The Atmosphere and Disease

being a Thesis

for the degree of M.D.

by

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The Atmosphere and Disease.

I Introductory remarks.

The vast aerial ocean which encompasses the earth, is the universal medium which maintains and diffuses animation and life. The atmosphere was at one time supposed to extend no higher than sixteen leagues, or forty five miles above the earths surface but meteorological observations have since shown that it probably reaches a height of at least two hundred miles. All organic substances are dependent strictly or indirectly upon its presence, and its disappearance would inevitably be followed by a general destruction of animals and plants, and the silence of death.

For long it was thought that the air was spiritual, that like the life it was the soul of the world, but now, it is almost needless to remark, we know that it is a material body, and like any complex substance, can be dealt with physically and chemically analysed.

Robert Boyle one of Englands greatest philosophers, termed the atmosphere "the most heterogeneous body in nature." It is the grand reservoir into which are poured all the vapours gases and emanations which arise from the face of the earth from plants and animals, from city, town or country, or as Boerhaave says: "Ut tota terra ejus aërem Cadentia Excepit omnia, ita tursum aër de tota universa accepit."

But it is with the atmosphere as one of the great factors in the production and diffusion of disease, that our present subject deals. It is not a new idea that diseases may come from the air. We read of Hippocrates in Greece, keeping out one wind, and letting in another by stopping and opening windows, and also by using perfumes and fires against plagues. The celebrated botanist Linnaeus looked upon clouds of sand dust and other bodies as infernal furies, bringing disease out of the ethereal chaos. Bishop Berkeley of last Century says:—
"The air is a mass of numberless different principles, the general

Sources of corruption and generation." Also that "the seeds of all things seem to be latent in the air, the extremely small seeds of ferns, mosses, mushrooms, and some other plants are concealed and wafted about in the air, every part whereof seems replete with seeds of one kind or other."

II Composition of the Atmosphere

Before investigating the morbid conditions and pathological states incident on atmospheric influence, let us consider briefly the various elements which enter into the composition of the air.

Chemically speaking the air is a mixture consisting mainly of Oxygen and Nitrogen in the proportion of 1 to 4 - or 20.6 volumes of Oxygen to 77.9 of Nitrogen. The relative quantities of these two gases remain the same or nearly so from whatever region the air may have been taken. Of the other important constituents, Carbonic Acid is present in the proportion of 0.04 vols. to 100 of air, but this quantity is very variable, being increased in densely populated districts by over-crowding, manufactories &c. Aqueous vapour is present in varying quantities, dependent chiefly upon locality, time and temperature. The only other necessary constituent is Ammonia, which exists in comparatively very minute quantities - about 1 in 1000 vols. of air. Ozone, Nitric Acid, Marsh-gas, Sulphurous Anhydride, Sulphuretted Hydrogen, may exist in traces, and are present or entirely absent, according to locality and other circumstances.

III Dust and Micro-organisms

But in addition to these, there are certain substances of an organic nature invariably present to a greater or lesser extent, which must be considered as accidental impurities in the atmosphere & it is with these, as elements in pathogenesis, that we shall first have more especially have to deal.

Solar light in passing through a dark room reveals its track by illuminating countless myriads of minute particles floating in the air. These particles which consist usually of soot, are invisible in the ordinary daylight but are practically never absent from the atmosphere, whether in

examine it at the bottom of the deepest mine, or at the summits of the loftiest mountains. Air may be entirely freed from aqueous vapour and CO_2 by passing it through U-tubes containing fragments of marble moistened with a strong solution of Caustic potash, and fragments of glass wetted with concentrated Sulphuric Acid. But air thus treated still contains its floating particles. Even if it be allowed to bubble through the liquid acid, or strong solution of potash, the particles may still be detected in the beam of light. When a stream of air is passed over the flame of a Spirit-lamp the floating matter is found to disappear, having been burnt up by the flame. It is therefore organic matter. Prof. Tyndall has shown, that when a Spirit-lamp is placed under a beam of light in a dark room the path of light over the flame is interrupted, leaving a black space. He says "Dimpling with the flame and round its rim were seen curious wreaths of darkness resembling an intensely black smoke. On placing the flame some distance below the beam, the same dark masses bowed upwards. They were blacker than the blackest smoke even seen issuing from the funnel of a Steamer and their resemblance to smoke was so perfect as to lead the most practised observer to conclude, that the apparently pure flame of the alcohol lamp required but a beam of sufficient intensity to reveal its clouds of liberated carbon. But is the blackness smoke? This question presents itself in a moment, & was thus answered: a red-hot poker was placed under the beam; from it the black wreaths also ascended. A large hydrogen flame was kept employed, and it produced the whirling masses of darkness far more copiously than either the Spirit-lamp or poker. Smoke was therefore out of the question. What then was the blackness? It was simply that of Stellar space; that is to say, blackness resulting from the absence of the beam of all matter competent to scatter light. When the flame was placed below the

Tyndall's Experiments.

be —, the floating matter was destroyed in situ, and the air freed from this matter, rose into the beam, jostled aside the illuminated particles and substituted for the light the darkness due to its own perfect transparency. Nothing could more forcibly illustrate the invisibility of the agent which renders all things visible" (" The floating matter of the air." Tyndall)
If a portion of air be perfectly enclosed and left undisturbed, the floating matter is found to gradually disappear. Tyndall demonstrated this by ~~doing~~ employing a chamber provided with a door, windows and window-shutters &c. Through the windows a beam of stray light is passed. The track of light is at first perfectly plain and vivid in the air of the chamber, but if all disturbance be avoided, the luminous track will become fainter and fainter and finally disappear entirely. What rendered the beam visible at first was the floating dust. But in the still air the dust gradually sinks to the floor, or sticks to the wall and ceiling, until finally the air is entirely freed from mechanically suspended matter.

Relation to putrefaction

Organic infusions placed in the ordinary atmosphere will rapidly undergo decomposition, even although previously sterilized by prolonged and discontinuous boiling. Examined microscopically when in a state of decomposition, they are found to swarm with the bacteria of putrefaction. But when a sterilized infusion is placed in one of Tyndall's chambers and allowed to remain undisturbed, months or years may elapse and yet the infusion remains perfectly sweet and entirely free from bacteria. In both cases the atmosphere has free access to the infusion. Why then the fresh difference in results? Manifestly, because in the latter case there is an entire absence of dust. Hence in the dust or floating matter inside the elements necessary for putrefaction. Allow but a one

particle to fall into the infusion, and in time a teeming mass of bacteria is the result. Indeed a single cell of the yeast-plant (Torula Cerevisiae) is sufficient to set up fermentation in a Saccharine Solution, so a single particle of Soot may originate the process of putrefaction. In addition we need only refer to the well-known experiments of Pasteur, which although a little different in detail all arrive at the same great discovery. He found that an organic infusion previously sterilized by boiling in a Florence flask rapidly underwent decomposition when exposed to the air. When the neck of the flask was heated and bent at a declining angle, the infusion if left undisturbed remained clear for a much longer time. In both cases the air had free access to the infusion, but in the latter the putrefactive germs could not readily mount the neck of the flask. Further, when the infusion was entirely shut off from the air by sealing the neck of the flask, decomposition was completely arrested.

Pasteur's Experiments.

Germ-theory.

The "germ-theory" of disease is the outcome of such investigations, and perhaps no medical principle or doctrine has ever been the subject of so much thought or so much discussion.

Historical foreshadowing.

In the medical literature of the past we can trace among all the numberless theories of disease, the fore-shadowing of this great doctrine. Thus the idea of ferments in the air is not a new one. Robert Boyle writing in the 17th Century says "There parts of the atmosphere which, in a strict sense, may be called the air, are in some places so intermixed with particles of different kinds, that amongst so great a number of various sorts of them, 'tis very likely there should be some kind of an uncommon or undiscovered nature" Again the likeness of fermentation to certain processes of disease had occured to him. In

Boyle.

his "Essay on the Pathological part of Physick" he says:-
"And let us add, that he that thoroughly understands the
nature of ferments and fermentations shall probably be
much better able than he that ignores them, to give
a just account of various phenomena of several diseases,
(as well fevers as others) which will perhaps be never
properly understood without an insight into the doctrine
of fermentations" In relation to this subject such
words as these have in them the force of prophecy.

Place A quaint writer Mr. Place, speaking of the Plague,
says:- "When we consider what a vast deal of vapours
a small thing sends out and what a large space of air
it will fill with it & diffuse itself through, we may con-
ceive a city thoroughly infected, to be, as it were clouded
with pestilential fumes, as it would be with smoke if on
fire. and if one can fancy such a representation 'tis hard
to ask what way men living amongst it receive the infection;
whether they draw it in with the breath, or it gets into the
stomach by the mouth &c. adhering to what they eat and
drink, or secretly climbs into the brain, by the sensory
of the nose since it is much but 'tis all these
ways" (Hypothetical notion of the Plague p. 12) Terentius

Varro. Varro, in the second century, speaks of minute
animals which cannot be followed by the eye, but
which enter into the body by the mouth and nose
and cause troublesome diseases.

Hahnemann Again let us instance the "psora-theory" of Hahnemann
In this day microscopical investigation was in its infancy,

Psora-theory and in determining the causes of diseases, the mind
would naturally frame its ideas upon that which
was tangible and visible. The cause of most chronic
diseases he believed lay in the human system a internal
entity "a sort of internal itch" which he designated by
the general term "psora". This "psora" may possibly be

comparable with the "Septic Diathesis" of the present day. However, Hahnemann held that "Psora" was a "miasmatic Chronic Disease" attributable to the entrance of a living organism into the body, and viewed in this light may be said to foreshadow the germ theory.

The bacteria of putrefaction as also the germs of disease have been carefully sought for, but so far have never been discovered as such in the atmosphere. An organic infusion boiled and shielded from atmospheric particles, will remain clear for an indefinite period, while a fragment of glass which has been exposed to the air, but on which no trace of a bacterium is to be found, will in two or three days develop in the infusion a multitudinous crop of life. But although we cannot discover bacteria in the atmosphere, they or possibly the germs from which they are developed, must certainly be there. As the yeast-cell owes rise to the process of fermentation so the bacterial germ may be said to impart to organic matter the conditions necessary for the production of bacteria (putrefaction and). These germs can be seen to exist in association with the floating matter of the air, many of the individual particles of which probably lie far beyond the reach of the microscope. Nevertheless such particles may be demonstrated collectively by their illuminating power in a beam of concentrated light, long after the microscope has ceased to distinguish them individually. Such particles abound in every pool, stream and river, all parts of moist earth are crowded by them. Every wetted surface which has been dried by the sun or air contains upon it those particles which the evaporated liquid held in suspension. From such surfaces they are detached and wafted away, their universal prevalence in the atmosphere being thus accounted for —

Relation to Surgery.

And now let us consider for a moment the bearing of such facts upon the practice of Surgery and Medicine.

Antiseptic System.

Perhaps the greatest Step ever taken in the art of Surgery, was the introduction of the Antiseptic System of Treatment, for which we are indebted to Sir Joseph Lister. However Surgical opinion may be as to the best antiseptics and the best methods of carrying out the System, the gain to Surgery has been incalculable.

We can now understand why in a case of fracture of the ribs with puncture of the lung by a fragment, the blood effused into the pleural cavity, though freely mixed with air, undergoes no decomposition. One of the offices of the air-passages is to arrest inhaled particles of dust and prevent them from entering the air-cells. The air is thus filtered and no germ can come in contact with the effused blood in the pleural cavity. If we were able to surround a wound with filtered air, that is to say with an "aseptic" rather than an "antiseptic" atmosphere, putrefaction could never occur. When using the Carbolic Spray we are said to interpose an antiseptic atmosphere, in place of one laden with the germs of putrefaction. How far this is true is very questionable, when we consider the process by which an atmosphere germ is wafted. To accomplish such a process would be a feat indeed, and we do well to remember that the same we seek to kill is in the air at least microscopically invisible. Were it not for some specific relation between the matter of the germ, and that of the liquid into which it falls, nothing would simply be

Filtered Air.

Aseptic and Antiseptic Atmospheres

Carbolic Spray.

impossible. Short of this however, by the antiseptic method we limit the entrance of putrefactive germs, and by various antiseptic lotions, under these germs innocuous, when they do gain access to a wound. The type of such a lotion is a perfect germicide, and one involving the least possible irritation to the part to which it may be applied.

A knowledge then of the atmospheric origin of germs has led to the discovery of a method by the aid of which we can not only fearlessly undertake the gravest operations, but confidently rely upon the healing process occurring without the intervention of sepsis, and an amount of success entirely foreign to the practice of last century Surgeons. Such a knowledge, is of no less importance in the domain of Medicine & we shall first deal with that Section of it which concerns epidemic diseases and fevers.

Relation to Medicine.

Epidemic diseases & fevers.

For many years the class of epidemic diseases were distinguished by the generic term "miasmatic", their origin being said to depend upon the presence of "miasms". These miasms constituted the contagious element of the disease, or what we now term the "contagium vivum". The emanations from marshy and malarial districts have been carefully examined for the presence of some principle to which the origin of a fever or disease might be attributed, but with very little result. But as we have already seen, such a principle does exist, which when introduced into the body is capable of fermenting living organisms. By the help of the microscope such organisms can be distinctly observed in the blood and tissues characteristic forms being found in different diseases.

Contagia

Splenic fever, or Anthrax, for example, owes its origin to the Bacillus Anthracis, a filiform bacterium which exists in countless numbers in the blood of a patient affected with the disease. In Relapsing fever also the specific contagium is the Spirillum Obermeieri, discernable in the blood in the pyretic periods of the disease. The contagia of many other diseases such as Cholera, Leprosy, Tuberculosis, Typhoid fever &c. have also been definitely traced to a specific organism, capable of ocular demonstration under the microscope. In some of these diseases the atmosphere may be the channel of communication. Anthrax in this country occurs chiefly in those who have to deal with the wool of animals who have died of Splenic fever. In these cases the poison may enter the system either by local inoculation or by inhalation of the dust containing it. Again, in the case definitely

Infective Diseases

"infective" diseases as fevers, the morbific agent is commonly conveyed by the atmosphere. It may

Their Atmospheric Dissemination

be transmitted by the air in the emanations from the skin, as in the case of Small pox; by the exhaled breath, as in Diphtheria. and in the adherent effluvia from the evacuations, as in Typhoid fever. The fine dust or scales from desquamating cuticle may also be carried by the atmosphere, and propagate the disease in this manner, as is frequently the case in Scarlet fever. In Typhus fever, the contagium is certainly propagated through the air by the exhalations from the lungs. The breath has a peculiar heavy smell, detectable within a foot or two of the patient's face. But if this be freely diluted with abundance of fresh air, its noxious

influence is entirely destroyed. Hence the facility with which the Spread of this Disease can be limited by isolating the patient in a large well ventilated room.

Malarial & Endemic Diseases.

With regard to the types of Intermittent and Remittent fevers, the generating poison may be carried by the air of marshes, a emanation from marshy soils. This class of diseases, is distinctively "endemic," affecting the inhabitants of a limited district. The poison is telluric in origen, or as Prof. Gairdner aptly terms it "adscriptus glebae". The malarial poison a marsh miasm has not been discovered as such in the atmosphere.

Marsh miasm

Its discovery

Much light however has been thrown on the subject by the researches of Professors Tomasi Crudeli of Rome and Klebs of Prague, who examined the lowest Strata of the atmosphere of the Agro Romano, in the Spring of 1879. They discovered microscopic fungus in the atmosphere, as well as in the marshy ground. Cultivation in various kinds of soil. The fluid derived from the latter was repeatedly washed and filtered, and the residuum introduced under the Skin of healthy dogs. All the animals experimented on suffered as a result from the intermittent fever. In the Blood which were analyzed as in human patients suffering from Ague, a large quantity of the characteristic fungus was present. (Quain's Dictionary of Medicine, Article "Malaria")

According to one theory Rheumatic diseases are attributable to a malarial cause. The possibility of this seems great when we consider the prevalence of Ague and Rheumatism as concurrent diseases in

malarial districts. This detrimental fever was at one time endemic in the fen-districts of Lincolnshire, and it is interesting to note in the various tales of the fens, how the authors make frequent mention of rheumatism as an alternating disease with ague. But as a result of the laborious efforts and engineering skill expended in the draining of the fen district these diseases have practically vanished, affording a striking example of how a noxious atmosphere may be purified and rendered salubrious by a due attention to the thorough sanitation of a soil.

Atmospheric transmission of epidemics

The malarial poison may be conveyed atmospherically to a considerable distance from its source by the aid of wind and currents of air. Epidemic diseases are found to follow the great highways of commercial and international communication. But apart from this, the atmosphere plays an important part in their transmission. How otherwise can be accounted for the vast distances such epidemics travel sweeping over deserts and oceans, as well as thickly populated districts? How otherwise can be accredited the inconceivable mortality caused by the great pestilence or "black-death" of the 14th Century, which originating in Cathay (North China) visited thence to devastate the whole world?

Epidemic precursors

The subject of epidemics is one which has long been shrouded in mysticism and superstition. The so-called "precursors" of epidemics were supposed to exist in the celestial "portents" such as comets and meteors, or in the more manifest terrene portents, such as earthquakes and volcanic eruptions. Hecker, in his "Epidemics of the Middle Ages" in tracing the

arising in China

course of the "black-death". Speaks of parching droughts in that country, succeeded by violent rain; of a mountain falling into the earth; of lakes being formed, and of want of rain; of a plague killing five million people. Of swarms of locusts, and unusual pestilence and floods. A few years afterwards the disease spread to the Island of Cyprus when violent sea waves and hurricanes, to their utmost to make the land a desert. And before an earthquake a pestiferous wind is said to have come with a poisonous odour, which caused them to die in dreadfully agonies. It is also said that a stinking mist advanced from the East and affected Italy, the formation of dreadful chasms and the existence of foul air on a great scale, being familiar. Amongst epidemic precursors also, are noticed exceptional development of insect life, human unusual prevalence of certain diseases, and remarkable perturbation of the weather. Towns and districts for example have often been visited by epidemics. The true explanation manifestly is to be sought in a common predisposing cause, rendering the inhabitants susceptible to the influence of disease. Bad water, unwholesome food, filth and over-crowding are the principal factors, and individuals long subject to such conditions, fall an easy prey. Such predisposing causes extended over a lengthened period, affecting large numbers of individuals, constitute the necessary conditions for the spread of epidemic diseases. The deterioration of the general health furnishes a soil suitable for the growth and propagation of the specific germ, and it may be said, that in

proportion to the exhaust and cultivation of such a soil is the fatality of the epidemic invasion.

Distribution of germs in atmosphere.

Tyndall has shown that the germs of putrefaction besides varying in kind, are unequally distributed in the atmosphere, floating in pumps or clouds. Thus of a large number of organic infusions of the same kind, being exposed to the air, the occurrence of decomposition is not simultaneous in them all some being affected before others. Thus exposed to the atmosphere on the 9th of Nov. 1875, a tray containing one hundred test tubes filled with an infusion of mutton. Tyndall's Experiments. He says "On the morning of the 11th Dec of the ten marsh the Stone had given way to putrefaction; three of the new week Sirland from the Stone had yielded, while seven and then on the way particular tubes were singled out, & smitten by the infection. + + On the 12th all the tubes had given way, but the differences in the contents were extraordinary. All of them contained bacteria some few others in Swarms. In some tubes they were sparse and sickly in their movements, in some apparently dead, while in others they darted about with rampant vigour." We have here possibly a picture of what occurs during an epidemic, the difference in numbers and energy of the bacterial swarms, resembling the varying intensity of the disease. Of two individuals exposed to a contagious atmosphere one may be severely, the other slightly attacked, though as regards susceptibility — they may be identical.

Foul odours and Sewergas.

These considerations also are of great importance, in connection with the presence of foul odours and Sewergas in the air. For so long as in habitation of such an atmosphere, cannot but be prejudicial

Their Significance in producing Disease.

with great danger to health, rendering the individual very susceptible to disease. For example, symptoms of general debility, nervous prostration, headache, languor, depression, glandular swellings, and increased tendency to catarrhal affections are common results. Nevertheless no specific affection ensues from the inhalation of such an air, unless the actual germs of specific diseases are present in it. How often in private practice we come in contact with cases of this kind. In my own experience I have met with an outbreak of Diphtheritic Sore-throat affecting ten individuals within a fortnight in one house, traceable to a defective condition of the drainage. Upon examination the clay soil in the basement was found to be impregnated with sewage matter in the neighbourhood of a heating ~~coil~~ pipe, & from which sewage-gas freely escaping, had permeated the atmosphere of the whole dwelling. The drinking water was unaffected, & of miasma could only have been so secondarily from the condition of the atmosphere. Each case presented the patchy appearance of the plaques & fauces, the concomitant symptoms varying greatly in intensity, while in three of the patients - at least, all the symptoms of true Diphtheria were developed. Thus the Diphtheritic Contagium was present in the sewage-gas, but the severity of its effects varied with the health of the individual upon whom it acted. Here it was evidently a question of varying susceptibility, rather than unequal diffusion of the atmospheric Contagium, though it is possible that the latter may have influenced to some extent, and accounted for the varying severity of the symptoms.

The most common vehicle for the dissemination of the

Typhoid fever poison, is drinking water which has become contaminated with sewage matter. But we frequently meet with cases where the disease is communicated by atmospheric contagion, for example, from the emanations from a newly opened drain or cesspool. At the Fifth International Congress of Hygiene at Vienna Prof. Brouardel of Paris, in his paper on the "Propagation of Typhoid fever" quoted a case where the disease was due to foul air. "In a family of nine, living on identically the same food, a son alone contracted Typhoid fever. It was found that under his room window there was an open soil pipe. In another family precisely the same incident occured (Lancet Oct. 87) The poison may thus be conveyed by sewage-gas which is forcibly inhaled. But more commonly water used for culinary or drinking purposes, becomes contaminated by the absorption of sewage-gas. Thus in a cistern, the overflow may act as a ventilator to the common drain, by opening into the soil-pipe, allowing the free access of sewage-gas to the water. When the overflow-pipe is conducted into the outside air, such a result is obviated. Again, when escape pipes from basins, baths, sculleries, &c are devoid of traps, or improperly disconnected, there result a free admixture of sewage-gas with the water, or atmosphere of the house. The presence of sewage-gas in a dwelling is largely affected by the condition of its ventilation. If there be an inadequate provision for the admission of fresh air, the drawing action of the fires will cause irregular streams of it to set in through every crevice, such as keyholes, chinks in windows, doors skirting-boards or floors. Now if there be any leaking pipes or other defective sanitary condition such streams will in great part be derived from the drains, and "drain-be-fouled" air will fill the rooms. Some of the serious

results of bad Sanitation are strikingly illustrated by J. Pidgen Teale in his work on "Dangers to Health" in which he shows how cases of illness may be strictly traceable to certain defective conditions of Drainage. For example he quotes cases, where the inhalation of air contaminated with Sewage gas resulted in such diseases as puerperal, typhoid and typhus fevers erysipelas, inflamed throat, diarrhoea, sick headache, neuralgia & rheumatism; and in our daily practice we are constantly meeting with cases of a similar nature.
The question may be asked, why, under the agency of presumably identical exciting or proximate causes, different diseases sometimes result? Thus, the inhalation of Sewage-gas, in the absence of all other causes, may produce at one time typhoid fever at another Scarlet fever, and at still another time Diphtheria. Manifestly, the reason must be looked for in the specific character of the contagium. If the inhaled air contains the Scarletina germ, if we may so designate it, Scarlet fever is the result. The contagium of disease invariably "breeds true". It is to all intents and purposes a "seed" producing its own fruit. As surely as a thistle rises from a thistle seed, so surely does the typhoid virus increase and multiply into typhoid fever, Scarletina virus into Scarlet fever. It is said that a field planted with a low scotch-oats can from time to time in London. Thus a corrupted air may promote but does not produce an epidemic, unless it carries with it the specific contagium. In studying epidemic and allied diseases, how important then, do such considerations become? We must imagine the atmosphere to be a vast Amphitheatre

through which an epidemic travels; that the latter consists of countless myriads of germs, sweeping it may be in clouds, invading villages and towns, when it finds a soil ready tilled and manured by every conceivable unhygienic condition; multiplying as it goes, and like a conflagration gathering fresh strength and intensity till it surprises in the desolation of a whole population. As a planted acorn grows into an oak, competent to produce a crop of acorns, each gifted with the power of reproducing a tree like its parent, and as from a seedling a whole forest may spring, so epidemic diseases literally plant their seeds, sow and shake abroad their germs, which find in the human body a fitting soil for their sustenance and growth. When visiting the Eden Gardens, Calcutta in october 1885 I was conducted to the great banyan-tree (Ficus Indica) a last product of several hundred years growth, and for the greatness it covered, capable of sheltering a small army. At some distance it appeared with its rooted perpendicular columns like a large grove of trees, but in reality the whole assemblage was the offspring of a single root. May we not suppose that in like manner an epidemic with its direful results may be the offspring of a single germ? We can but inadequately conceive, how a given specific disease, with its definite course, and well-marked train of symptoms, should have for its essence a microscopically minute organism. But we can better grasp the fact, when we suppose that such a germ is capable of setting in action certain processes, or of giving rise to certain products upon which the genesis of the disease depends. A parallel case is furnished in the truly marvellous

process of reproduction.

In the ovum and Spermatozoon, we have the factors, not only for the exact propagation of Species, but individual peculiarity, Disposition, and even morbific tendency.

But we must pass from this Section of our subject, and see in what other respects the atmosphere may influence the production of Diseases.

The animal function which of all others, is so intimately dependant on the aerial State, is that of respiration, and upon the due performance of which function the well-being and health of the whole organism so greatly depends. Hence, in Considering Disease from this Standpoint, the affections of the pulmonary organs and passages must necessarily occupy a prominent position.

IV. Varying Conditions of the Atmosphere

If the atmosphere were at all times and places uniform in Composition, Diseases of respiration would be few indeed. But as we have seen the air is affected by a large number of Conditions, and in proportion as these are of a Salubrious or noxious nature, so does the health-affecting State of the atmosphere vary. Thus its gases may be increased in quantity and kind; its temperature, humidity, pressure, density and Rarefaction may vary in degree; and suspended or carried by it, may be not only numerous Species organic, but even inorganic substances. In what way these varying atmospheric States may prove beneficial or prejudicial, may predispose, or become the direct factors in the aetiology of Disease, we shall now enquire.

Gases. The relative quantities of the Constituent gases of the air, may be altered either on the side of

oxygen. increase or diminution. An atmosphere rich in Oxygen, or Containing an appreciable quantity of

Ozone has a bracing and exhilarating effect. It promotes the oxydation of the tissues generating heat, evolving the necessity for repair in the shape of food, and results in an increased appetite. When oxygen is inhaled in excess, death is produced by over stimulation. An atmosphere pure in oxygen, has the opposite effect and life cannot be prolonged in its absence. The relative proportion of Oxygen and Nitrogen of the air, is subject to only very trifling differences in town, country, seashore and mountain districts and even in various geographical latitudes. Sea air from its greater density is richer in oxygen than that of mountain districts.

Ozone. The most important agent in the purification of the air seems to be the ozone contained in it. It has the property of destroying the gases produced through organic and inorganic decomposition and upon the quantity of ozone depends to a large extent the degree of salubrity of the air. Sunlight and vegitation have been said to be the most important sources of Ozone, the former probably determining its amount in sea air, the latter in the air of forests. The bracing and exhilarating effect of the air of glaciers is probably due as suggested by H. Weber not only to its purity, from the absence of organic impurities, but to the amount of ozone it contains, produced by evaporation. The peculiar odour observed when an electrical machine is worked, is caused by the presence of ozone, and in nature ozone most probably owes its origen to the discharge of atmosphere electricity. Thus it is said to be produced during thunderstorms, by the dashing of waves on the seashore, and in the downward rush

the waterfall.

Carbonic Acid. Carbonic Acid in excess is always injurious to health, causing headache, dyspepsia, and nervous depression. The atmosphere of a room containing 0.1% CO_2 is unfit for respiration. Perhaps one of the most serious predisposing causes to disease, is the continual respiration of air which has been already breathed. For example, in crowded apartments or workrooms, in lecture-halls and places of entertainment, when numbers of people are brought together at the same time. Not only does the air under such circumstances lose much of its vital principle or Oxygen, but becomes loaded with CO_2, and the effete matter given off by the lungs, and emanations from the skin. The habits of the breath becomes offensive, due to the diminished oxydation, & consequent accumulation of the nitrogenous waste products within the body. The condensation of such breath shows the presence of fœted matter, & thus how injurious must this prove when constantly inhaled? In speaking of the aetiology of epidemics, we have referred to overcrowding as a predisposing cause. In this cause we must include foul air the inhalation of which exerts such a singular potency in favoring the action of morbid poisons in individuals and communities. This with each of the other factors mentioned, tend to produce an excess of those decomposing effete matters, with which the blood is normally charged. Such decomposing matters may be introduced directly with the inhaled air, or may be generated in abnormal amount within the body. If the inhaled air be foul, or the proportion of its constituent gases much altered, the respiratory act is performed laboriously, or becomes seriously impeded

Injurious effects of confined air.

and secondarily to this, the function of the great emunctories, viz. liver, intestinal glands, kidneys, and skin, is improperly carried on. As a result the nitrogenous waste products increase, the healthy vigour of the body is lowered generally, and a predisposition to disease is established. As shown by Dr W. B. Carpenter "the presence of nitrogenous matter in a decomposing, or decomposable state, affords the best possible pabulum, either for the development of bacillar organisms, or for the action of ferments" (Quain's Dict. article Predisposition to Disease) Thus the susceptibility to the poison of zymotic or epidemic disease is increased or fostered by the presence in undue amount of such waste products, or "materies morbi" in the system.

Relation to phthisis.

Such facts as these throw light on the effect of bad ventilation and confined air, as the fruitful predisposing cause of Phthisis. Dr Guy has shown that Consumption is commoner amongst persons of indoor occupations, than amongst those employed out of doors; this being true not only of printers, compositors and tailors, but also of tradesmen who live in hot gaslit shops, and often sleep in miserably ventilated bedrooms. Of nearly 6000 cases of phthisis admitted into the Brompton Hospital during 10 years, two-thirds had indoor occupations, amongst them milliners, dressmakers and tailors, furnish the largest quota, who all live in close rooms to which they are almost entirely confined. Since the discovery of the tubercular bacillus by Koch in 1882, the supposition that phthisis is a truly infective disease assumes a much greater degree of probability. We have seen that the air is the "Catholic receptacle" of all emanations, and we

Can readily understand how bacilli less than the 1/3200 of an inch in length, could be carried into the atmosphere with the aqueous vapour of the exhaled breath. By Ehrlich's method and others, we can demonstrate with absolute precision the presence of the tubercular bacillus in the Sputum of a phthisical patient. Now by the process of evaporation, this expectorated matter rapidly dries, and becomes broken up into dust, which soon finds its way, freighted with bacilli, into the surrounding atmosphere. Persons confined in small rooms with phthisical persons, breathing the same atmosphere again and again, it may be day after day for months or years, must thus inevitably inhale the very essence of the tubercular disease. Provided the State of health is robust, no evil immediately results. But in process of time, from the continual exposure to the other debilitating elements of a confined air, a depreciation of the general health is brought about, a susceptibility to disease established and the inhaled bacillus at length finds in the weakened pulmonary tissues a fitting soil for its sustenance & growth. In visiting cases of Consumption, as well as infectious diseases, we are daily exposed, and doubtless frequently inspire the atmospheric contagion. How often we notice, and feel inconvenienced by the sickly smell in the appartment of a Consumptive patient, who is perhaps expectorating the characteristic phthisical Sputum? Let us escape, doubtless because the specific germs are unable to effect a lodgment, or from the activity of our functions fail to seriously compromise the integrity of our tissues.

Phthisical Sputum.

Surrounding and want of fresh air not only

Fatality from Confined air.

Seriously injures the health, but may even prove speedily fatal, when carried to extreme lengths. Of 146 prisoners confined in the "Black Hole of Calcutta," 123 died in one night, and many of the survivors afterwards succumbed to "putrid fever."

It is an interesting fact that an atmosphere saturated with aqueous vapour, and filled with 3 to 4% of CO_2, as in the Spray bath at Rehme, leaves the general state of feeling often entirely unaffected, while the air, of a room filled with human beings, containing only the tenth part of this percentage of CO_2, is often insupportable. As we have seen, the explanation is to be found in the volatile putrescible matters given off from the skin and lungs with which the air in the latter case is charged; there being thus not only a subtraction of the life-giving principle of the air, but an addition of noxious substitutes.

Further effects of CO_2.

Carbonic acid in moderate quantities has a stimulating effect on mucous membranes and raw surfaces, hence the beneficial action of the cool spray baths of Rehme, Nauheim, Kreuznach, Reichenhall, Elmen &c in cases of Ozæna and Chronic Catarrh of the throat and bronchial tubes. But if the temperature of such baths be too high, CO_2 is liberated too freely into the atmosphere, and the inhalation of this air not only without beneficial effect but followed with very injurious consequences.

Of the direful effects of large quantities of CO_2 in the air, we have examples in the numerous

After-damp accidents from "Choke-damps," or "after-damp" of mines. Also in blasting operations on a large scale, when the combustion of gunpowder results in the sudden evolution of CO_2, which from its great density sinks and may flow along the ground, poisoning the lower strata of the surrounding air for a considerable distance. One and only instance as a case in point, the terrible Loch Fyne Blasting Disaster of the autumn of 86, when so many persons were killed from this cause. In the burning of various kinds of fuel, and in lime kilns, enormous volumes of CO_2 may be found out, so that persons living in the immediate neighbourhood have been suffocated.

Nitrogen. The part played by Nitrogen in the atmosphere seems to be a comparatively unimportant one, and from a chemical point of view the gas is marked by negative rather than positive actions. It seems to exist merely as a diluent, or vehicle for the administration of Oxygen. Probably an atmosphere rich in Nitrogen is comparable in its results, with the rarified air of mountain districts, which possesses a smaller quantity of Oxygen than that of lower levels. The waters of the Lippspringe and Inselbad Spas evolve a large quantity of Nitrogen, the inhalation of which has indisputably been proved to be nitrogenous. The beneficial effects of the "Gas Inhalations" "gas-inhalations" of Inselbad Spas is probably due more to the saturation of the air with aqueous vapour than to the Nitrogen it contains. Phthisical patients feel comfortable in this atmosphere

the irritation to cough is allayed by the non-irritating air, and the sick person can draw a deep breath without coughing. It admits air into many neglected parts of the lungs, the breathing becomes freer, and a considerable increase of the vital capacity of the lungs results.

Other gases. Of other gases which may impair the purity of the atmosphere, H_2S, CS_2 + NH_3 are amongst the most noxious. Putrefaction of animal and vegetable matter is a common source of these, and to their presence the foul odour of sewage gas is mainly due.

H_2S &c. H_2S is one of the most poisonous gases, and air containing much more than 1% produces symptoms of general discomfort, trembling, faintness, giddiness, even clonic spasms and delirium, and diminished frequency of the pulse. Such symptoms in slighter degree may follow from the inhalation of the air over strong gas springs, e.g. in Nenndorf, Eilsen, and Langenbrücken. The inhalation of air containing sulphurous fumes, although such may be imperceptible to smell, may produce diarrhoea in sensitive subjects, as occurs occasionally at Harrogate.

Offensive emanations. In various manufactories, noxious gases often escape into the atmosphere, and to a greater or lesser extent endanger or injure the health of the workers. For example, Chlorine gas evolved in the Soda-ash process when inhaled causes a very great amount of irritation in the air-passages; the vapours of sulphurous muriatic and nitrous acids, and Benzol in works for the preparation of aniline dyes. Offensive emanations from the melting of fats, in the manufacture

of size and glue, in the boiling of oil, in the boiling of bones, and in the maceration of hoofs. A considerable quantity of Carburetted Hydrogen, together with Carbonic Oxide, escapes unconsumed from furnaces, and Coal-gas is a common impurity in the air in the neighbourhood of gas-works. A proportion of 3% of Coal-gas in the atmosphere has proved fatal. Coal-gas owes its toxic effects principally to the Carbonic Oxide it contains. The latter is an extremely active poison, having a paralyzing effect upon the blood corpuscles, rendering them unable to take up oxygen. The danger of Charcoal as a fuel depends upon the evolution of Carbonic Oxide, and many deaths have occured from sleeping in rooms in which there is no flue or provision for the escape of the fumes given off from the burning Coke or charcoal. Workers in common or yellow phosphorus, are often the subjects of Chronic poisoning, due in great part to the inhalation of phosphorous vapours. Caries of the teeth, and necrosis of the lower jaw, are the principle ~~Symptoms~~ subjective Symptoms. Chronic Arsenical poisoning from arsenical wall-papers, is probably due to the inhalation of arseniuretted Hydrogen from the volatilization of the Arsenic, though it may in part result from the mechanical transfer of pigmentary dust to the air-passages. Both of these modes occur. In alloying Zinc with Copper, an affection of a febrile character occasionally attacks the workers known as "Brass-founders ague", and is attributable to the Zinc fumes which are generated by the melting process.

Coal-gas.

Carbonic Oxide.

Phosphorus

Arsenic

Zinc fumes

Temperature of the air.

The health-affecting state of the atmosphere is influenced to a large extent by its varying degree of temperature. Nevertheless we have the manifestation of life under all ~~temperatures~~ degrees, whether of the most intense heat, or the greatest cold. The freezing waters and air of the polar regions teem with animated species, while tropical forests abound with animal life. The existence of man in such varying zones of temperature is due in great part to the accomodative power of his various organs.

Accomodative power of man to varying temperatures.

Thus in cold countries elimination of watery excreta is carried on principally by the skin and lungs, while in tropical climates this function devolves to a much greater extent upon the skin. In cold climates there is therefore a conservation of bodily heat, in hot climates, a relative diminution owing to the lowering effect upon the bodily temperature produced by rapid evaporation of the cutaneous perspiration. It is a well-recognized fact, that undue strain upon a given organ or increased function lasting over an extended period, engenders an especial tendency to disease in such organ or function. Thus, diseases of respiration and of the kidneys are characteristic of a cold atmosphere. Cutaneous and hepatic diseases being relatively more frequent and fatal in warm climates.

Sudden changes.

The injurious effect upon the health of sudden change in the temperature of the air seems to depend upon the excessive strain thrown upon the accomodative power of the different organs. The functional adjustment of such organs one to another becomes upset and in proportion to the delicacy and fineness of their balance as well as to the degree of disturbance, may be said to depend, the severity of

the injury incurred. Hence the increased liability to sudden colds and respiratory diseases, in the changeable climate of this country. The sudden chills produced by passing from the cold atmosphere into heated rooms, or from the latter into the lower temperature of the outside air, are to be accounted for in a similar manner. One of the dangers of continental travel, is sudden chill produced by the unguarded passing from the blazing Street, into some cold cathedral or picture gallery.

Temperature dependent on moisture of air.

The temperature of the air varies with the quantity of aqueous vapour it contains. When very moist the temperature of the air, is as a rule higher and more equable. Tyndall has shown that the great body of the atmosphere is a practical vacuum, as regards the transmission of radiant heat. The withdrawal of the sun from any region over which the atmosphere is dry, is followed by rapid refrigeration. Thus in Thibet the winters are almost unendurable from this cause: and in the Sahara where "the sand is fire, and the wind is flame" the cold at night is often painful to bear. But the aqueous vapour of the air, interposes an obstacle to the radiation of heat, and hence the more equable temperature of sea and moist climates. To quote from Tyndall's classical work "Heat as a mode of Motion" speaking of aqueous vapour, he says - "No doubt can exist of the extraordinary opacity of this substance to the rays of obscure heat: particularly such rays as are emitted by the earth after being warmed by the sun. Aqueous vapour is a blanket more necessary to the vegetable life of England than clothing is to man.

Remove for a single night the aqueous vapour from the air which overspreads the country, and you would assuredly destroy every plant capable of being destroyed by a freezing temperature. The warmth of our fields and gardens would pour itself unrequited into Space, and the Sun would rise upon an island held fast in the iron grip of frost. The aqueous vapour constitutes a local Dam, by which the temperature of the earths surface is deepened: the Dam however, finally overflows, and we give to Space all that we learnt from the Sun."

Cold. As a general rule in the colder seasons of the year, the bodily functions are increased, and the change of substance accelerated, while in the warmer it is retarded. Thus respiration is in winter more frequent and deeper than in Summer. Nutrition, Sanguification, the functions of the muscular and nervous Systems, and also all physical action, are in general more vigorous in winter and temperate Zones, than in Summer and in the tropical Zone. It is probably for this reason that persons in ill health, or suffering from impairment of any of the bodily functions, suffer from cold, their power of reaction and regulation being weakened. Thus are often found symptoms of amelioration complained of in bright cold weather by patients suffering from Neurasthenia or general debility. The clear dry air of a frosty day, especially when the Sun is shining and a breeze blowing, produces in such cases a too powerfully stimulating effect. Too great activity is demanded of the functional powers which become fatigued, or fail to respond to the extra strain laid upon them and a feeling of general depression, languor and prostration is produced. When the atmosphere is still, warm and moist, as on dull wet days, so oppressive

to the person in health, the debilitated subject often brightens up wonderfully, and feels a regeneration of his failing powers. Great cold however when associated with great stillness of the atmosphere, retards the loss of heat, so that such persons may even receive benefit under such conditions. It is said that for this reason consumptive patients do well in the ~~cold~~ dry cold of the Hudson Bay countries.

e. Humidity of the air. The influence of moisture in the air upon the animal economy is a matter of daily observation. Aqueous vapour as we have seen tends to equalize the temperature of the atmosphere, by enabling it to obstruct the heat of radiation. The warmer the atmosphere the more water it is able to absorb. Thus in Summer it is moister as a rule than in winter. But here we must distinguish between absolute and relative moisture. the former term indicating the amount of aqueous vapour contained in a given volume of air; relative moisture denoting the proportion which exists between the given absolute amount of water and the amount of water which the air is capable of holding at a given temperature. "In other words, relative moisture denotes the difference between the point of saturation to be reached by the air at a given temperature, and the amount of water really existing: the former being taken at 100, an actual amount of water of 75 is therefore 25 from the point of saturation" (Braun's "Baths and waters")

Absolute & Relative moisture.

In a given district the absolute amount of moisture in the air, is regulated by its temperature and density, by Currents of air and the supply of water exposed to evaporation. So that we may add, also, the amount of local rainfall, dependent upon season and nature of the soil whether moist or dry. The relative degree

of moisture is the result of all these conditions combined.

Absolute moisture & respiration.

The absolute moisture of the atmosphere influences especially the function of respiration. Thus in cases of Bronchial Catarrh, expectoration is promoted, and breathing facilitated, probably from the softening mechanical influence of the exhaled vapour. The amount of moisture in the exhaled breath seems to be inversely as the quantity contained in the air. Thus the less the absolute saturation of the air, the more is evaporated within the lungs and the greater therefore will be the loss of water from the lungs. Accordingly the loss of water from the lungs theoretically is greater in winter and on high mountains.

Relative moisture as affecting Skin.

The relative moisture of the air seems to affect the skin principally, modifying its power of perspiration. Thus the more moisture the atmosphere contains, the less work does the skin give off, and vice versa. During a brisk evaporation of moisture from the skin ceases. Very high temperatures can be endured when the atmosphere is dry, the bodily heat being kept down by perspiration. In dry air, which favours evaporation, experience has shown that man can sustain a temperature of from 194° to 212°F. The labourers at the Suez Canal were able to endure the rays of the burning sun at a temperature of perhaps 220°F. while plentifully supplied with water, enabling them in the dry air to keep up a constant perspiration.

Dry Atmosphere

Soil as affecting humidity of atmosphere.

A damp soil especially when of a clayey nature usually means a humid atmosphere cold atmosphere, and a greater prevalence of catarrhal and respiratory diseases. The town of Huddersfield for example owes its high death rate from respiratory diseases in great part to this cause. It has been shown that when a proper system of drainage of soil-water is carried on, the tendency to pulmonary

disease is very greatly diminished. Thus clay soils are cold and damp, determining a moist atmosphere; while sandy and gravelly soils which readily drain themselves, are warm and dry, and usually coexist with a like condition of the atmosphere.

Fog. The prevalence of fog is dependent upon the quantity of moisture in the atmosphere. Fogs may be "radiational" in origin, resulting from the strong radiation of heat from the earth into space, chilling the ground, and through it the superincumbent air, and causing the condensation of its moisture. But fogs may arise from the gentle impinging of a cold current of air on one of higher temperature and humidity.

Wet. A marked difference is found between fogs on the sea or country and those observed in large towns, the former being as a rule whiter, more damp and distinctly less irritating to the mucous membranes than the latter. This would seem to depend on the fact that in towns the particles of fog become coated with the sulphurous acid, carbonic acid and ammoniacal vapours poured into them by the countless chimneys of our houses, and thus after a day or two they become almost intolerable to those who have to inhale them. The continuous prevalence of

Dry. a dry fog for some days often raises the death-rate in London to an excessive height, but when the fog is mild and wet its effects are less serious to health. The power of fogs to retard the dissemination of impurious vapours and gases is remarkable. In London the source of so much foul gas this is especially noticeable. As soon as the fog envelops the city than persons begin to choke and experience all the unpleasant symptoms of impeded respiration, owing to the fact that the vapours are prevented from rising

and passing away. A similar retardation of the radiation of heat is produced by fog of any considerable thickness, and especially by wet fogs.

Atmospheric Pressure. The pressure of the atmosphere exerts a most important influence on the human frame. This pressure being about 15 lbs. on the square inch, a man of ordinary stature sustains a load of about 14 tons; but as air permeates the whole body and presses equally in all directions, no inconvenience is experienced. As it has often been remarked the mechanism of *Enarthrodial joints.* enarthrodial joints is dependent upon the atmosphere; for example the head of the femur being kept in close apposition with the acetabulum by the pressure it exerts. The function of *Respiration.* respiration also is regulated by the pressure of the atmosphere, the expiratory act being effected in ordinary breathing almost entirely by this agency alone.

Extremes of atmospheric pressure. As a general rule man can endure great extremes of atmospheric pressure without much interference with the state of his health. Nevertheless even slight variations of the barometer occurring suddenly as we have seen with respect to temperature, may seriously affect his well-being. Life can be carried on at an elevation of 15000 feet above the level of the sea and under the pressure of two atmospheres in the "diving-bell," whilst slight variations of the barometer of a few millimetres may affect the most important organic functions, and this the more perceptibly in sensitive and nervous individuals. Regular variations however in the atmospheric pressure may

be said to exert a beneficial influence on the functions of life, favouring those phases of repose and excitement upon which organic life seems to be in every respect dependent.

Rarified Condensed air.

Atmospheric pressure exerts an influence especially upon the functions of respiration and innervation. Various erroneous theories have been held in connexion with this subject. Thus it was supposed that rarified air afforded the lungs less oxygen and somewhat less CO_2, and that accordingly in rarified air, less oxygen was inhaled, and less CO_2 exhaled. To this hypothesis it was inferred that the more rarified the air the more it was necessary for a man to ~~breathe~~ pant of it. So in the climatic treatment of phthisis a rarified air deficient in oxygen must be pernicious, inducing an artificial dyspnoea and an increased desire for oxygen. For this reason Vivenot, a writer on the pneumatic apparatus, concluded that it is only by condensed air that dyspnoea can be diminished, and tissue-change retarded. The pneumatic apparatus seems to produce a palliative effect in attacks of asthma, but this is to be explained not from the larger quantity of oxygen in the condensed air, but from the greater tension of the gases inhaled. The greater this is all the greater quantity is admitted into the blood; a moderate hindrance to respiration can thus be compensated by stronger tension of the gases respired (Meinert). A distinction must here be drawn between the oxygen in the inhaled air and that actually received into the blood, the average relation of which is about 15 to 20 volumes per cent of the oxygen in the air, therefore only 25 per cent is on an

Pneumatic apparatus

average need for respiration; so that at high elevations, there is still more than sufficient quantity of oxygen, and not so rarified as to retard the change of substance from a deficiency of oxygen.

Combustion in rarified air. Tyndall's and Frankland's experiments.

The experiments of Tyndall and Frankland, on Combustion, although purely physical, throw considerable light upon the true effect of atmospheric pressure on the function of respiration. Six Stearine candles were allowed to burn for an hour at Chamouni, the loss of weight being carefully determined. On Mont Blanc 12000 feet higher the experiment was repeated with the same candles, the flame being perfectly sheltered from the action of the wind in a tent. It was found that the brightness of the flame was much diminished at the high altitude, but that in both cases the loss of weight was precisely the same. "Thus though the light-giving power of the flame was diminished to an extraordinary degree by the elevation, the energy of combustion was the same above as below. This curious result is to be ascribed mainly to the mobility of the air at this great height. The particles of oxygen also penetrate the flame with comparative freedom, thus destroying its light and making atonement for the smallness of their number by the promptness of their action. I found indeed, that by reducing the density of ordinary atmospheric air to one-half, we nearly double the mobility of its atoms." "Heat as a Mode of Motion" page 50. Tyndall.

Frankland has also shown that by condensing the air around a Spirit-lamp, the Sandemanian flame may be rendered as bright as that of Coal-gas and even rendered absolutely smoky, the oxygen present being too sluggish to effect the complete combustion of the carbon. In this case also the brightness of the flame is increased

but not the rapidity of the combustion of the material.

Respiration of oxygen at high altitudes.

From such investigations we obtain the idea of the inertness and mobility of the oxygen of the atmosphere and may we not apply the physical to the physiological process of respiration and oxygenation? As with the Carbon of Combustion, there is in respiration an interchange between the oxygen of the air, and that of the blood and tissues. The facilitating effect of rarified air upon vital function and change of substance without diminishing the latter, may thus be said to depend upon the greater mobility of the atmospheric oxygen prevailing in high situations.

As we have seen Condensed air Causes more oxygen to the blood, and so accounts for the increased energy of the functions at the Seashore. The change of substance is stimulated resulting in an increase of urea and a decrease of uric and phosphoric Acids in the urine, while the appetite improves and the body gains in weight. But if the Constitution fails to respond to such stimulation, from any morbid condition of the organs of assimilation or excretion, injurious instead of beneficial results follow.

Mountain and Sea-air as affecting health.

Mountain-air produces similar effects to the air of the Seashore but exercises its stimulating action more slowly and gently. Seaair demands a robust condition of the functions especially of the heart and Lungs. Mountain-air on the other hand exerts a beneficial influence on persons who suffer from weakness and increased irritability, having a calming and indirectly strengthening effect, while in such cases the Seaair would overpower and prove too stimulating.

High Attitudes.

On first arriving at high altitudes, it is said that strangers are usually affected with difficulty of breathing, owing to the extreme rarity of the atmosphere. But as we have seen the rarity of the air does not increase the rapidity of respiration, and any exhaustion experienced at high elevations must be explained rather on the ground of fatigue, especially as balloonists at quite as great heights have not complained of any difficulty of breathing. Again Surveyors have pitched their Camps on the Himalayas, at much higher elevations, without experiencing any of the supposed inconveniences of the situation. It cannot however be denied that many people at these elevations suffer from giddiness and vomiting. In Bolivia this sickness is known as the "Puna" or "Soroche," which affects not only man, but may even prove fatal to mules and other beasts of burden. In the Argentine Republic at the Mexicana Silver Mine, situated between 13000 to 15000 feet above the Sea-level the oppressive effects of the rarified air, is clearly manifested on the Indian labourers. The miners live in badly-lighted little huts, above the clouds, where the thermometer always remains below zero in the Shade, the elevation surpassing by near than a thousand feet, the Salt regions of Tibet and Himalaya. To quote from "Brown's Countries of the World" "Although the extremely rarified air regularly causes headaches and other indispositions to novices, the lungs soon become accustomed to it, and it produces a peculiar activity. The movements of the body, at this height however cautious they may be, occasion a palpitation of the pulse and a very great agitation of the respiratory organs. It is dolorous to hear the sighs and groans

of the apnoea of Porters who come from the depths of the mine to discharge their sacks filled with from fifty to eighty Kilograms of ore." Such statements and illustrations as these however, must be taken in the light of what we have already seen to be the probably true explanation of the action of rarified air.

V Suspended Matter of the Air.

We have already seen that the atmosphere abounds with floating particles, and have dealt with the action of air-borne dust and micro-organisms to the process of putrefaction, and the dissemination of infection and allied forms of disease. But the floating particles of the air both organic and inorganic may affect the health not only in virtue of their specific infective nature, but because of the more direct mechanical disturbance they are capable of setting up when received into the body. Such disturbance may take the form of local irritation either Chemical or physiological, manifesting itself on the cutaneous or mucous surfaces. Again atmospheric particles on gaining access to the body may be followed by poisonous effects and particles of this kind are usually of mineral origin.

a Vegetable particles.

Various of the organic particles carried by the atmosphere are derived from the vegetable Kingdom. The experiments of Dr. C. H. Blackley of Manchester have clearly shown that hay-fever is due to the influence on certain mucous membranes of various species of pollen grains.

Pollen & hay-fever

It has been found that large quantities of pollen float in the air during the Summer months, and that the number and severity of cases of hay-fever depends on the amount of pollen present in the atmosphere. The application of the pollen to the various mucous membranes has been found experimentally to produce the symptoms of hay-fever, the pollen of grasses being

most potent. The action of the pollen-grains does not seem to be influenced by their size or form, but depends upon the bursting of the pollen-sac, from absorption of moisture from the contiguous mucous membrane, the contained minute granules being extruded and causing irritation. The widely varying conditions of constitution and susceptibility is forcibly illustrated by such facts as these, when we see so few persons comparatively subject to hay-fever, although living in an atmosphere often laden with pollen-grains. The pollen may be said to furnish the ~~cause~~ "causa proxima" comparable with the contagium virum of specific disease, but there must doubtless be the inherent or acquired tendency, or exposure to the special predisposing causes upon the mucous membranes can become morbidly influenced by the irritating particles. A similar argument applies as we have seen to epidemic pestilence, when during an outbreak, some persons are attacked and others remain quite free from disease.

Odoriferous matter.

Of other vegetable matters in the air, we need only refer to the power many drugs possess of manifesting physiological action when present in a fine state of division in the atmosphere. Thus in sensitive subjects - Ipecacuanha produces violent sneezing & other symptoms of discomfort, owing to the inhalation of particles when the drug is being compounded.

Resinous emanations.

Odoriferous matters of vegetable origin such as essential oils, balsams and resins, may be atmospherically conveyed, and in the form of inhalations we employ them therapeutically. The air of pine forests and wooded districts, doubtless owes its beneficial effects in cases of respiratory disease, in part to the resinous evaporation from trees and shrubs. At Arcachon ~~the~~ the emanations from the

pine-trees are on some days very marked and some of the good effects in Cases of phthisis, are ascribed to this element in the atmosphere. Such emanations have doubtless an antiseptic action, and together with the presence of ozone, may account for the salubrity of the air of wooded districts.

6. Trades and Manufactures

And now let us consider briefly the influence of trades and manufactures on the composition of the air. We have already alluded to the noxious gases and offensive odours with which various industries contaminate the atmosphere we breathe. But perhaps even more serious and injurious are the effects which result from the inhalation of an atmosphere charged with solid particles.

Smoke

The enormous volumes of smoke which are daily poured forth constitute the most common impurity in the atmosphere of towns and manufacturing districts. Of the injurious effects of ~~an atmosphere~~ the inhalation of such an atmosphere laden with particles of carbon, we have abundant example in the greater prevalence of various forms of respiratory disease and dependent upon these, the higher death-rate in smoky districts. In estimating the average mortality from such diseases we must of course take into account, all the other possible factors of a town life, such as overcrowding, deficient ventilation, and defective sanitation generally. The presence of smoke which consists of particles of carbon in a fine state of division, in the air becomes very apparent in towns in foggy weather. Thus how often we note the dark or even black colour of expectorated matter during the prevalence of fog?

But carbonaceous particles may exist in the atmosphere

Coal-dust.

to a much more dangerous extent, as in the air of mines, where the constant inhalation of particles of coal-dust is the common cause of anthracosis and fibroid phthisis.

Varieties of dust particles

Amongst the very numerous kinds of dust particles given off into the air by the various industries, we may mention the particles of steel and iron in grinding and in shovelling steel and iron filings and turnings; the particles of stone and grit in quarrying; organic fluff or "fly" in shoddy mills, flax and woollen factories and mills; the dust in potteries, chemic works, button manufactories, in polishing and cement works in brass works, in marble and steel polishing works of various sorts, especially where emery is used. ~~Some of these substances~~ The severity of the effects is chiefly dependent on physical conditions of the particles, such as angularity, roughness, smoothness; and we shall now see in what way these fine particles do mischief.

Their effect on the air-passages.

There exists in connexion with the mechanism of respiration, an automatic arrangement, whereby inhaled particles are prevented from settling in the lungs. When solid particles reach the larynx the irritation they set up in the delicate epithelial lining membrane excites the reflex action of coughing. If this should prove insufficient to expel the particles, the latter become enveloped by a glairy fluid, which is poured out by the laryngeal and bronchial follicular glands and by a further act of coughing this fluid is expectorated carrying the particles with it. Should they however find their way lower down into the air-passages the beautiful mechanism of the cilia covering the mucous membrane comes into play.

Mechanism of expulsion

These cilia by their constant waving movement in an upward direction, tend to carry the solid particles away from the lungs, and so out of harm's way. This wonderful provision is sufficient for the purpose, provided the strain be not too prolonged, but when the supply of irritating particles is constant or nearly so, the nerves and muscles involved in the mechanism become exhausted and cease to perform this process of expulsion. The irritating particles are now no longer removed from the delicate mucous membrane of the air-passages, this membrane becomes swollen and inflamed, and its secretion is poured out in increased quantity, but it is no longer healthy mucus, but an altered thickish fluid much resembling actual fibrine, which has to be brought up by many acts of coughing. If the irritation is still kept up by the inhalation of fresh particles of dust, the condition remains a constant one, and chronic bronchitis, with all its possible secondary troubles such as emphysema, dilatation of the right ventricle with tricuspid regurgitation, is the result. But the inflammation at first only affecting the superficial membrane, may sink into the deeper tissues, and affect the lung itself, leading to bronchial & interstitial pneumonia, pneumonia proper, and predispose at least to fibroid phthisis. To the above mechanism for the expulsion of particles, we may add the important assistance afforded by the bronchial muscles. These have not only a regulating function, limiting the quantity of air admitted to the air-vesicles, but in virtue of their peristaltic action, doubtless materially aid in the expulsion of phlegm, and are hence termed by Prof. Gairdner, the "Scavenger-muscles." The

Diseases they may lead to.

irritation set up by inhaled particles may cause spasmodic contraction of these ~~particles~~ muscles, giving rise to the set of symptoms collectively known as "asthma".

Mineral particles. Their poisonous effects. Lead oxides.

There is scarcely a mineral employed in the arts, which cannot by inhalation excite a predisposition to disease. Some of these substances not only act as mechanical irritants when breathed, but as direct poisons. For example, manufacturers of white and red lead, often suffer from lead poisoning through inhalation of the oxides. These oxides when suspended in the air often impart to it their distinctive white or red colour. Again, workmen who use arsenical compounds as in the making of wall-papers, artificial flowers &c. are often the victims of poisoning from Arsenic. The

Arsenical wall-papers.

poisoning by arsenical wall-papers seems to be due almost entirely to the inhalation of the particles flown off into the surrounding air. Owing to variations of heat and moisture the green particles are constantly being set free from the paper and carried about the room by ventilation. The green pigment may contain as much as 5% of arsenic, so that a square foot of the wall-paper contains on an average, as Prof Simpson has pointed out, more than sufficient Arsenic to poison twelve persons.

We have now considered the principal atmospheric conditions productive of disease and dealt with the various States of the air as affecting the health of mankind. With such a subject before us an exhaustive study would be impossible within the limits of a Thesis,

VII. Electrical phenomena of atmosphere

and then still remain many aspects of it upon which we cannot enter. In conclusion we would only make mention of the electrical phenomena of the atmosphere a subject which has hitherto been very little investigated & concerning which little is definitely known. With many people a feeling of languor and depression and more commonly severe headache sometimes intense in degree heralds the approach of thunder, the symptoms disappearing with the discharge of atmospheric electricity. But how adequately to account for such effects as these is as yet a matter of conjecture.