and yellow fever, written by Dr. Edward H. Barton, exhibits a rare example of patient research; he having discussed with minuteness all the epidemics of cholera and yellow fever in relation to the meteorology of the district as far back as the meteorological observations are trustworthy, and he points out the meteorological condition during the rise and progress of each epidemic. His results, in many instances, are in close accordance with those I have stated in my Report.

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## No. II.

### Report on the Examination of certain Atmospheres during the Epidemic of Cholera. By Dr. R. D. Thomson.

THE facts with which we are acquainted in reference to the condition of the atmosphere, indicate that its main constituents, oxygen and nitrogen, are very stable in their proportions. The mean of experiments made on the composition of the air in various parts of the globe shows that the amount of oxygen by measurement is approximately 21 per cent., and that of the nitrogen 79; but in certain cases within the tropics, the conditions of which have not yet been thoroughly investigated, the quantity of oxygen falls to 20·3 per cent. The influence of this diminution would be slightly to lower the weight of a given bulk of air, a result the reverse of what it is understood was observed during the first introduction of cholera into this country (Prout). No physiological facts seem to indicate that such a slight departure from the normal state of the air would be attended in the human organization with a disease possessing a regular type, nor even would such a consequence be liable to occur during greater irregularities in the atmospheric equilibrium in this direction. The agency of carbonic acid in inducing disease can scarcely be quoted as likely to occur on a great scale in nature, since the diffusive power of this and other gases, so sagaciously discovered by Priestley, and applied by him to explain the respiratory process, always tends to preclude its concentration, except under a limited number of peculiar circumstances. The accumulation of ammonia, another recognized normal constituent of atmospheric air, from the insignificance of its possible amount, could scarcely be quoted as a likely source of disease, however much it might be valued as an indication of the collateral existence of other bodies of organic origin in the air. If this reasoning be admitted, we should be compelled to look for the source of endemic diseases to the vapour of the atmosphere or to organic bodies, either disseminated through the air by the agency of heat or evaporation from inorganic or organic matter placed on the earth's surface. Intermittent fever or ague is one of those diseases which has been thoroughly ascertained to be endemic, and to be dependent on terrestrial causes of a peculiar character. Whether the cause be the nature of the atmosphere in which the human system is immersed or the introduction of a poison into the circulation, is a question open to discussion. The fact that removal from the marshy or intermittent atmosphere to an elevated and dry mountain summit or table land obviates or speedily terminates the morbid accession, affords support to the view which would ascribe the occurrence of the disease to immersion in an atmosphere nearly saturated with vapour, and the consequent interference with the necessary evaporating processes over the surface of the healthy body, and even possibly with the exhaling powers of the pulmonary organs. But this aspect of the case seems to obtain less support from the circumstance that relapses are liable to supervene when the patient, even at long intervals of time, is placed in atmospheres where different conditions prevail to those which originally gave origin to the disease. Of 22 cases of ague which were under my charge at Whampoa, in China, in a pre-eminently intermittent atmosphere, situated in extensive rice grounds which are flooded by the tide, relapses occurred in five instances. Three of these relapses came under treatment in the China sea; but three other persons were attacked on the same sea with ague, who had escaped all its symptoms in the malarious atmosphere of Whampoa. Another relapse took place in the Indian ocean, and the fifth relapse occurred in Table Bay, with a temperature of 71° and dry weather. But the most striking fact was that three persons who had enjoyed good health in China were seized with ague, one the second day after losing sight of the Chinese continent, and two others in the China and Java sea, while another instance occurred off the Cape of Good Hope. On scrutinizing carefully these facts, it appears that least difficulty is experienced in explaining them by the supposition that a poison had been absorbed into the system and had incubated and developed itself into disease in such constitutions as were predisposed to a morbid state. But there was no disposition manifested towards the propagation of the disease from one individual to another. I have not observed a similar character to prevail as to the protracted period of incubation in the remittent fever of China, but I think it probable that similar cases may have occurred. It is well known that the African remittent fever has its symptoms developed frequently at intervals of two or three weeks after exposure to the causes which seem to produce it (Captain Owen's Survey of the East Coast of Africa); and there is a sufficient analogy between all these types of fever to warrant the suspicion, at least, that they are regulated by analogous laws.

Brought by such a process of reasoning to the inference that the production of endemic diseases, as illustrated in the case of intermittent fever, is most easily explained by the hypothesis that a poison is introduced into the system by absorption from a malarious atmosphere, it remains to be considered whether the poison is disseminated in the air in the gaseous, vaporific, or mechanically diffused condition. There are no facts with which we are acquainted having any tendency to indicate that the respiration of vapours is capable of producing a disease characterized by a regular type, or that gases act physiologically otherwise than as dilutents of oxygen, or as simple poisons. Neither is the evolution of gases alone from organic matter calculated to induce such diseases of endemic nature as are recognized by a regular sequence of symptoms. For example, the extrication of sulphuretted hydrogen, one of the most poisonous gases with which we are acquainted, or of phosphuretted hydrogen and resulting poisonous phosphorous and mild phosphoric acids, would not be followed in a marshy district by ague, so far at least as our knowledge of the physiological action of these bodies enables us to predicate. The products of putrefaction of an elastic gaseous nature are not the chemical substances most to be dreaded in the production of disease, as is demonstrated by the result of such action on the poison of cow pox or small pox, or of dissection wounds. It is the fresh, undecomposed matter which is alone capable of propagating the noxious influences so familiar in the instances to which allusion has been made; and any agent which interferes with the integrity of the morbific molecule destroys its capability of inducing a regular disease.



It was in consequence of the result of this mode of reasoning that I have long been of opinion that the cause of endemic diseases, if disseminated in the air, must exist there, either in the condition of solid particles, or in a state allied to the vaporific form. The practical bearing of this conclusion is, that we are not to expect any information respecting the morbid condition of the air from experiments on a small scale upon the chemical constitution of the normal gases in any given atmosphere, or even on the minute traces of abnormal gases which may be detected by the most delicate appliances of science. The fact, which seems to be well authenticated (Boussingault), that the inhabitants of South America are enabled in some localities to withstand the attacks of endemic diseases by mechanical applications, such as veils placed before the organs of respiration, so as to sift the air from morbid solid particles, supports the view of the organic nature of malarious poison. Absorbent porous bodies used instead of veils, such as charcoal, have been long disused in manufactories from their power of condensing gases, which are replaced by the inspired air in its passage through them, and are thereby carried into the circulation. Proceeding on the idea involved in this view of the nature of the cause of endemic and epidemic diseases in 1849–50, at the former invasion of cholera, I subjected a a large quantity of external atmospheric air in an infected district to chemical investigation with the view of condensing any vapour, or of detaining solid particles which might be disseminated through the air. The result was entirely negative. (See *Chemical Researches on the Nature and Cause of Cholera,—Transactions of the Royal Medical and Chirurgical Society*, vol. xxxiii. 1850.)

When the Board of Health, during the occurrence of the epidemic in 1854, gave its sanction to investigations bearing upon the discovery of a tangible cause of the disease, I began to follow out on a more extended scale the experiments which I had executed in 1849–50. For this purpose, as before, the system of aspiration was adopted for drawing a quantity of air through tubes, and subjecting it to various condensing influences. A large air-tight cistern, of the capacity of 16 cubic feet, was constructed of wood and lined with zinc. A pipe connected with a water cistern conveyed water to an aperture in its top, while a tap at the bottom allowed the cistern to be emptied. The cistern was fitted with a graduated glass gauge tube at the side, which indicated the amount of water and air contained in it. An aperture in the top of the cistern was supplied with a flexible tube, and was connected with Woulfe's bottles and tubes, containing fluids through which the air was drawn from an infected atmosphere by the aspirating power of the water contained in the cistern as soon as it was allowed to flow out by the lower tap. From the interest taken by the authorities of St. Thomas's Hospital in all that concerns the progress of medical science,* I was enabled to erect this apparatus adjoining the wards set apart for the reception of cholera patients, and without moving the cumbrous mechanism could thus examine the expired air of the cholera ward under various circumstances together with the external air, and the air of other atmospheres. The ward whose atmosphere was specially examined was the casualty ward of the hospital occupied by female patients attacked with the epidemic, but the atmosphere communicated with an adjoining ward filled with male cholera patients. The meteorological conditions which prevailed during the period when a series of experiments was carried on have been distributed under five different heads or tables. From the dates appended to these tables it will be observed that the apparatus was kept in action during 87 days, or, with short intervals caused sometimes by its slight derangement, the experiments extended with little intermission from the 13th of September to the 23d of December inclusive. The total quantity of air subjected to examination under different conditions during this period approached 1,800 cubic feet, or precisely 1,794·6 cubic feet.

## First Experiment.

*Examination of the Atmosphere of the Cholera Ward when filled with Patients.* (Table I. Plate I.)

In this experiment glass tubes carefully washed with distilled water and dried were conducted from the centre of the ward along the roof of the ward, and terminated by dipping into distilled water in a Woulfe's bottle. A second Woulfe's bottle was connected with the first bottle by a tube dipping likewise into distilled water. Beyond these was an U tube, which was filled with pumice stone moistened with sulphuric acid. The U tube was connected with the aspirating cistern by means of a flexible vulcanized caoutchouc tube. The cistern being filled with water, and its interior placed freely in communication with the system of tubes and bottles, on the tap at the bottom of the cistern being opened, the cistern began to be emptied, the water running into a sink placed immediately beneath, while its place was taken by the air of the ward, which traversed the distilled water in the Woulfe's bottles and the sulphuric acid in the U tube. The distilled water was carefully prepared, and just before being introduced into the Woulfe's bottles it was rapidly boiled. A portion of the same water in a stoppered bottle was placed beside the apparatus, and was carefully examined microscopically after the completion of the experiment, and compared with the distilled water through which the atmosphere of the ward had passed. The air was allowed to stream through the water and

* The drawings of the objects condensed from the several atmospheres have been most skilfully and truthfully executed by Mr. Tuffen West.

AIR OF CHOLERA WARD; Oct. 5th to Oct. 21st 1854. Pl. I.

a. *Blue and red cotton.*
b. *Hair.*
c. *Wool.*
d. *Fungi.*
e. *Sporules.*
f. *Fungi in very Early stage.*
g. *Vibriones.*
h. *Fungi in advanced stage.*
i. *Particles of Silica and Dirt.*

sulphuric acid during four days, until 98·6 cubic feet had traversed the tubes. On the second day after the commencement of the experiment it became very evident that organic matter was carried along with the air in its transit through the tubes, as the sulphuric acid in the U tube became distinctly dark coloured, and as the process proceeded, this charring effect augmented until it assumed a colour analogous to that familiar to chemists in the case of Nordhausen acid. The distilled water subjected to the action of the air was found to give a strongly acid reaction with litmus paper. On the addition of nitrate of baryta a copious precipitate of sulphate of baryta fell, which was insoluble in hydrochloric acid. The source of this acid was no doubt the product of the combustion of the sulphur of coal used for heating the ward, and probably also of the gas employed for lighting the ward. The sulphur of the pyrites of the coal and the traces of bisulphide of carbon frequently found in gas, yield, when subjected to combustion, sulphurous acid, which again, when brought in contact with water and air, speedily takes up more oxygen, and is converted into sulphuric acid. No chlorine nor other mineral acid could be detected in the distilled water. During the course of the experiment delicate filaments became distinctly visible in the distilled water, which were easily recognized without the application of any magnifying power; and after the cessation of the experiment they increased in magnitude, thus giving strong evidence of their vital vegetable character. It deserves notice that the greatest amount of vegetation and of mechanical matter visible to the eye existed in the second Woulfe's bottle and not in the first, which shows the difficulty of detaining such light bodies by the resistance of water alone. Plate 1 exhibits a view of the objects visible at one time under the field of the microscope, with the exception of *h*, which has been introduced subsequently, to exhibit a more advanced stage of the vegetation of *d*. The coloured fibres in the drawing are good examples of filaments of cotton, which are characterised by their ribbon-shaped flatness and sharp edge, while they are tubular, and somewhat tend to a spiral curvature. Two filaments of this description are visible in the drawing marked *a*: the larger painted with royal blue, or steamed Prussian blue, and the smaller of a pink tint, derived probably from madder. These objects are magnified 150 diameters. The figures attached to the other objects indicate the number of diameters to which they have been magnified. The object in view in thus presenting them was to afford the advantage of a prospect of everything existing under the object glass of the microscope at the same time. To form a correct notion of the nature of the drawing, we have only to consider the slide containing the figures represented to remain stationary under the microscope, and that some of the smaller objects have been increased in size merely by altering the powers as was found to be requisite. The most striking objects in the drawing next to the cotton fibres are filaments of hair, *b*, and probably wool, *c*. On the latter objects it is by no means easy to give a decided opinion; but their characters, perhaps, approach more nearly to those of a worn portion of wool than to any other object likely to be present in such a locality. Grouped around and intermixed with the cotton filaments, may be observed fine confervoid looking fungi, *d*, tubular, with their tubes occupied at intervals with granular or vesicular bodies; *f* represents these fungi in a very early condition of their growth, and *h* one which has been subsequently introduced into the drawing, and which I endeavoured to bring towards maturity by growing in shallow water. During the limited period at my disposal, I did not, however, observe any tendency towards the formation of fructification. Sporules (*e*) were abundantly distributed over various portions of the field of vision, and in one specimen examined, two potato starch granules could be distinctly detected. In various points small masses of siliceous matter, traces of soot and dust were visible, which seem to have been entangled in the web of fungoid mycelium, which rapidly increased in volume by continuous growth; vibriones (*g*) were also readily recognized in numerous parts of the field, which were characterised by great activity and rapidity of transit from one point to another. Some of these were of considerable length, but were too minute to enable their anatomy to be made out even by a power of a thousand diameters. It is not easy to decide as to the nature of the dottings and minute lines which can be traced along the margins of the larger objects, although their forms do not present much dissimilarity to those of vibriones (although no movements were recognized). They also resemble what has been observed among the products of fructification of certain classes of lichens. From this experiment we learn that considerable quantities of matter are diffused in an inhabited apartment through the most distant portion of the enclosed atmosphere from that in which the patients breathe and are immersed, since the tube employed in the trial detailed opened near the ceiling of the room, and yet constituted the medium by which fragments of cotton fibre detached from the garments of the female inmates were conveyed. Besides these mechanical impurities, the source of which can be so readily detected, we find likewise the sporules of vegetables and likewise the ova or germs of animal existence. This view seems more consonant with the circumstances than the idea that the plants and animals themselves were actually dispersed through the atmosphere, although there appears nothing paradoxical in the anticipation that if particles of dress are so volatile they may be accompanied by portions of vegetation which may also have been previously deposited on the same articles of clothing.

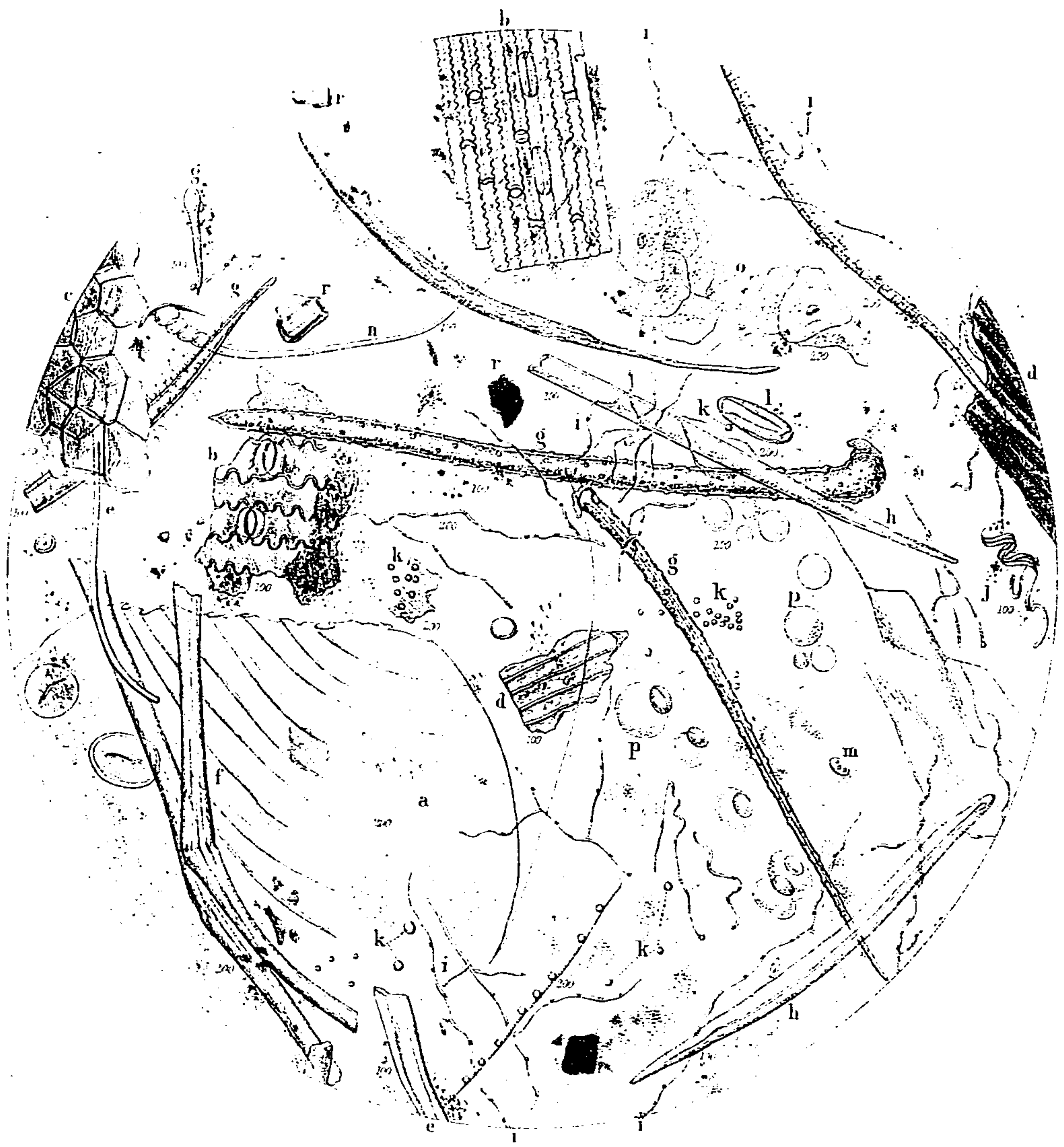
### Second Experiment.

*Examination of the Atmosphere of the Cholera Ward when half filled with Patients.* (Table II. Plate II.)

As I had resolved to prosecute the examination of the air of the cholera ward continuously, and the first experiment having terminated when cholera was somewhat on the wane, the second experiment was entered upon when the amount of patients did not exceed half of the previous number. New bottles having been charged with carefully prepared distilled water, the apparatus was arranged so that the air should traverse two Woulfe's bottles, containing

AIR OF CHOLERA WARD:
(Partially Empty.)
Sept<sup></sup>

Pl. 2.



a. *Organic matter*
b. *Vegetable Epiderm.*
c. *Vegetable Cellular Tissue.*
d *Fragments of Wood.*
e *Cotton.*
f *Linen?*
g. *Vegetable Hairs.*
h *Sponge Spicula?*
i *Fungi very minute*
j *Fragment of spiral vessel.*
k *Sporules.*
l *Spore case of Oidium Tuckeri?*
m. *Sporecase?*
n. *Stipes of Botrytis?*
o. *Epithelium*
p *Oil globules.*
r *Silica and Dirt.*

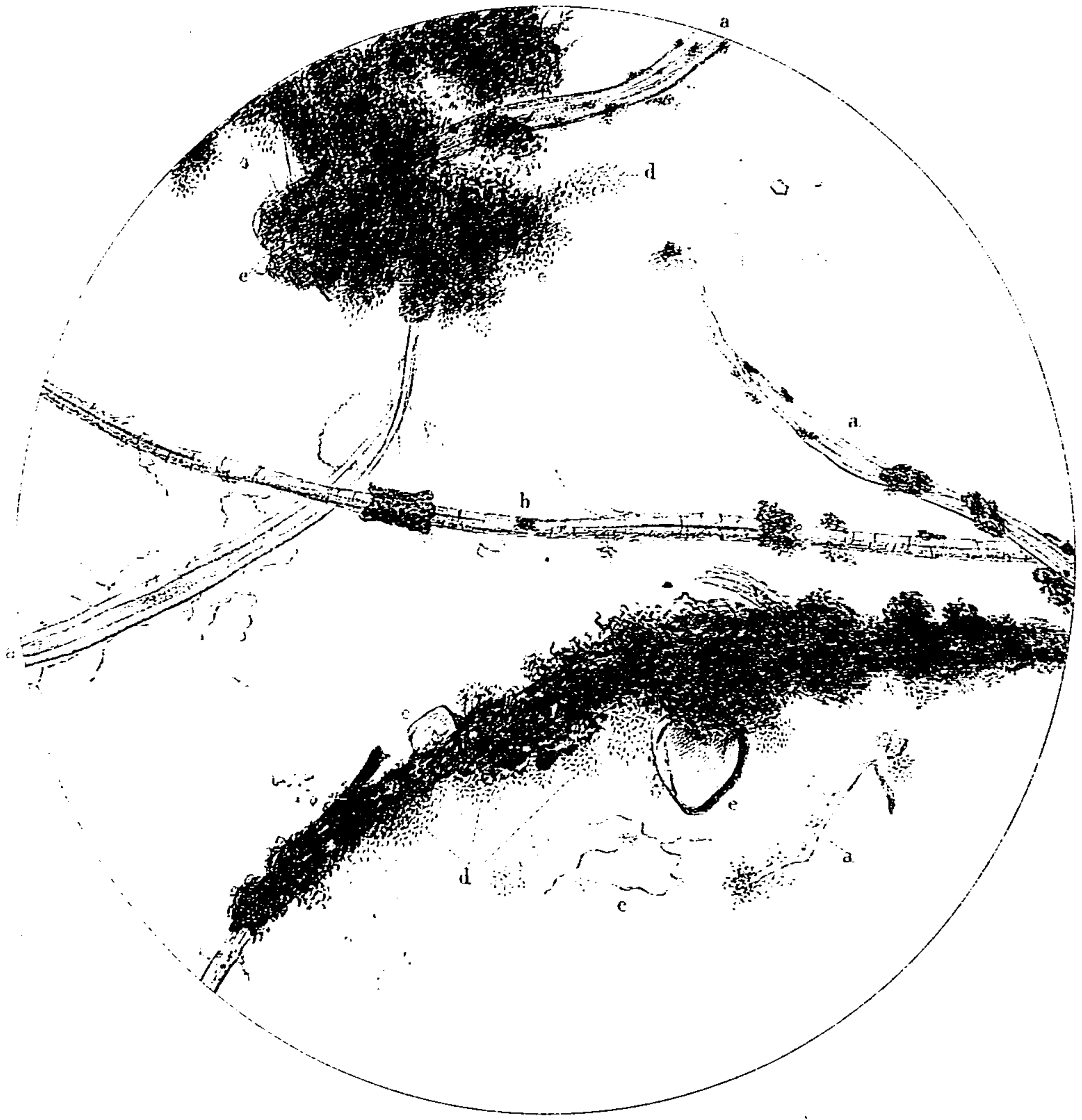
distilled water, and a U tube, which was surrounded with ice and was placed between the Woulfe's bottles and the aspirating cistern. Table II. affords a view of the conditions of the atmosphere during the experiment, with the amount of air passed. The air examined amounted to 240 cubic feet, and was allowed to pass through the tubes during 13 days. The quantity of air transmitted during that period was 240 cubic feet, and the proportion passed daily was pretty equally distributed over the fortnight during which the experiment lasted. The water in all the bottles was found to be strongly acid at the conclusion of the trial, and to give a copious precipitate with nitrate of baryta, indicative of the presence of free sulphuric acid. The second Woulfe's bottle contained a larger amount of visible matter detained than the first bottle, while in the U tube, which had been surrounded by the ice, a very considerable quantity of organic and other forms could even be detected to a certain extent by the eye. The amount of water in the U tube, which must have been conveyed from the distilled water in the Woulfe's bottles by the transmitted air, and condensed by the cooling application, amounted to above a fluid ounce, since the tube was carefully cleaned and dried out at the commencement of the experiment. I find it noted that the U tube contained more mechanical matter diffused through the water condensed in it than appeared to exist in either of the Woulfe's bottles. Plate 2d represents an accurate delineation of the forms visible under the field of the microscope at the same time, the powers employed varying from 100 to 200 diameters, as represented in the attached figures. The forms are somewhat different from those in the first plate, for while fragments of higher organic tissues predominate the comparative absence of fungi is sufficiently striking. *a* appears to be organic matter, but of too indefinite an aspect to enable an opinion to be risked of its origin; *b* is obviously vegetable epidermis, and may have been detached from an onion used as food; *c* is vegetable cellular tissue; *d* is a fragment of wood; *e* a filament of cotton dress dyed with madder and Prussian blue; *f* bears much resemblance to a filament of linen; *g* seems to be vegetable hairs (wheat?), approximating in some respects to those of tobacco leaf, but this suggestion occurred from the circumstance that tobacco was smoked in the adjoining ward, and on one occasion at least, in the ward itself; *h*, from its stationary character, it was concluded, was a sponge spicula, although in some respects it might be mistaken for a higher order of organism; *i*, minute fungi, are remarkably scanty in amount compared with their prevalence in the products of the first experiment. Sporules, *k*, however, were distributed scantily over the field, and a spore case, *m*, apparently could be detected, while *l* bore a strong resemblance to the spore case of *Oidium Tuckeri.* A fragment of spiral vessel, *j*, occurs on the right of the plate, similar objects being visible in the epidermic membrane *b*. The form represented at *n* has much similarity to the stipes of Botrytis; *o* is obviously a portion of epithelium, which has floated up after detachment from the inmates of the ward; *p* bears a strong resemblance to oil globules. Throughout the field dark masses are noticeable which seem to be particles of siliceous matter and various impurities which are capable of being detected in all atmospheres where disturbance of dust is liable to take place. The present experiment differs in a remarkable degree from the results of the previous trial, by the circumstance that no animal matter was capable of being detected in the second case, while in the former instance a considerable amount of vitality was clearly discernible. But after careful examination repeatedly resumed, no trace of vibriones was visible in the matter detained in the second air examined, notwithstanding the much larger proportion of atmosphere conveyed through the tubes. We observe also among the present products epithelial matters from the human surfaces, and are thus presented with ample evidence of one of the consequences of a too condensed population by the possible thorough contamination of the air which must be used for respiration with not only the impure exhaled gases, but likewise even with solid particles of human origin, detached and diffused through the atmosphere in which the inmates of houses are immersed.

### Third Experiment.

*Examination of the Air of the Ward after the Removal of all Patients.*
(Table III. Plate III.)

In this trial the apparatus was preserved in the same state of arrangement as in the second experiment, the bottles, however, and tubes, as in the previous cases, being quite new, and having never been employed for chemical purposes previously; they were carefully washed out and dried. Two Woulfe's bottles occupied the same position as previously, and a U tube surrounded by a freezing mixture connected the last bottle with the aspirating cistern by means of a vulcanized caoutchouc tube. This experiment lasted for fifteen days, from the 5th to the 21st of October inclusive, and comprehended the examination of 304 cubic feet of ward atmosphere; (Table III.) The patients had ceased to enter the ward in consequence of the decrease of the epidemic, and the only disturbance which could occur in the atmosphere must have been due to the operations of cleaning and airing the apartment. The distilled water through which the air passed was, as on the preceding instances, possessed of an acid reaction due to the presence of sulphuric acid. The visible amount of detained matters was more minute than previously, and it was this circumstance that led to the aspiration of more air in this than in the foregoing trials. But, although no patients existed as inmates of the ward, there was a free communication with the adjoining ward, which was occupied by males affected with the epidemic, where fires and gas were in an active state during the twenty-four hours. This is sufficient to account for the large amount of lamp black (plate 3 *e*,) which occupies such a prominent place in the drawing. The circumstance that the ward had been occupied by females, and had undergone the process of sweeping and washing, explains the occurrence as in the former experiments of the blue and red filaments of cotton, fig. *a*, and of what corresponds best with wool, *b*. But notwithstanding the amount of air which traversed

AIR OF EMPTY CHOLERA WARD; Sept 13th to Sept 19th 1854. Pl. 3.




a. *Cotton fibres.* b *Wool?* c *Fungus.*
d ?
e *Carbonaceous & Siliceous Particles*

EXTERNAL ATMOSPHERE;
Oct.r 21st to Nov.r 16th 1854.

Pl. 4


a Cotton fibre ?	c Crystalline body	e Sporules

b Wool ?	d Fungus in various stages	f Carbonaceous matter



the tubes, it cannot fail to attract attention, that but a minute fragment of fungus (*c*) remains, while it is still more worthy of remark, that sporules seem to have entirely ceased to pervade the same atmosphere, which during the period when the ward was filled with inmates, was characterised by abundance of these vegetable forms. The siliceous particles mixed with the fuliginous matter (*c*) constitute a considerable portion of what is often termed dust, and what is so familiar when a strong draught is made to permeate an apartment, or the deposit on the objects in a room is disturbed. The objectionable character of an atmosphere contaminated by dust and smoky particles is not, however, diminished by its familiarity, since pathology points out to us the results of such noxious influences in the densely black charged lungs of the weaver and collier; the former with the lamp black from the murky atmosphere of his oil lamp, and the latter from a similar cause, with the superadded auxiliary of the finely diffused coal dust of his subterranean cell. These, and the facts which have already emphatically forced themselves on our attention during the discussion of the present examinations of air, show us that when we can detect such impurities in a comparatively well ventilated apartment, we may not be surprised if the air of densely crowded dwellings, allowed to stagnate as in some of the cellars in the Soho district which I visited, packed with six to twelve inmates in a cube of 12 feet, should induce disease and early death. Whether we admit or not with the Stoics of old "that every man is rich who has the free enjoyment of earth and air," certain it is that the human being must be reckoned poor indeed who is continually immersed in an impure atmosphere.

### Fourth Experiment.

*Examination of the External Atmosphere.*

(Table IV. Plate IV.)

In this research the same form of apparatus was employed, and the same mode of arrangement as has been already described, with the modification in the adjustment that the tubes leading from the ward were dispensed with, and their place supplied by a flexible caoutchouc tube, which, protruding into the external air through a window, was carried along the wall of the building a few feet, and was then made to project. The experiment lasted for 21 days from the 21st October to the 16th of November (Table IV.), during which 560 cubic feet of air streamed through the apparatus. It was long before any visible appearance of mechanical deposit was exhibited. But as soon as any object was discernible a comparatively rapid augmentation in volume ensued, affording strong evidence of the development of vegetation so beautifully represented in Plate 4. The tardiness in the growth of the fungus may perhaps receive some explanation from the fact which is very obvious in all the drawings, viz., the presence of some foreign matter, as wool or cotton. Until some such bodies were detained by the water, it may be easily understood that no very striking object could be discerned by the eye. As soon, however, as a filament of cotton gained access to the fluid, it would exercise an obvious tendency to aggregate any other extraneous bodies which might be diffused through the water, and by affording a point of attachment to sporules would enable them to remain in a certain degree of comparative rest, and thus enable the incipient stage of germination to proceed. For, on the cessation of the streaming of the gas through the water, and afterwards, when the fluid was placed in perfect stillness, even in the absence of light, vegetation advanced with great rapidity. Plate 4 exhibits a filament of cotton (*a*) of a brown tinge, magnified, as well as the other objects, to the extent of 200 diameters. Interlaced with it is what agrees most nearly with a filament of worn wool (*b*), and a crystalline body (*c*) somewhat resembling in some respects a sponge spicula. A fungus (*d*) in various stages of its growth occupies the prominent portion of the field, and sporules (*e*) similar to those probably from which the plant originally sprung are observable in different parts of the drawing. Throughout the vegetable masses dark fuliginous matter is distributed, derived from the soot of the chimnies or from the gas burnt in the wards. The proximity of the source of the air to the building renders it possible that the vegetation may have proceeded from the same source as in the preceding experiments, and this could only have been decided by experiments conducted in different free atmospheres at a distance and in approximation to inhabited neighbourhoods. As during the present investigation every day was occupied in the examination of different atmospheres for comparative purposes, more prolonged researches must be deferred to another opportunity. The present results seem to hold out encouragement that, by various improvements and expansions in the mode of experimenting which have suggested themselves in the course of the collection of the facts observed in this report, some important additional light may be thrown on the subject of impure atmospheres, and on the best means of removing the extraneous matters which constitute their contamination, either by ventilation conjoined with chemical applications or by mechanical or other auxiliary means. In common with all the experiments, except the first, when the ward was filled with diseased patients, no trace of animal movement could be detected, and although the acid reaction of all the solutions was equally distinct, no vibriones were visible except on the first trial, although in that instance the amount of air subjected to examination was greatly inferior to that employed in all the subsequent examples.

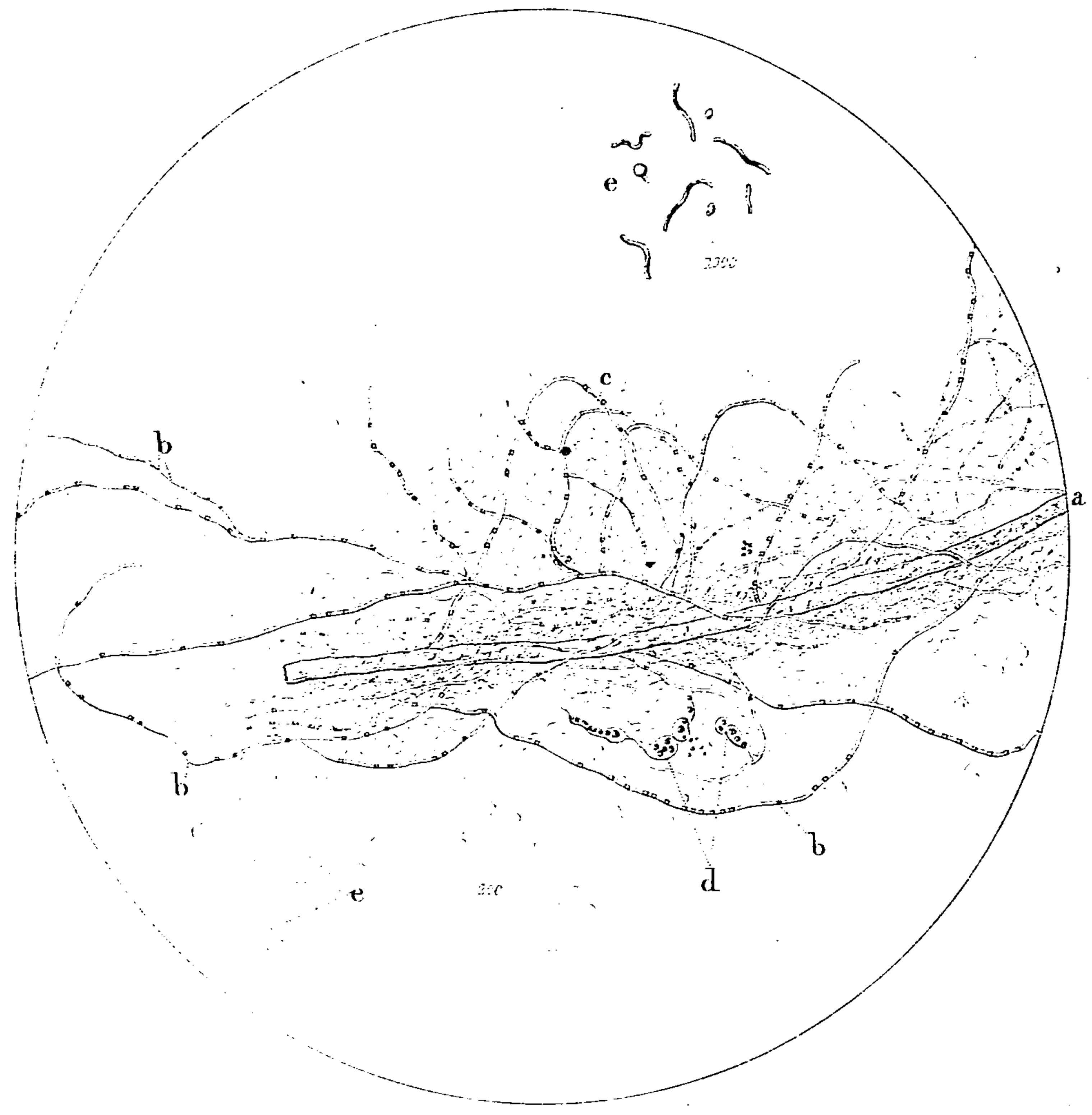
### Fifth Experiment.

*Examination of the Atmosphere of a Sewer.* (Table V. Plate V.)

There can be no doubt in the mind of any one who has been in the habit of directing his observation to the condition of the soil in a city, that there exists under the dwellings of the inhabitants, and under the streets, sources of impurity which may well induce us to ascertain if some amelioration of the present circumstances cannot be adopted. To test the conditions generated by the fluids thrown off from city habitations, the present experiment was made. The most accessible means of chemically examining the question,

SEWER ATMOSPHERE. Pl. 5.

Nov.r 22nd to Dec.r 23rd 1854.




*The figures refer to the number of diameters*

a. *Fragment of Wool?* b. *Fungus.* c. *Sporules.*
d. *Spore cases?* e. *Vibriones.*

Ford & West Imp.

seemed to be to subject to scrutiny the atmosphere in immediate contact with these fluids themselves. For this purpose a new gas pipe was conducted from the atmosphere of the sewer, and connected with the apparatus by means of a flexible tube. The extremity of the gas pipe dipped downwards to within a foot of the surface of the contents of the sewer. The Woulfe's bottles were arranged as in the previous experiments with a U tube, the air having been allowed previously to stream through the flexible tube alone in connexion with the cistern to displace the common air contained in the apparatus. The experiment was carried on during 27 days, from the 22nd of November to the 23d of December inclusive, and during that period, 592 cubic feet passed through the tubes. (Table V.) The amount of mechanical matter detained was less than in any of the preceding experiments, but still it was visible to the eye, and when allowed to deposit in an inverted conical vessel, the sediment could be, although with some difficulty, from its levity, collected for the purposes of microscopical examination. The distilled water, which in all the previous investigations had been rendered strongly acid, yielded on the present occasion the most unequivocal evidence of powerful alkaline reaction, due to ammonia, which is an usual result of the decomposition of such animal and nitrogenous vegetable substances as occur in the sewer waters. Plate 5 exhibits a delineation of the matters detained in the transmission of the sewer atmosphere through the distilled water. Prominently, as in the previous drawings, a large filament (*a*), probably of wool, appears to act as a nucleus or means of aggregating the rest of the sediment. Beautifully convoluted round it we find branches of the elegant mycelium of a fungus, which appears to be developing. Spore cases (*d*) are seen in the lower part of the drawing, while sporules (*c*) are scantily discernible. All these objects are magnified to the extent of 200 diameters. In the upper part of the plate we detect, in much larger quantity than in any of the previous trials, a nest of vibriones, magnified to 1,000 diameters, characterised by the most lively and active motion, traversing the field of the microscope with a great rapidity, propelled by their peculiar vermicular like action. Of a smaller size, but in great abundance, similar bodies may be noticed to the lower left of the drawing, and thickly stretched among the ramifications of the mycelium. These appeared strongly to assimilate to vibriones in their physical outline, but movements were not so visible, except in some cases to a limited extent. The peculiarity in the results obtained from the examination of a sewer atmosphere, affords a sufficient distinction to enable us to discriminate it from the air contained in wards, and in the free atmosphere; for while all the other atmospheres investigated have been highly acid, the air in the sewer has been strongly alkaline, and the amount of animal life in the sewer has been found greatly to predominate over that which has been detected in the atmospheres above ground. It is obvious, then, that, in addition to the noxious gases, such as sulphuretted hydrogen, carbonic acid, carburretted hydrogen, &c., which may be evolved in various proportions from the decomposing organic matters in the sewer fluids, there exist in the sewer atmosphere living beings of vegetable and animal origin, or at least the sporules and germs of these organisms exist there. That analogous growths are capable of being propagated in the animal systems is well known. That the sources of the latter are extraneous, seems to receive countenance from the interesting researches of my colleague, Mr. Rainey, in his investigations on the pathology of cholera. I refer to his report, which relates the fact of his having discovered an entozoon in the opening of the air passages, the analogues of which have hitherto only been found imbedded in the tissues of the human body, thus yielding evidence of the foreign origin of such animals. His observation, too, of the absence of growing fungi in solutions when the supernatent air has been filtered, but which under ordinary exposure to the atmosphere are covered with these vegetations, affords strong evidence of the distribution of such seeds in the air, and of their tendency to take root and grow in congenial soils. It seems scarcely necessary to observe that the probability of the air deriving any wholesome virtue from the presence of such vital powers distributed through it is highly improbable, while the possibility, on the contrary, of their presence being liable to be followed by noxious results to health appears self-evident. In the Soho districts I found great complaints widely distributed, of the nauseous and sickening odours emanating from the gratings placed over apertures communicating with the sewers, and although these smells might alone not be capable of engendering diseases of a characteristic type, they are not only calculated of themselves to prejudice health, but they are indications of the accompaniments of foreign organic beings, merely traces of which it is probable have yet been detected. The investigation having been made during the winter, when decomposition of organic matter is much checked, and when the diminished temperature is antagonistic of organic life, it would be necessary to conduct comparative trials in summer, before conclusions could be drawn as to the prevalence of such beings in any atmospheres. Simultaneous observations on the meteorological condition of the atmosphere are likewise of importance, as bearing on the powers in action on its mass, to obviate any stagnant tendency of the air and to prevent the accumulation of extraneous and morbid influences.

## Summary.

From the results which have been obtained in the course of the present researches, the following deductions may be drawn:—

1. That in the atmosphere of a cholera ward, mechanical matters were diffused throughout the air derived from the inmates, that sporules of fungi and germs of vibriones, or vibriones themselves were obtained by filtration from the atmosphere—all of these bodies being adulterations, so to speak, of the pure oxygen and nitrogen, which alone constitute the wholesome predominating constituents of the elastic fluids destined for respiration.

2. That from a ward only partially filled with patients affected with cholera, substances were separated which were mechanically



dispersed to the very summit of the apartment, mixed with fungi or their sporules, while no vibriones, unless in the form of faint traces, could be detected.

3. That in the atmosphere of an empty ward, communicating however with a ward containing cholera patients, mechanical matters were obtained and traces of fungi, and perhaps of vibriones.

4. That in the external air adjacent to an hospital, substances mechanically distributed were likewise found, and sporules with fungi were also detected to a considerable extent, but no vibriones.

5. That in the atmosphere of a sewer, bodies were also found in mechanical diffusion associated with sporules, fungi, and vibriones.

6. That the air contained under the three first conditions from wards possessed an acid reaction, that the external atmosphere likewise indicated a similar chemical condition, and that the sewer atmosphere was alone alkaline.

7. That although animal and vegetable life seem unequivocally to be diffused through cholera atmospheres, it would be premature to infer a connexion between the disease and these organisms until comparative trials have been extensively made on other conditions of air; and that the present researches must be only considered as a single stone placed as a contribution towards the foundation of a larger structure.

Robert Dundas Thomson, M.D.

St. Thomas's Hospital,
18th February 1855.

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## TABLES.

### I.—First Experiment on Atmosphere of Cholera Ward when filled with Patients.

| 1854. | Air passed in Cubic Feet. | Barometer Corrected. | Dry. | Wet. | Maximum. | Minimum. | Wind. Direction | Wind. Force. |
|---|---|---|---|---|---|---|---|---|
| | | | ° | | | | | |
| Sept. Wed. 13 | 6 | 29·894 | 68.7 | 64·1 | 75·9 | 61·8 | S.W. | Strong breeze. |
| ,, Thurs. 14 | 42 | 29·742 | 65·1 | 59·2 | 69·9 | 59·9 | S.W. | ,, |
| ,, Fri. 15 | 16 | 29·943 | 65·0 | 59·3 | 68.2 | 54·3 | W.S.W. | Gentle breeze. |
| ,, Sat. 16 } | | 29·845 | 70·0 | 64·7 | 69·1 | 61·0 | W.S.W. | Strong breeze. |
| ,, Mon. 18 } | 34·6 | 30·098 | 67·1 | 57·6 | 70·9 | 53·2 | W. | ,, |
| ,, Tues. 19 } | | 30·004 | 63·1 | 61·0 | 67·5 | 57·4 | N.W. | ,, |
| | 98·6 | | | | | | | |

### II.—Second Experiment on Atmosphere of Cholera Ward when half filled with Patients.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sept. Wed. 20 | 16 | 29·882 | 69·7 | 63·5 | 68·2 | 57·3 | W. | Strong breeze. |
| ,, Thurs. 21 | 16 | 30.093 | 60·0 | 53·0 | 69·3 | 48·2 | N.W | ,, |
| ,, Fri. 22 | 16 | 30·327 | 51.2 | 48·1 | 61·6 | 45·1 | N.W. | Gentle breeze. |
| ,, Sat. 23 | 16 | 30·223 | 58·5 | 55·7 | 59·0 | 49·6 | N.W. | ,, |
| ,, Mon. 25 | 16 | 30.289 | 58·0 | 57·1 | 67·0 | 46·4 | N.W. | Fresh breeze. |
| ,, Tues. 26 | 16 | 30·361 | 57·1 | 52.3 | 56·8 | 46·4 | W. | Gentle breeze. |
| ,, Wed. 27 | 16 | 30·337 | 63·8 | 55·9 | 62·2 | 46·7 | E.S.E. | ,, |
| ,, Thurs. 28 | 16 | 30·142 | 64·1 | 54·8 | 66·0 | 48·6 | S.E. | ,, |
| ,, Fri. 29 | 16 | 20·131 | 56·8 | 53·9 | 65·6 | 45·7 | W.S.W. | ,, |
| ,, Sat. 30 | 16 | 30·185 | 54·3 | 52·4 | 60·6 | 46·5 | S.W. | ,, |
| Oct. Mon. 2 | 32 | 30·054 | 53·4 | 57·6 | 58·5 | 45·0 | Calm. | |
| ,, Tues. 3 | 32 | 29·771 | 59·9 | 56·5 | 60·8 | 48·1 | W.N.W. | Fresh breeze. |
| ,, Wed. 4 | 16 | 29·826 | 56·4 | 50·1 | 60·8 | 45·0 | W.S.W | Gentle breeze. |
| Total cubic feet | 240 | | | | | | | |

### III.—Third Experiment on Atmosphere of Cholera Ward when empty.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Oct. Thurs. 5 | 16 | 29·582 | 64·9 | 58·4 | 64·0 | 52·7 | S.W. | Fresh breeze. |
| ,, Fri. 6 | 16 | 29·527 | 56·4 | 54·8 | 67·5 | 53·9 | E. | Gentle breeze. |
| ,, Sat. 7 | 16 | 29·958 | 54·8 | 49·7 | 57·0 | 46·5 | E. | Strong breeze. |
| ,, Mon. 9 | 16 | 29·714 | 58·4 | 57·6 | 58·0 | 52·1 | Calm. | |
| ,, Tues. 10 | 16 | 30·046 | 59·4 | 56·6 | 61·2 | 50·4 | W. | Gentle breeze. |
| ,, Wed. 11 | 32 | 30·149 | 58·6 | 52·2 | 59·0 | 50·5 | N.W. | Fresh breeze. |
| ,, Thurs. 12 | 32 | 30·531 | 52·6 | 46·9 | 59·4 | 43·0 | N. | Gentle breeze. |
| ,, Fri. 13 | 32 | 30·448 | 46·4 | 44·8 | 59·9 | 37·0 | W. | ,, |
| ,, Sat. 14 | 16 | 30·309 | 51·9 | 50·2 | 52·0 | 43·4 | W. | ,, |
| ,, Mon. 16 | 16 | 29·996 | 50·8 | 46·2 | 53·3 | 43·1 | N.N.E. | ,, |
| ,, Tues. 17 | 16 | 29·360 | 50·1 | 47·4 | 52·5 | 38·5 | E. | Fresh breeze. |
| ,, Wed. 18 | 16 | 29·277 | 49·9 | 48·8 | 51·4 | 43·2 | N.W. | Gentle breeze. |
| ,, Thurs. 19 | 16 | 29·798 | 46·8 | 42·8 | 51·0 | 37·9 | W. | ,, |
| ,, Fri. 20 | 32 | 29·370 | 52·8 | 49·9 | 53·1 | 43·3 | N.W. | ,, |
| ,, Sat. 21 | 16 | 29·606 | 51·9 | 48· | 53·0 | 43·2 | N.W. | Fresh breeze. |
| Total cubic feet | 304 | | | | | | | |

In these Tables the temperatures refer to the external atmosphere in the shade. During the period of experiment no ozone was detected.



### IV.—Fourth Experiment on the Air of the External Atmosphere.

| 1854. | Air passed in Cubic Feet. | Barometer Corrected. | Dry. | Wet. | Maximum. | Minimum. | Wind. Direction | Wind. Force. |
|---|---|---|---|---|---|---|---|---|
| Oct. Sat. 21 | 16 | 29·606 | 51·9 | 48·0 | 53·0 | 43·2 | N.W. | Fresh breeze. |
| ,, Mon. 23 | 32 | 29·348 | 51·7 | 47·2 | 55·8 | 42·9 | W. | ,, |
| ,, Tues. 24 | 32 | 29·511 | 48·9 | 44·8 | 53·1 | 37·4 | S.W. | ,, |
| ,, Wed. 25 | 32 | 29·043 | 46·4 | 45·5 | 50·9 | 40·9 | E.N.E. | ,, |
| ,, Thurs. 26 | 32 | 29·746 | 45·4 | 43·1 | 47·4 | 36·3 | W.N.W. | Gentle breeze. |
| ,, Fri. 27 | 48 | 30·389 | 44·9 | 43·1 | 48·5 | 34·0 | S W. | ,, |
| ,, Sat. 28 | 32 | 30·346 | 54·9 | 50·0 | 54·5 | 41·0 | S.S.W. | Fresh breeze. |
| ,, Mon. 30 | 32 | 30·192 | 57·9 | 54·1 | 54·0 | 44·1 | S.W. | Gentle breeze. |
| Nov. Wed. 1 | 32 | 30·423 | 49·8 | 48·5 | 63·7 | 44·6 | N. | ,, |
| ,, Thurs. 2 | 16 | 30·366 | 52·0 | 51·0 | 62·4 | 45·1 | S. | ,, |
| ,, Fri. 3 | 16 | 30·285 | 50·0 | 45·4 | 54·6 | 44·3 | N.W. | Fresh breeze. |
| ,, Sat. 4 | 32 | 30·226 | 46·8 | 44·2 | 50·6 | 38·3 | N. | Gentle breeze. |
| ,, Mon. 6 | 32 | 30·403 | 48·0 | 44·2 | 54·3 | 40·1 | N.W. | ,, |
| ,, Tues. 7 | 16 | 30·546 | 46·1 | 44·2 | 49·2 | 35·8 | W. | ,, |
| ,, Wed. 8 | 32 | 30·257 | 46·9 | 44·6 | 47·8 | 39·1 | W.S.W. | Fresh breeze. |
| ,, Thurs. 9 | 32 | 30·230 | 41·9 | 38·5 | 49·5 | 35·1 | N.N E. | ,, |
| ,, Sat. 11 | 32 | 30·095 | 47·1 | 45·5 | 49·5 | 36·5 | N. | Gentle breeze. |
| ,, Mon. 13 | 16 | 30·171 | 44·6 | 42·1 | 44·3 | 32·0 | S. | ,, |
| ,, Wed. 15 | 32 | 29·117 | 46·8 | 45·4 | 47·2 | 33·3 | S.W. | ,, |
| ,, Thurs. 16 | 16 | 29·041 | 48 4 | 47·2 | 48·0 | 40·2 | E.S.E. | ,, |
| Total cubic feet | - 560 | | | | | | | |

### V.—Fifth Experiment on the Atmosphere of a Sewer.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nov. Wed. 22 | 32 | 29·972 | 40·4 | 39·0 | 43·5 | 35·1 | N.W. | Gentle breeze. |
| ,, Thurs. 23 | 16 | 29·093 | 48·4 | 37·1 | 40·8 | 32·0 | E.N.E. | ,, |
| ,, Fri. 24 | 16 | 29·316 | 33·2 | 38·0 | 39·2 | 32·1 | N. | ,, |
| ,, Sat. 25 | 16 | 29·616 | 39·1 | 38·1 | 40·5 | 32·5 | N. | ,, |
| ,, Mon. 27 | 16 | 30·086 | 31·4 | 30·2 | 37·2 | 27·8 | N. | ,, |
| ,, Tues. 28 | 16 | 29·832 | 40·9 | 40·0 | 40·5 | 28 9 | W. | Fresh breeze. |
| ,, Wed. 29 | 16 | 29·033 | 47·1 | 44·1 | 47·0 | 37·6 | W. | ,, |
| ,, Thurs. 30 | 16 | 29·675 | 41·5 | 39·5 | 48·0 | 39·5 | W. | Gentle breeze. |
| Dec. Fri. 1 | 16 | 29°664 | 44·4 | 42·1 | 48·6 | 38·4 | N.W. | Fresh breeze. |
| ,, Sat. 2 | 16 | 30·009 | 43·8 | 39·6 | 45·8 | 35·6 | N.W. | ,, |
| ,, Mon. 4 | 16 | 30·170 | 47·1 | 43·3 | 48·6 | 41·3 | W. | ,, |
| ,, Tues. 5 | 16 | 29·597 | 50·1 | 47·5 | 50·2 | 46·0 | W. | ,, |
| ,, Wed. 6 | 32 | 29·607 | 43·6 | 40·4 | 51·2 | 35·6 | S.W. | ,, |
| ,, Thurs. 7 | 32 | 30·243 | 40·5 | 38·9 | 44·6 | 34·5 | N. | ,, |
| ,, Fri. 8 | 32 | 29·847 | 46·2 | 45·2 | 46·0 | 32·4 | W. | ,, |
| ,, Sat. 9 | 32 | 29·486 | 43·8 | 41·2 | 49·3 | 40·8 | N.W. | ,, |
| ,, Mon. 11 | 16 | 30·061 | 36·4 | 35·0 | 38·5 | 27·5 | S.S.W. | Gentle breeze. |
| ,, Tues. 12 | 16 | 30·161 | 40·1 | 38·4 | 44·6 | 35·2 | W.S.W. | ,, |
| ,, Wed. 13 | 32 | 30·249 | 44·2 | 42·2 | 45·6 | 35·2 | W.S.W. | ,, |
| ,, Thurs. 14 | 32 | 29·972 | 53·0 | 51·8 | 54·3 | 41·3 | W. | Fresh breeze. |
| ,, Fri. 15 | 32 | 29·977 | 52·9 | 49·1 | 55·4 | 48·3 | W. | Strong breeze. |
| ,, Sat. 16 | 16 | 29·850 | 45·9 | 43·1 | 54·6 | 43·8 | N.W. | Fresh breeze. |
| ,, Tues. 19 | 16 | 29·890 | 36·0 | 32·8 | 41·4 | 31·6 | W. | Gentle breeze. |
| ,, Wed. 20 | 32 | 29·533 | 43·1 | 42·5 | 43·4 | 32·7 | N.N.W. | Strong breeze. |
| ,, Thurs. 21 | 16 | 30·143 | 39·9 | 39·0 | 44·6 | 31·2 | W. | Gentle breeze. |
| ,, Fri. 22 | 16 | 29·855 | 52·1 | 51·0 | 53·4 | 36·2 | W.N.W. | ,, |
| ,, Sat. 23 | 32 | 29·944 | 45·5 | 43·0 | 54·0 | 40·8 | W. | ,, |
| Total cubic feet | - 592 | | | | | | | |