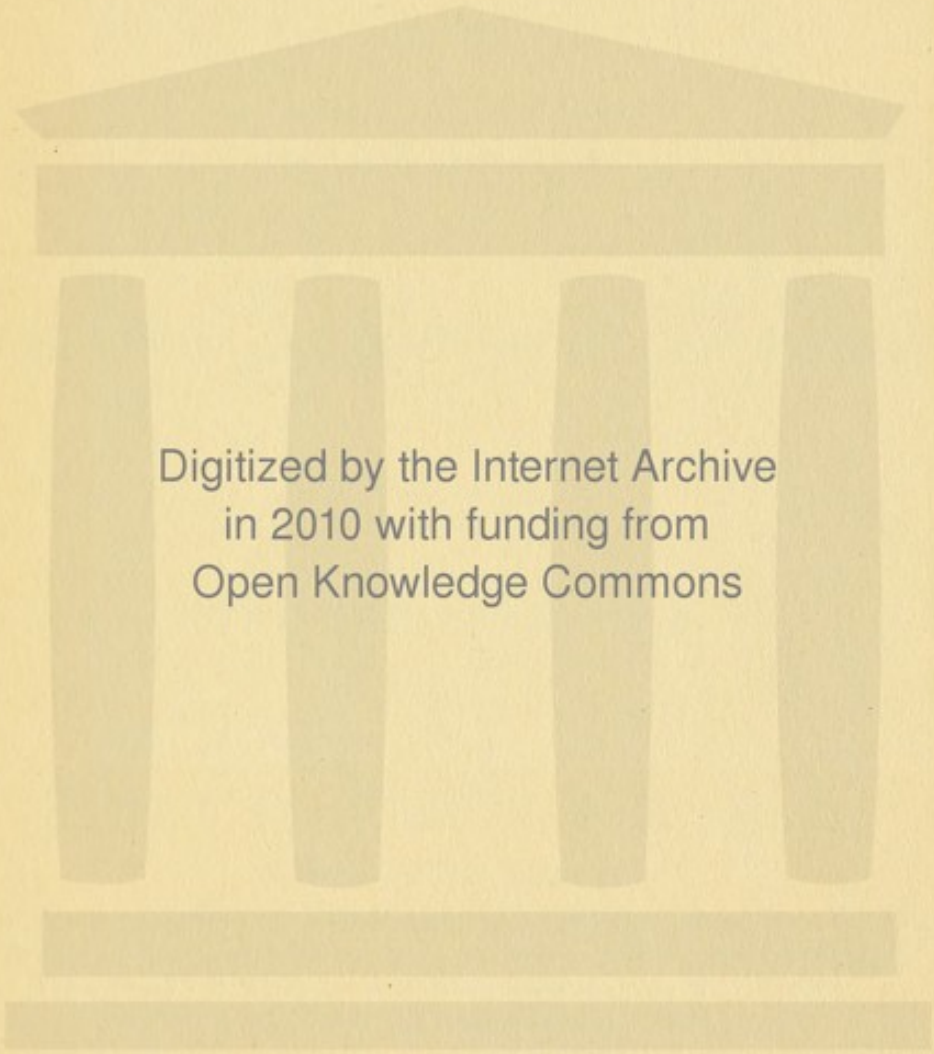
The recent advances of sanitary science : The relation of micro-organisms to disease.



THE RECENT ADVANCES OF SANITARY SCIENCE.

THE RELATION OF MICRO-ORGANISMS TO DISEASE.

ANNUAL ADDRESS

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BY

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PHILADELPHIA:

1883.

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The unexpected honor which one year ago your kind suffrages conferred upon me in electing me to preside over your councils, I hold to be equally shared by a thoughtful discharge of the duties of the office. The profession at large may be congratulated that the American Academy of Medicine owes its origin and existence to a wide-spread spontaneity of feeling that the times were ripe for and demanded some organized effort to aid as a controlling power in elevating the standard of medicine in our country. How well thus far we have succeeded must be left, not to our own prejudiced views, but rather to the unsparing criticisms of all interested in a higher medical education. Since, by our position, we have invited it, let it arouse each one of us to yet better endeavors in the discharge of our self-imposed task. He who studies the history of medicine in a broad philosophic spirit will learn much of both interest and profit. Viewed from this standpoint, its evolution in the present generation in common with its sister sciences, marks an era in civilization. Differences of opinion, even on the fundamental factors of our polity, have and very likely will continue to exist. Other things being equal, the better trained and armed soldiery win and hold the field. Whatsoever the diversity of gifts, the profession should be actuated by one spirit. Under its guidance, moved by a generous rivalry, the divine decree of the golden rule should be its only code. In the clear light of science rationalistic medicine can have no rivals, and the *isms* and *pathies*, which smack of ignorance and superstition, will cease to exist. New fields of investigation, yet more attractive, because nearer to the great source of truth, will open, and there will arise a more noble emulation for the still greater advancement of a united and harmonious profession.

A few weeks since, as I stood on the rock-bound coast of the Bay of Fundy, and beheld its insurging tides, rising more than half a hundred feet, converting empty gorges into deep rivers, and wide-spreading meadows into broad bays, I read in this mighty unseen

force the symbol of the progress of our age. The quiet waters of the harbor of Louisburg, whose blue expanse covers the wrecks of the French and the English armadas of a past century, at whose stormy burial sank the hopes of nations who would fain have founded in a new world empires based upon the aggrandizing ambitions of kings and clergy, gave no hint, save in the mournful desolation of its shores, of a fatal policy which so long dominated the ages of the past. In the busy subdivided occupation of happy peoples, each individual adding to the common store of good, national interests interwoven in one grand commonalty by the iron bands of commerce, we mark the monuments of our age, in the elevating of the masses to a higher plane of intellectual and moral development than the world has ever seen.

In the proud contemplation of such progress, the thought arises, have the science and art of medicine grown in ratio with the general development of the age? To discuss a question of such magnitude in the short hour at my disposal would provoke a smile. And yet, stimulated by the belief that, although proud of present progress, we are on the eve of far greater discoveries and clearer knowledge, we would counsel and urge upon the Academy the greatest devotion and most enthusiastic zeal in elevating the standard of medical education.

The late lamented Dr. Edward H. Clarke, of Boston, whose memory is enshrined in the loving remembrance of many classes of pupils, divided the teachings upon materia medica into a course for two years, one devoted entirely to the *circumfusa* of the patient, and one to the *medicines* which might be administered. In a somewhat similar spirit I would divide the duties of our profession, and would place first the prevention rather than the cure of disease.

Sanitation can hardly be called a science. Many of its most important factors are, at the best, but imperfectly understood. The sanitary laws instituted by Moses are based upon principles which cannot be under-estimated or ignored, and the Egyptians for centuries previous had understood some sanitary questions and their solution better than ourselves. The traveler to-day may see in the elegant courts of the old Pompeian houses the marble basins, with their leaden pipes and stop-cocks still seemingly ready to turn the treasured waters of the distant mountain into their old, time-accustomed channels, alike to bath and fountain, and go again singing in joyous cadence, ministering to need and pleasure as they found their way through the once busy city to the bay below. Our

modern system of water carriage to remove sewage is but the adaptation of means to ends well recognized by the ancients, and it would to-day be difficult to find a better specimen of sewer or masonry than the Cloaca Maxima of old Rome.

That age of Grecian prosperity and extraordinary intellectual activity, which gave to the world Pericles, Sophocles, Aristophanes, Pindar, Plato, Xenophon and Socrates, also furnished Hippocrates, the father of medicine. He it was who formulated the fundamental principles of sanitary science, "Pure air, pure water, and a pure soil." The little island of Cos was his home, and here was located one of the most celebrated temples of the Asclepiadæ, or priest physicians of the Greeks. If Hippocrates, living upon this pearl of the Ægean archipelago, whose leafy groves were musical in the evenly-tempered, balmy breezes which ever played in health-giving zephyrs, whose gentle rills were fed from springs gushing forth the distilled dews of heaven, whose verdant slopes, basking in the clear, warm sunlight, were kissed by the deep blue waves of the Mediterranean, the very place of ideal purity and loveliness, recognized the importance of such maxims, what should be their value to the multitudes crowded, at the behest of commerce, in localities selected without thought of sanitary surroundings?

The discussion of the problems of life, and the important factorage of ills thereto belonging, by the wise and thoughtful of the ages long ago, is not alone instructive, but has a fascination of its own. Whatever else may be said of Mohammedism as a code of morals and virtue, its cardinal principles of cleanliness and careful living deserve special recognition at the hands of science. The great plagues of the Middle Ages and the desolations following the Crusades which swept over Europe, were filth diseases of a preventable character. Although spurred into recognition by the bitter experiences of the passing generations, sanitary science is yet under only partial recognition of the laws, and a popular interest is scarcely aroused, even among our more intelligent classes of citizens.

The vital processes, in their sway over matter, hold the balancing between waste and repair. This hypothetical equilibrium is perhaps the best definition of health, and the safe removal of the waste, worn-out material, is one of the chief factors of sanitary science. This, to the individual as ordinarily situated, might seem a question for easy solution. In the wide stretches of country surroundings, although there are many exceptions, this is generally true, but in the crowded

conditions of city life there is no problem more pressing or complex. The law of decomposition is *vital* rather than chemical, and in the changes which ensue there are reproduced, in the most marvelous abundance, lower forms of microscopic vegetable life, which in their death-dealing danger are far more potent than the evolution of noxious gases. The relation between the house we occupy, its location and surroundings, its water supply and the best means of removal of waste, are as yet but imperfectly understood. The local causes in the production of disease are occupying in a greater degree at present than ever before the best scientists of the medical profession. Although many vital points are yet undetermined, great progress has been and is being made. It is sufficiently established that the water drank which is contaminated with the specific infection of cholera, typhoid fever, and other diarrhœal diseases, will, at least in certain conditions of the system, reproduce these diseases, and if these conditions are wide-spread an epidemic will ensue. A similar law holds good in reference to malarial or intermittent fever, although it is very probable the sources of contamination are not confined to the water supply alone. Heat, moisture, and the resulting decomposition are the seeming gross factors, but it is quite certain that minute living organisms introduced into the system are the potent factors in the production of these diseases.

The condition which this age of steam brings, with its modern miracle of civilization, massing the population in great centres, gives new sanitary problems of a very difficult and complex character.

Surrounded by a media from which there is even momentarily no escape, and which we must ever breathe, atmospheric impurities must be considered as of the highest importance. The air has no absolutely fixed normal composition; however, its two essential elements, oxygen and nitrogen, under ordinary circumstances, are so nearly invariable they may be regarded as stable factors. Although, in a simple mechanical mixture, the air is very rarely free from carbonic acid and water, yet carbonic acid, so far as known, is a harmless, but superfluous agent to the animal economy, while, on the contrary, to the vegetable world it is food of the most important character. Some plants go through their entire period of evolution dependent only upon this element and water.

The mechanical admixture of water in the form of vapor is a constantly varying factor, dependent upon location, climate, temper-

ature, etc., and, although rarely entirely absent, is of itself an element comparatively unimportant, but, combined with other factors, it makes possible the development of lower forms of the vegetable organisms, to which we are now warranted in ascribing some of the most dangerous and wide-spread diseases of the entire animal kingdom. In its indirect bearings upon climatology, influence upon heat, etc., atmospheric moisture is of the first importance.

In the analysis of air, ozone, from its admitted powers, especially in its bearing upon climate and health, should be carefully considered. It is an allotropic form of oxygen which has attained new properties, of an intensely active character, supposed to have been chiefly produced by the action of electricity. Its molecular weight is 48, oxygen 32, and its density is about one and one-half times greater than oxygen. According to Houzeau, the maximum quantity of ozone in the air never exceeds $\frac{1}{700000}$ part of its bulk, and it is often entirely wanting. More ozone is found during the night than the day; in winter than in summer; upon high rather than low lands; in country than in town; and most of all, after a severe thunderstorm.

Ozone owes its great value as a disinfecting agent to its exceedingly powerful oxidizing qualities. The compounds of ammonia, phosphorus and sulphur are acted upon with great rapidity, and the odors resulting from animal decomposition are removed instantly. It is probably destructive to all the minute vegetable organisms when in active development, but its effect in destroying the vitality of the spores of plants has not yet been determined.

From the exceedingly active properties of ozone in destroying the low forms of vegetable organisms, and consequent prevention of putrefaction, as well as the induction of catarrhal affections, when experimented with artificially, the important query of its value as a factor of atmospheric composition, and its relationship, if any, to epidemic diseases, has arisen. A committee of the American Medical Association, under the efficient leadership of Dr. N. S. Davis, of Chicago, during the last three years has been doing a considerable amount of work in the solution of this important, but complex problem. Under their direction, careful tests to determine the amount of ozone in the atmosphere are daily made in a number of our large cities, in which localities, clinical records are taken by a number of independent observers, to ascertain the initial date of

acute diseases. Reports of progress have been made, but sufficient data have not been secured to warrant any general conclusions. The committee desire a wider interest and assistance in the further accomplishment of a work which promises to be of great value.

[1] "There is much evidence in favor of adopting the analysis for oxygen, instead of that of carbonic acid, as a test of atmospheric purity; the test would be an absolute one, if we could be sure of the uniformity of the proportion of oxygen in pure air. Taking this, as we probably may, for granted, we can say that the carbonic acid, in most cases, increases directly at the expense of the oxygen of the air, and therefore a diminution of oxygen points logically to an increase of carbonic acid. There is this disadvantage in taking the oxygen test, it removes from view the accidental impurities, such as the discharges from chimneys, which are certainly important."

Carbonic acid is a product of combustion, and in its formation represents in nearly fixed ratio the destruction of oxygen. The entire animal kingdom is constantly consuming oxygen and emitting carbonic acid, and atmospheric conditions dangerous to life would ensue, were it not for the equilibrium maintained by the consumption of carbonic acid and generation of oxygen by vegetable growth. Owing to the remarkable diffusion of gases, the wind currents, etc., the immense amount of carbonic acid poured out into the air as the product of combustion never produces atmospheric changes in any marked degree. It is estimated by Smith that in Manchester, from this source alone, over fifteen tons of carbonic acid are produced daily, and yet, when this is added to the product of respiration and animal waste, he found the entire quantity was not sufficient to raise the average percentage above four parts in ten thousand, which is within the so-called normal limits of a number of investigators. The decided increase of carbonic acid in cities is due mainly to the confinement of air in courts and alleys, and the sanitary lesson should be, the construction of wide streets, with open courts or squares.

Too much importance has been placed upon carbonic acid as a deleterious constituent of the atmosphere. Very little, if any, annoyance is felt from the accidental escape of pure carbonic acid in the charging of soda fountains, although the air may contain two per cent. of the gas. Förster states that he had no difficulty in

[1] "The Atmosphere." By D. F. Lincoln, M. D., Ziemssen's Cyclopædia, Vol. xviii, page 605.

remaining ten minutes in a cellar containing fermenting wine, although the carbonic acid gas amounted to forty parts per thousand.

There is a vast difference when the oxygen is lessened in proportion as the carbonic acid is increased, as, for example, the entering of a chamber where candles are burnt until extinguished for want of oxygen; or again, where the carbonic acid is produced by respiration. The presence of this gas in living-rooms in any appreciable quantity is of first importance, not so much as a deleterious chemical agent, as because of the bad company in which it is found, and the presence of which it indicates. One serious objection to the numerous gas-jets of the brilliantly lighted salon and audience room is found in the fact that the ordinary burner consumes as much oxygen as four persons. From a sanitary standpoint, lighting our homes by electricity will be a great gain, and this evil obviated. One large room in a Lowell mill, lighted by four hundred gas burners, had been ever a source of complaint in its defective ventilation and great heat. Lighted by electricity, the change was surprising, while the difference in temperature was over twenty degrees.

Products of decomposition from cess-pools, the organic exhalations from respiration, the lessening of oxygen from the combustion which is going on in the brilliantly lighted rooms, all these are dangerously infective and devitalizing elements which demand a system of ventilation usually ignored in modern house-construction.

From the address upon State Medicine before the American Medical Association at St. Paul, 1882, by Dr. Gihon, Medical Director, U. S. N., I quote, all too briefly, "So long, however, as society, in its highest development of rank and culture, ignorantly jostles and wedges itself in contracted parlors and drawing-rooms, already defiled by blazing gas-jets and defective furnaces, where hundreds of lavishly dressed human machines befoul the air and poison one another with the noxious gases and their own effete animal products in deadlier quantity than the ragged rabble which herd in the open street, and call this pleasure; so long as godly people drowse and yawn in badly ventilated churches, surcharging their brains and impairing their minds with blood not half aerated, and ungodly ones exhaust their whole reserve force to resist the insanitary influence of the no less badly ventilated theatre and exhibition hall, and call the one pious worship and the other rational amusement; so long as men toil to amass riches and then

build residences palatial, or sham palatial, and in the name of luxury and æstheticism flood them with artificial light and heat to consume the oxygen which prince and beggar must breathe, and admit the invisible filth by the sumptuously decorated closet and bathroom by which they think to exclude the vile necessities of humanity which prince and beggar alike cannot escape, and call this comfort and refinement; so long as our children are sent to overcrowded and unwholesome schools, where their eyes are bleared, their hearing dulled, their plastic bodies distorted and their brains fuddled, and call this education; so long as men and women violate daily in themselves and in their children the simplest precepts of hygiene, parents countenancing half-dressed daughters wearing out their strength in unwholesome ball-rooms, seeking their slumber that cannot refresh only when dawn appears; sons launched upon the world to encounter physical wreck in a thousand channels where no beacon warns of danger; old men, senators, judges, divines, perchance learned doctors, uncomplainingly breathing the foul air of public conveyances and apartments in which every door and window have been carefully closed and ventilator carelessly ignored; streets reeking with filth which decrepid laborers play the farce of sweeping in broad daylight; what can State Medicine hope to accomplish in legislative chambers and halls of Congress which are themselves *even* evidences of sanitary ignorance, sanitary neglect and sanitary indifference?"

The foreign ingredients of the atmosphere are very various; as dust they are carried great distances by the wind and deposited often hundreds of miles from their source. African organisms have been found in the air of Berlin. It is often difficult to obtain air free from the pulverulent debris of vegetation, and both vegetable and animal organisms abound. From the vegetable kingdom come pollen, vegetable hairs, fibres, scales, cells, seed capsules, etc., also spores of fungi and various forms of bacterial growths in marvelous abundance. In the air of living-rooms we may find portions of food, animal and vegetable fibres, pus globules, fatty crystals, scaly epithelium, and a number of the micro-organisms.

[1] Dr. Sternberg, in his Report to the National Board of Health, says: "The fact, observed by myself, that during the summer months the mud in the gutters of New Orleans possesses an extraordinary degree of virulence, shows that pathogenic varieties of

[1] Special Report to National Board of Health. April 30, 1881.

bacteria are not alone bred in the bodies of living animals. The more I study this subject the more probable it seems to me that in this direction lies the explanation of many problems which have puzzled epidemiologists, and that the sanitarians are right in fighting against filth as a prime factor in the production of epidemics; a factor of which the *rôle* is easily understood, if this view is correct. The presence of septic organisms, possessing different degrees of virulence, depending upon the abundance and kind of pabulum furnished them, and upon meteorological conditions more or less favorable, produces, in my opinion, the *epidemic constitution of the atmosphere,* which wise men were wont to speak of a few years ago as a cloak for ignorance. It must be remembered that the gutter mud of to-day, with its deadly septic organisms, is the dust of to-morrow, which, in respiration, is deposited upon the mucous membrane of the respiratory passages of those who breathe the air loaded with it."

The spores of certain forms of these lower orders of vegetation have a remarkable vitality. They are of extreme minuteness, often less than a two hundred thousandth of an inch in diameter and have resisted a dry heat quite above boiling water. Tyndall was the first to make popular the test of a beam of light through the air as one of the best to show the presence of minute particles. Indeed, it is only owing to these particles that the beam of light is revealed, for in purified air it ceases to be visible, and air thus purified no longer possesses the power of exciting putrefaction in albuminous fluids previously sterilized. From the almost universal presence of these minute forms of micro-organisms and their difficulty of exclusion arose the belief in spontaneous generation. Owing to a better knowledge of these organic constituents ever present in confined spaces and the dangers therefrom to wounds, has arisen the revolution in surgery during the last decade.

By a slower process, because beset with far greater complications and difficulties, there is being surely evolved the so-called germ theory of disease which, although not dependent upon the atmosphere alone for the spread of contagion, is the more usual medium for the dissemination of infection. The organic matter exhaled from the lungs is molecular and is disseminated by atmospheric currents. The odor from the decomposition of these organic elements is generally perceptible when the carbonic acid reaches seven parts in ten thousand, and is strong when it amounts to ten

parts. The microscopic examination of these exhalations into the air of crowded rooms, when condensed with the vapors upon the cold glass of the window, often shows them to be undergoing decomposition, in the process of which are developed confervoid growths intermingled with myriads of bacteria and micrococci. One danger from tuberculous patients may be found in the careless disposition of the sputum. This not seldom falls to the ground, is pulverized and distributed as dust. In respiration of the atmosphere thus infected, the bacilli are lodged upon the mucous membrane of the lungs. In the laborious researches recently published of M. Vignal, of Paris, upon the bacillus of tubercle, he dried in a flat receptacle some sputum containing bacilli; this he afterwards pulverized, then moistened and subsequently dried. The specimen was in this way moistened and dried eight times, and the bacilli were as abundant as in the fresh sputum.

Owing to the multiplicity of agents and causes rendering air impure, its analysis has, as a rule, been very uncertain and unsatisfactory. The term albuminoid ammonia, much used in the analysis of air as well as of water, has usually represented a whole series of unknown factors. Like amaurosis of the eye by the older writers, it gave a learned phraseology to ignorance and disfigured science, much in keeping with the making of the geographical map of our boyhood, where the vast unexplored region of the territories this side of the Rocky Mountains was called the Great American Desert.

It was first noticed by Gay Lussac that all the nitrogen of organic matter, when heated with caustic hydrates, appeared as ammonia. Albuminoid compounds, when disorganized by the growth of the lower forms of organisms, set free ammonia, and the quantity of the free ammonia may, in a general way, serve as a standard to indicate the amount of decomposition which *has* taken place.

The term albuminoid ammonia, on the contrary, stands for the quantity of nitrogenous material in air or water which *may* serve as food for the growth of these infinitesimal organisms. This as yet undecomposed organic matter is not by any means in itself necessarily hurtful, although always objectionable. Combined with moisture at ordinary temperatures, it furnishes the condition for bacterial growth and may prove sufficient for the development and spread of an epidemic of some one of the class of contagious diseases. We can have no *chemical* test for discriminating between hurtful

and harmless organic matter, since the poisonous infection is *vital*, and where found must ever be looked upon with suspicion.

I take great pleasure in referring to the microscopic investigations of atmospheric impurities by Surgeon J. H. Kidder, U. S. N., Washington, published in the Report of the Surgeon General, U. S. N., 1880, and continued in report for 1881, by Passed Assistant Surgeon T. H. Streets.

The material for examination was collected by the use of a funnel-shaped instrument connected to a winged vane, causing the opening to face the air current, which is made to impinge upon a slide placed horizontally, a portion of which has been moistened in glycerine. In out-of-doors air thus collected and examined, he enumerates the following substances as the most important :—

"1. Epithelium from the skin and mucous membranes.
2. Vegetable epithelium and unrecognized debris.
3. Hairs and threads of various fabrics.
4. Particles of sand, glass, metals, soot and starch.
5. Parts of the chitinous shells of small insects.
6. Bits of feathers and the pappous bristles of composite plants.
7. Minute, highly refracting dots, simulating *micrococcus*.
8. Crystals of various forms and sizes.
9. Pollen spores of many different kinds.
10. Leaf hairs.
11. Mycelium and spores of fungi.
12. Nucleated cells resembling leucocytes.
13. Bacteria, as *bacterium*, *vibrio*, *bacillus* and *micrococcus*, and under the forms of aggregation known as *zöoglœa*, "swarms," *leptothrix* and *torula*."

Dust collected dry, by simple exposure of slips and disks to the air, contained sand, soot, etc., and numerous crystals, mostly rods and radiating needles. And, finally, the disks and tubes containing collections made in hospital wards abounded in epithelium, starch, cells resembling leucocytes, and threads and hairs. Epithelium, as appears from the foregoing summary, is always and everywhere present in the air. Considering the probability of the communication of contagious exanthemata by this mode, the constant presence of epithelium in the air becomes a fact of considerable hygienic importance. Minute, highly-refracting dots, very numerous in winter dust, are likely to be mistaken for *micrococcus*, especially when mounted in fluid and agitated by the Brownian movement.

"They are usually the most minute parts of coal ashes, and may be distinguished from organic forms by the fact that they are not affected by strong sulphuric acid. * * * After a long series of observations I am, however, constrained to believe that there is no absolute reliance to be placed upon identity or similarity of form in the recognition of crystals occurring in dilute solutions."

In the sanitary investigations of Dr. Streets, the cultivation of the organisms of atmospheric dust gave most interesting results. The rare form of *bacillus ruber* accidentally appeared in some of the culture tests and was made the subject of a number of laboratory studies, and from their cultivation the air of the laboratory became so completely infected with them that unless extraordinary care was exercised they appeared as a pervading element in all cultures.

From my own laboratory studies I have been made aware of the great difficulty in excluding germs during the manipulation of sterilized nutrient fluids. To the special student, Dr. Street's observations are of great interest. I cannot forbear quoting concerning his growing the bacillus ruber upon rice under a bell jar in a darkened room. "Whenever the bell glass was removed the nostrils were greeted by an agreeable odor of apples; several persons noticed it. * * * The bacillus (Beck's No. 10 immersion) was shown to be in single rods or two joined together, rarely four or more united. Each rod enclosed two brightly refracting granules usually one at either end. The movement of the rods was active and perpendicular to the stratum of liquid in which they swam; moving points only were seen coming apparently in contact with the thin glass cover; as their motion became less active the rods floated horizontally in the liquid."

A proper discussion of the impurities in water would far exceed the limits of this entire paper. Chemically pure drinking water is neither necessary nor wholesome. Soaking into the earth, certain mineral constituents must be present in varying quantity. These have long been recognized and may be easily determined. In all natural waters there is more or less organic matter in solution. This is reduced to the minimum in the supply from springs and deep wells properly protected. Organic material may not be injurious, dependent upon its character; dissolved vegetable material may deeply color the water, or the low form of algæ give it a very disagreeable taste without being especially harmful; on the contrary clear, sparkling, tasteless water may contain impurities in the

highest degree dangerous. Water containing albuminoids in solution, if allowed to become standing, is sure to undergo deleterious changes, from its infection by the ever present atmospheric germs which utilize these products as food and reproduce in numbers utterly beyond conception. It is owing to such infection that the water drainage from swamps and marshes, especially in hot climates, has ever been a prolific source of intestinal disease.

As in the discussion of atmospheric impurities, we found the ever-present moisture an important factor, so in the treating of the water supply, soil pollution must be necessarily therewith taken into consideration. In this relation no question is more important than the power of the soil to purify water by filtration and the retention therein of injurious products. The albuminoid compounds may here be utilized as food for the higher order of plants, and thus be extracted from the aqueous solution. Under the influence of sunlight oxidation destroys many of the lower growths, and air and water both thus become purified. It has long been recognized that certain soils in time lose their ability to filter out the impurities from polluted waters. Many cases of disease and even epidemics have been traced directly to the use of water containing sewage that had passed a greater or less distance through the soil. It is apparent that this danger has been greatly underestimated by all classes. The specific contamination of the ground water and thereby of the supply for household use, is the more common and wide-spread source of certain of our most dangerous diseases, the example of which best known is typhoid fever. It is also an established fact that the air which everywhere permeates all soils to the ground water, moves in consonance with every barometric change of the outer atmosphere; these air currents, also modified by heat, are of importance from a sanitary standpoint. Every vault, every cesspool, is a source of pollution, and these subsoil air currents are drawn into our cellars from all directions when they are used as is the custom of most of our northern cities, as the source from which the heat in winter is distributed through the house.

The National Board of Health instituted a very elaborate series of investigations in order to determine the extent to which different soils are able to filter the injurious properties out of the air passing through them. The most interesting report upon the relation of soils to health, by Profs. Smyth and Pumpelly can here only be referred to. Their conclusions show the utter worthlessness of sand

as a filter for germinal matter. Our government in no wiser way could aid in the general well being of her citizens than by the continuation of such investigations.

"The facts here brought out seem to us of importance considered with reference to the sources of supply of our drinking waters; the relative location of wells, cess-pools, etc., in our towns; and also with reference to the methods of removal of excreta, especially during the prevalence of an infectious disease, the infectious materials of which may be communicated through water. A good bed of sand has commonly been regarded as one of the most efficacious forms of filters, amply protecting our well water against all contamination, even though the wells be sunk at no remote distance from sewers, cess-pools, cemeteries, etc. But we see that sand utterly fails to remove germs of putrefaction, such as are normally found in the air and in water, while its power of absorbing dissolved matter, organic or inorganic, must also be seriously questioned.[1]"

The subject of germ transmission through the soils demands on the part of sanitarians the most searching investigation, not only on account of the possibility of contamination of our drinking waters, through infiltration of germs, but also because the air, especially in our dwellings, may become infected if the soils in their natural condition possess no power of retaining germs or their adult organisms. For whenever in an infected soil the ground water from any cause rises to the surface, germs may be carried with it, and upon drying be taken up by the atmosphere.

The importance of a supply of pure drinking water cannot be over-estimated, and its pollution is in a very large degree due to germ contamination. This is no exception, even in sparsely settled country districts. In New England, almost entirely exempt from malaria, the danger from specific contamination of the drinking water is shown in the marked increase of typhoid fever. In Massachusetts alone there occurred, from 1840 to 1880, 390,000 cases of typhoid fever and 40,000 deaths.

In the military service, during the late bloody contest between the States, zymotic diseases caused a larger number of deaths than resulted from all the battles of the entire war. We quote from the report of the Surgeon General: "The entire number killed in battle and died as the result of wounds was 93,443; died from dis-

[1] Supplement No. 13, National Board of Health Bulletin, p. 18.

ease, 186,216; died from zymotic diseases alone, 108,666." If to these hecatombs of victims sacrificed in the vigor of early manhood, we add the suffering represented by over 1,700,000 reported cases of diarrhœa and dysentery, and 1,100,000 cases of malarial fever, every village and hamlet of our broad domain still having its representatives of wrecked humanity from these causes, we gain some idea of the dangers resulting from insanitary conditions, although our armies were in service in a mild climate, and the best clothed, fed and housed soldiery the world has ever seen.

The number of deaths in the United States during 1880 from diphtheria alone, was 38,398, a proportion of 51.33 per 1000. From typhoid fever there occurred 22,905 deaths, a proportion of 31.21 per 1000.

These terrible scourges, like consumption, are the messengers of death which make their daily visitations, and to which people have become so accustomed as to regard their ravages as the inevitable, or, as the clergy have been wont to express it, "the hand of divine Providence laid heavily upon us." The medical profession talk learnedly of the wise means adapted to the cure. Different schools of pharmacists have their vaunted remedies; but the sad, humiliating lesson of the mortality tables teaches that these invisible monsters are stalking broadcast over the land, seizing prince and beggar alike in their remorseless grasp.

Since the history of man, the wise of all generations have sought for the cause of disease, yet it would appear that the key to many of these labyrinthian mysteries has been reserved as one of the triumphs of science for the latter part of the nineteenth century. It is now generally conceded that the danger to wounds is a particulate organic infection, which, like the virus of inoculation or vaccine, germinates, and induces systemic poisoning. The whole subject of modern wound treatment is based upon the recognition of this ever threatening danger, and securing the best means of its avoidance. This recent recognition of the dangers from the simplest form of microscopic vegetable growth, has evoked the important question of the means best adapted for their destruction. Extremes of heat and cold are by far the most universal, and are the wise measures which nature has adopted as limitations to their development. For a long time carbolic acid has been the surgeon's *sine qua non*, and the agent most trusted for the disinfection of the sick-room. A long series of careful laboratory investigations conducted under my

supervision have given results not unlike those of Koch and Sternberg, and place the bichloride of mercury preëminently at the head of the list of germicides.[1] The solution of one part to 2000 is as trustworthy as the 1 to 20 of carbolic acid. Properly marked, to guard against danger, such a solution may be wisely brought into requisition in every household. Under the light of its new values, preparations of mercury in certain diseases are likely to be restored to their old time professional confidences, and teach that the clinical deductions of the fathers were not without foundation in fact.

The first of the diseases, and the one the clear history of which is perhaps the best known, is anthrax, or malignant pustule. Here the rôle of specific micro-organisms as cause and effect has been conceded. No more interesting subject could command attention than the analysis in detail of the entire group of zymotic diseases In a purely conservative sense, it is not too much to claim, that it may be shown that each of these affections has its probable origin from, and owes its dissemination to, a *contagium vivum* of a definite, particulate character. We do not, however, intend by this to convey the meaning that our knowledge, as yet, if ever, will enable us to differentiate each individual factor. In the light of recent astonishing discoveries, no wise man would prognosticate a limit to our future knowledge in this direction. Certainly, the greatest progress in medicine since the days of the fathers is this pertaining to the causes of disease. It is not too much to predicate as possible, or even probable, that the medical art, in the near future, will hold control over the entire class of zymotic diseases as effectually as vaccine has controlled and relegated to an almost hypothetical danger the terrible scourge of smallpox, which ravaged humanity during the many centuries of the historic past.

The laborious researches of our distinguished friend, Dr. Henry I. Bowditch, in establishing the relation of soil moisture to consumption, builded for himself a monument more grand and enduring than granite or bronze. The ineffable something, the existence of which he was equally sure, remained for younger eyes to discover, and the patient, pains-taking labors of the well trained German student to demonstrate the specific bacillus tuberculosis.

It is very probable no publication of modern time has awakened so much discussion or caused the undertaking of so great an amount

[1] See *American Medical Association Journal*, August, 1883—"Germicides and Their Relative Values."

of study and investigation. Dr. H. C. Ernst, of Boston, read an exhaustive paper, upon this subject, in part a contribution of laboratory work, before the Massachusetts Medical Society in June last. He made a table of references to fifty publications upon this subject, and I am quite sure I have seen nearly one-quarter as many more articles published since this date worthy of reference. Dr. Ernst's conclusions are as follows:—

"I. A staff-shaped micro-organism exists in all forms of the tuberculous process, and its presence has been demonstrated in them.

"II. It is more abundant in the rapid than in the slow form of the process.

"III. Its specific nature as the cause of tuberculosis is claimed by Koch on the ground of his observation.

"IV. Its specific character has not been successfully refuted by trustworthy observations.

"V. Its value as diagnostic evidence of tuberculosis is very great, although its absence cannot be considered as excluding that process."

The latest novelty in the germ theory of disease is found in the ingenious exposition of the yeast fungus as the cause of diabetes, by Prof. Ekland, of Stockholm.[1] It is offered as theory rather than demonstration, and yet the array of facts brought to support this explanation, if not conclusive, throws at least new light upon this disease, which has ever been considered a dark enigma.

Dr. Hassall communicated a paper upon the development of Torulæ in Urine to the Royal Medical and Chirurgical Society of London, in 1853, in which he arrived at the conclusion that there is a species of fungus which is developed in urine containing even minute traces of sugar, which may be considered characteristic, since it occurs in no other condition of the urine. Dr. Beale[2] says: "This is the sugar fungus. But neither the character nor the occurrence of the fungus are sufficiently constant to enable us to accept implicitly Dr. Hassall's conclusions as to its value as a test for the presence of sugar. The sugar fungus which grows in diabetic urine is identical with the yeast plant." From the above it would appear that both Drs. Hassall and Beale believed these organisms developed only after the exposure of the urine to the atmosphere.

In the archæological museum in Cambridge may be seen whole series of adult skulls from certain of the prehistoric races of South

[1] *N. Y. Medical Journal*, July 28, 1882.

[2] "Kidney Diseases and Urinary Deposits." Third edition, 1870, p. 393.

America with perfect teeth. The mouths so well furnished are alas closed to our interrogatories of the why. The last generation of Americans, living upon hot bread and fried meats, might have been described as a teeth-aching race. Our native genius, rising to the necessity of a *felt* want, evolved a new profession, earlier called the Dentist, now the dental and oral surgeon, and the present generation may be styled a teeth-preserving and teeth-manufacturing people. An army of seventeen thousand trained specialists are busily engaged, at an estimated annual cost, in the United States alone, of from forty to fifty millions of dollars. In the highest consideration this is a very imperfect compensation for the damage done these comparatively minor members of the body by the ever-present micro-organisms which riot in this usually filthy cavity. An antiseptically clean mouth and our dentists would become rivals of the historic Micawber, and dyspepsia be placed at the bottom of the lists of diseases.

A blind man, no matter how well armed and how active, is a dangerous ally; his blows may fall equally upon friend and foe. How can one who is blind as to causation direct as to the prevention of disease?

The fundamental basis of all sanitary law, and I may also say of the treatment of disease, lies in the acquisition of such causative knowledge. The application of sanitary law to city life must demand an atmosphere reasonably free from the defilement of organic waste. This necessitates a system of sewerage which shall continue from the house in a steady, unbroken current to its discharge at a safe distance from habitation. This current should be of sufficient rapidity to prevent sedimentation, and deliver the house products before time sufficient for putrefaction, even in summer, has elapsed. This can never happen in the systems now in use in those cities situated upon the sea shore, since here the sewers are practically tide-locked a large fraction of the day, and a cessation of current with sewerage deposit must ensue, while a backward pressure is necessarily produced upon the sewer air which, loaded with organic products, must escape into the house through any one of the water traps now in use.

Sewer-gas poisoning, which means air changed not so much in its chemical constituents as defiled by organic impurities, is thus by no means, in our best constructed houses, a hypothetical danger, here often the greater, for the costly luxuries of water-closets and basins

are each a standing menace, and are to be regarded with suspicion. Boston, which has and yet continues to drain into its Back-Bay and harbor its sewerage, by more than fifty outlets, is upon the eve of inaugurating its new system at an expense of nearly $5,000,000, by which the sewerage is to be pumped into a storage reservoir situated upon Moon Island and discharged into the out-going tide, and thus protect the harbor from defilement by sewer drainage.

The wise political economist and world-renowned historian, Mr. George Bancroft, in discussing the future of civilization, once said to me: "I look upon New York city as the future commercial metropolis of the world, a great centre of ten or fifteen millions of inhabitants." This prophecy of years ago has gone on toward a steady fulfillment, until, like London, she exacts tribute from the entire world. Situated upon a narrow neck of land between a mighty river and a deep bay, it would seem that good soil drainage would be most easily secured; and yet her sanitary authorities state that the imperfect, incomplete, and broken sewers have caused the soil of whole districts to become so charged with sewage that the saturation point is reached. Nearly four millions of people pour their waste into the river and harbor, as is most convenient, while miles of her shores are fringed with wooden wharves built upon piles, not alone themselves undergoing decay, but a fertile source of detention of putrefying material. The New York physician will tell you that, no matter what disease he has under treatment, the added factor of malaria from such defilement must be taken into consideration. Rich and poor must alike suffer from such danger, and if the prophecy of America's distinguished scholar is to be fulfilled, New York must take her sewage out of the harbor, and rival London and Liverpool with docks of solid granite for the merchandise of the globe.

The water supply must ever be pure and ample. The extraordinary expenditure necessitated by most cities has made water a costly product. Rivers and lakes in sufficient proximity for such use are liable to defilement from suburban towns and manufactories, and only by the greatest vigilance can pollution be prevented. Boston has freely expended her millions upon a water supply confessedly inadequate in amount, and of a character which is a constantly recurring source of complaint and danger. Much of her water supply is retained in artificial, shallow storage basins, from which the surface soil was never removed, and whose water-shed

comprises a very considerable population; and Natick, with its 8000 inhabitants, still drains its waste into Lake Cochituate, the original source selected for the city supply.

The Board of Health returns for Boston, August, 1883, out of a total of 521, gives from zymotic diseases alone 194 deaths, while 135 cases of typhoid fever were reported.

For September, in a total mortality of 765, there were 253 deaths from zymotic diseases, and 215 cases of typhoid fever were reported.

With astonished gaze the traveler views the great arches spanning and crossing the Campagna, which once bore to old Rome the pure waters of the distant Albian mountains. The last generation of scant population, with singular energy and foresight, at the behest of commerce, wedded by a waterway, more than three hundred miles in length, the Great Lakes with the Hudson river. The twentieth century will exhibit yet greater marvels for the securing of pure water. The project is already under discussion to supply the great Metropolis from no nearer source than Lake George, with the thought of protecting its water-shed from further pollution, and carrying its pure, sparkling water to the thirsty city, at an estimated expense of no less than two hundred millions of dollars.

The danger from the dead must not be forgotten. As we invite our friends to sympathize in our sorrow, let it not be to their peril. Revive, if need be, the custom of Egyptian preservation, or reinaugurate the use of the Roman funereal urn, but do not sow the seeds of an epidemic of the ever prevalent contagious diseases by our present display of decomposing remains, adorned as if for a reception. Let the genius of some sanitarian devise a casket at once hermetically sealed, rather than do violence to time honored custom or shock the deepest and most sacred feeling of broken hearts by urging cremation. The public health act of Great Britain makes the holding of a "wake" over the body of one dying from contagious diseases subject to a fine of five pounds. Let American authorities equally protect from similar dangers.

We turn reluctantly from the consideration of questions having so great and vital an interest to the medical profession, and of primary importance to the entire animal kingdom. If Rip Van Winkle experiences be granted to us in the twentieth century, with little aid of the prophetic power we may forecast some of the advances then made known to us of our science. In the light of

past history, with its fashions and foibles of the *medicamenta*, few would presume upon the mission of its pellets and powders.

Surgery and sanitary science are, however, based upon entirely different factors of our knowledge, and must remain the great corner-stones of a divine art, as wide reaching as humanity. Upon these shall be builded the grand Æsculapian temple of the future, where will be taught a science foreshadowed in the deeds of the great Galilean Master.

The citizen must not be lost in the physician. A Republican Government demands service of all. As I turned from the motley crowd in Castle Garden I shuddered at the thought that these men were so soon to be my peers in our government; but the bright-eyed children, hiding in the scanty skirt of the mother, looked hopefully up, as if to say, "Welcome us in our escape from the oppression and over-crowding of the centuries." Then came the vision of our broad domain scattered all over with school houses, academies and colleges. Rosy-hued with health, in youthful vigor, our women in tens of thousands have devoted their best years to the training of the young. Four hundred American colleges and universities with open doors invite to a higher education. Universal knowledge is the Republic's only safety, and further needs have only to be made known to be liberally met by the generosity of the American people. The necessity for research and pure science are recognized as never before, and may the day soon come when our youth will no longer require, for their best development and higher education, European training.

Be it our bounden duty as physicians to disseminate to the masses proper instruction in the cardinal virtues of right living, and to demand from our government wise sanitary laws, both State and National, in the enforcement of which every house shall be builded and maintained as sanitarily safe as architecturally; rich and poor alike abundantly supplied with pure air and water, and have their habitation upon an uncontaminated soil.

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Marcy