviction that the treatment should be continued much longer to insure permanent results. She goes home, promising to return soon, especially if any old symptoms reappear.

April 24th.—Has worked considerably about the house and garden since last report. General health continues good, but sciatica returns in mild form. Again place her on four inspirations daily of equal volumes of O, N_2O, and common air. Lung capacity 200 cubic inches.

May 3d.—Steady improvement since last report. Sings with good voice, which she has not done for years; walks and rides without pain or extra fatigue; also does considerable light work about the house. Her complexion is now clear and fairly ruddy; headaches slight and infrequent. No sciatica, no eczema.

May 18th.—Treatment suspended. This patient has astonished her friends—*and her physician!*

September 15th.—Continues free from all her former complications, except occasional disturbances of a physiologically weak heart. Most of these are, however, attributable to her own indiscretion in the matter of active exertion. She has attended to active household duties ever since treatment was omitted.

APPENDIX.

In 1870, Dr. Andrew H. Smith read a paper on "Oxygen Gas as a Remedy in Disease," which was made the Prize Essay of the Alumni Association of the College of Physicians and Surgeons of New York, and was published in pamphlet form; later it was republished, with some additions, by the New York Oxygen Gas Company.

This paper escaped my notice at the time, and not until the present season (1884) has a copy come to hand; otherwise some apology would be due to Dr. Smith for an apparent neglect to recognize his very valuable and able résumé of the subject. In addition to his own unequivocal testimony, Dr. Smith cites many of the authorities quoted by me and also others whose reports had not come to my notice. But he seems to have used oxygen unmixed and unmodified, except by occasionally diluting it with atmospheric air.

As will be seen by reference to what I have written on the subject, I have constantly insisted that the proper modification and dilution of oxygen, when exhibited as a remedy, *is as essential as any other feature of the treatment.*

Nothing can be more thoroughly established, at least empirically, than the fact that while nitrogen monoxide is itself a therapeutic agent of decided value when used, properly diluted, by itself, it is fairly invaluable as a modifier, adjuvant, and synergist of pure oxygen. In addition to its own "tonic," "alterative," and soothing effects on the nervous, vaso-motor, and circulatory systems, it renders the oxygen with which it mingles *more assimilable*, and hence more promptly available in the general system.

The precise *rationale* or *modus operandi* of this important result it is yet impossible as well as unnecessary to discuss.

Compressed or condensed air is being tried as a diluent and modifier of oxygen. Dr. Younghusband, of Detroit, reports encouraging results from the use of this agent, and it may, in time, be found a valuable addition to our resources. The careful study of its capabilities opens an extensive and interesting field, and no resolute or persevering inquirer will be dismayed by the recent adverse report of Professor Germain Sée. His experiments are no more conclusive than have been those of some equally eminent investigators in connection with oxygen.

Under a certain degree of tension or condensation, it is at least presumable that the nitrogen and oxygen elements of common air assume new and unusual states, from a changed molecular arrangement. Further inquiry in this direction is desirable.

At Reichenhall, Germany, the condensed-air baths have been quite extensively used for some years, and the professional interest in them is steadily increasing. Dr. Von Liebig, son of the eminent chemist, has written a pamphlet on the subject, which does not accord with the unsatisfactory experiences of Professor Sée. However, it is noteworthy that the latter confines his observations to those maladies—chiefly cardiac complications—in which Dr. Von Liebig asserts that the condensed-air treatment is contra-indicated.

There are many morbid conditions, particularly visceral congestions and capillary engorgement, in which condensed air, either by inhalations or by general baths, is rationally indicated; for in addition to the marked impression which may be produced on the entire physical economy by a gradual but distinct change in the pressure of the surrounding media, as well as of the air inspired, it is evident that the system at the same time receives, and doubtless utilizes, an increased quantity of oxygen.

Therefore, while I appreciate the valuable work done and research made by Dr. Smith, he certainly fell short of the fullest measure of success by neglecting to make

use of any form of modifier or adjuvant with his oxygen, as well as by want of thoroughness and care in his method of evolving the gas.

Despite these serious drawbacks, this earnest and accomplished experimenter arrived at results which ought to have commanded more attention from the general profession.

I take pleasure in quoting some of his conclusions, which, from my own experience, I can fully corroborate. It is to be hoped Dr. Smith will not permit his Prize Essay to be the sum total of his contributions to the literature of pneumatic medicine.

"When we shall be able to regulate the proportion of oxygen in the atmosphere of the sick-room as easily as we now regulate the temperature; when closely packed and ill-ventilated tenements can be supplied with this element, the free enjoyment of which is necessary to health; when by its use the contamination of the atmosphere by the furnaces of factories and machine-shops shall be prevented or counteracted, who can tell what will be the sum total of the result? Yet all this seems now attainable whenever the public shall become sufficiently awake to its importance" (p. 9).

"Small quantities of oxygen inhaled daily frequently have the effect of stimulating the appetite to a remarkable degree. . . . That the increased amount of food is assimilated is shown by a corresponding gain in weight" (p. 20).

"The effects heretofore obtained have resulted from a hap-hazard use, such as in the case of any other remedy would have insured its total failure. Only when we learn to use it with the same discrimination and care that we exercise in the use of opium or strychina, shall we know the limit of its power for good" (p. 33).

"There is much to encourage the systematic use of oxygen in phthisis. Indeed, considering the extremely limited number of cases in which it has been thoroughly tried, and our ignorance as yet of its proper management, the results may well challenge comparison with those from any other mode of treatment" (p. 39).

"He [Trousseau], whose knowledge of therapeutics has rarely, if ever, been surpassed, speaks of having by its means in several instances '*recalled to life* women regarded as lost,' from great depression of the digestive powers consequent upon puerperal hemorrhage or excessive lactation" (p. 41).

Among the diseases named by Dr. Smith as having, on the authority of eminent observers, including Trousseau, Demarquay, Byfield, Goolden, Kollmann, Hooper, La Passe, Mackey, Beddoes, Ramskill, Birch, etc., been cured or greatly improved under oxygen treatment, I may mention *anæmia*, *asthma*, *Bright's disease*, *capillary bronchitis*, *consumption*, *croup*, *cardiac diseases*, *diabetes*, *diphtheria*, *epilepsy*, *emphysema*, *gout*, *neuralgia*, *pneumonia*, *poisoning* from chloroform, opium, chloral, etc., etc.

It has been tried in cholera, a few authorities reporting marked and immediate success, the majority, however, abandoning it. These failures are no more conclusive than the many failures reported in connection with other diseases in which other observers have achieved the most marked success. Hence no earnest experimenter need be discouraged by them.

It is not impossible that hydrophobia, hitherto considered intractable, will eventually be made to succumb to oxygen.

A correspondent of the *New York Herald* asserts that a discovery of a cure for the fearful malady (rabies) has been made in Russia, this remedy being pure oxygen. A little Russian girl was recently attacked by the disease, and the physician thereupon made her inhale three cubic feet of oxygen. In the course of an hour and a half all the symptoms disappeared, and the child remained calm. On the next day but one the malady returned in all its distressing characteristics. A fresh inhalation of oxygen was tried, and at the end of forty-five minutes the attack subsided and never returned.

A new method for obtaining oxygen cheaply is announced by M. Zenno. The full details are not given, but it is stated that the gas is obtained by the reaction of potassic permanganate and baric peroxide, placed together in water. These salts are cheap, and are said to yield two hundred centimetres of the gas for every gramme of the mixture. A cheap supply of oxygen would be more valuable to the world than the discovery of a score of silver mines.