at the apex of the left lung broke through the pleura, and introduced air into the pleural cavity, converting the simple sero-fibrinous effusion into pus, and establishing empyema with pneumothorax. I will not stop to inquire what were the agencies at work in the process of conversion: whether the perpetual influx of air was alone sufficient to accomplish the change, or whether it was in great measure owing to the simultaneous introduction of puriform and putrid materials from the vomica—an event which must surely take place in phthisical pneumothorax, although its possible influence has been strangely overlooked. For a while, the broncho-pleural fistula remains open; at length it closes; and in this state the patient comes under my care. Ultimately, in consequence of the expansion of the lung and its renewed activity after the operation in February, the closed orifice in the pleura reopens. At the time, I expressed sorrow and contrition for having authorised the paracentesis. I think differently of the matter now; but let that pass for the moment, and let us proceed to the autopsy.

The *post mortem* appearances were in the highest degree satisfactory, in so far as they verified to the letter the interpretation we had put upon the case. I will not dwell at length upon the immunity of the lungs from tubercularisation, so strikingly contrasted with the presence of tubercle elsewhere, however interesting this may be from a pathological point of view. It is true that, even practically regarded, the possible development of tubercle, as a result of infective processes, is a matter of serious moment when we are deliberating on the treatment of a pleuritic effusion which may be, or may become, an empyema. In our case, however, the tubercles were unimportant, and had nothing whatever to do with the fatal issue. The points of real importance were the disorganisation of the right lung, the quantity of pus in the pleural cavity, and the wide, straight, unbroken channel of communication between that cavity and the trachea. And now, gentlemen, that we are in possession of all the facts—the disclosures of the dead-house, and the history and progress of the case from beginning to end—dare we venture to affirm that we could have prolonged the life of this man for a few days or weeks? I cannot say more: he was too far gone for a new lease of life. As a preliminary to the solution of this problem, let us examine the mode of dying. An immense amount of pus had been long as it were overflowing in successive gushes through an open and capacious broncho-pleural fistula. Now reflect for a moment on the mobility and incoherence of pus pure and simple, as distinguished from the comparative viscosity of sputa in general, and you will be prepared to acknowledge that there is reason in the following remarks. With declining strength, with sharp pleurisy and a damaged lung on the right side, with a feeble cough and failing powers of expectoration, it became almost inevitable that a portion of the outgoing pus from the left pleural sac must find its way backwards—regurgitate, so to speak, through the right bronchus into the corresponding lung, the only lung on which devolved the duty of such expectoration as could be accomplished by lung-tissue under the circumstances. For some time the right lung continues to perform this duty, resents the invasion of pus, and eliminates it; but all the while, of course, it is suffering from irritation; and in the end the irritation becomes inflammation, or quickens pre-existing inflammation. The elasticity of the lung is profoundly impaired, and its intrinsic powers of elimination are reduced to a minimum. Empyema with pneumothorax on one side, and extensive phthisical pneumonia on the other, must of necessity prove fatal in a short time, even without the oozing of pus into the trachea, or its regurgitation through the opposite bronchus. With this oozing, and with this regurgitation, you may easily understand how it might prove immediately fatal. The least movement of the chest-walls, the slightest change of posture, propels the fluid into the trachea, where part remains, while part regurgitates; a far stronger movement is demanded for its expulsion; under the co-operating influences of exhaustion and inflammation, that movement is not forthcoming, and the patient dies asphyxiated. This is the great danger we have to dread. Can we obviate it? I believe the best thing we could have done, now that we are enabled to read the case backwards, was to have inserted the drainage-tubes in the first instance after the operation in February. We were not then, however, in possession of all the data; and, in inference to the recognised custom of inserting the tubes when the pus is foetid, and withholding them when it is inodorous, it was determined to close the wound, and reserve the chest for a future operation, if necessary. The question now arises, Was there a necessity for a second operation? In my own opinion, there was. I candidly own that, if twelve great authorities, surgical and medical, had met in consultation, six might have ranged themselves on one side, and six on the other; or perhaps the majority might have pronounced against paracentesis. Any how, there would have been no unanimity. Nevertheless, I adhere to my opinion. Undeniably, the drawbacks were serious. Hectic

fever and far-gone consumption are not to be lightly rated. On the other hand, the event which actually occurred in our case must occur almost as a matter of course in a similar case without an operation. Understand me rightly, however. The second operation should not have been delayed until the pleural cavity became brimful of pus; it should have been performed, and the drainage-tubes inserted, as soon as there was evidence that the pus, though evacuated in immense amount, was steadily gaining ground, while the air was fast disappearing.

I have dwelt in detail upon this case, inasmuch as it offered from the beginning, and even yet offers, the amplest scope for speculation and discussion. Moreover, cases of pneumothorax are few and far between even in the large experiences of hospital practice; and this particular case requires in great measure to be estimated on its own merits. You will derive little advantage in the solution of the problems propounded by consulting the text-books. For the most part, they content themselves with saying that, in pneumothorax with phthisis, paracentesis should be reserved for an emergency. By emergency is meant, in all probability, the *existence* of dangerous dyspnoea. It is not so certain that the *prospect* of dangerous dyspnoea is contemplated under the term; but I am convinced in my own mind that, even prospectively regarded, the operation may be justifiable.

Gentlemen, as I have already intimated, on second thoughts, after mature reflection, I have been induced to modify some of the opinions I formerly expressed to you. To recapitulate and to conclude. I am of opinion now that, whatever the view taken of the case on admission—whether, in our judgment, the man was phthisical, or not—whether a gap in the pleura existed at the time, or not—whether such a gap had ever before existed, or not—under all circumstances, an operation was unavoidable. But the drainage-tubes ought to have been inserted either on the instant, or, at any rate, after the discovery of the following conditions: free and direct communication between the left pleural cavity and the trachea, advancing disorganisation of the right lung, and ever-increasing accumulation of pus, in spite of its enormous discharge. By adopting these measures, we might have kept the pus within bounds, and diverted it from the trachea and bronchi; we might have arrested for a while those pneumonic processes which were so rapidly disabling the only lung of any real use in respiration; and, although the man must inevitably have died an early death from combined exhaustion and apnoea, we might at least have saved him from dying of downright suffocation—literally drowned in pus.

ON THE DISINFECTION OF AIR.*

By A. ERNEST SANSOM, M.D. Lond., M.R.C.P.,

Physician to the Royal Hospital for Diseases of the Chest, and to the North-Eastern Hospital for Children.

Few physicians will be inclined to deny that the material poisons of many of the spreading diseases are capable of being wafted by the air from place to place and from person to person, and that in this manner the maladies of infection are in many instances transmitted. In certain diseases—among which may be especially enumerated variola, scarlatina, rubeola, pertussis, pyæmia, erysipelas, and diphtheria—the subjects are centres whence the evolution of disease-inducing particles takes place. It is obvious that complete isolation of an individual, and removal of all the chances of his directly infecting others, are practically impossible; and, even if such were possible, the disease-poison would yet be cast off to attach itself to any surrounding material, still capable of inducing its effects in the future. It would be a measure of the highest importance if the disease-poison, while existing in, or wafted by, the air, could be rendered inert. This is what I mean by disinfection of air—the rendering inert of the disease-poison which in some infectious disorders is contained in, and transmitted by, the atmosphere.

Many practitioners have attached an importance to the attempt to disinfect the air poisoned by the emanations of those sick of an infectious disease, as a positive duty; and have adopted various methods of carrying it out. Others, however, urge that all attempts in this direction are futile—that it is impossible to disinfect the air.

Let me discuss briefly what is the nature of the material, which I have for convenience called *poi-on*, that we desire to render inert. It is ponderable, and obeys physical laws. It often remains active for long periods of time, and hence is unaffected by the frequent mutations of the atmosphere; but is so minute as to be entirely undemonstrable by any ordinary direct physical means, and undetectable by the highest

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powers of the microscope. The diffusion-experiments of Chauveau and Sanderson have given convincing proof that in vaccinia, variola, and sheep-pox, the poison is a *solid*, insoluble and indiffusible. This conceded, the area of speculation becomes narrowed; for it is impossible to imagine the material an agent merely organic and gifted only with the properties of inanimate matter. If it be an organic solid, neither solid nor diffusible, how does it interpenetrate the tissues of the body it so profoundly affects? and how can we explain its immeasurable powers of reproduction? It is not my purpose to trace the analogies of the disease-poison, nor to follow the evidence which points to the probability that it is endowed with the properties of *living* matter. We must admit one of these two views—that it is vitalised, or else that it acts by an inexplicable process of catalysis; and, if the analogy of other so-called catalytic processes be invoked for the elucidation, we shall find that, as science progresses, these become less and less explicable, on the hypothesis of causation by dead organic material in any state whatever. In fact, I believe it to be true, in the present state of science, that no kind of catalytic change of organic bodies ever takes place without the intervention of living things or their active secretions. I will now turn to the consideration of the methods which have been hitherto adopted for the disinfection of air, and the *rationale* of their action.

First come what are called OXIDISING DISINFECTANTS.

1. Foremost among these are the alkaline permanganates, which, when dissolved in water, it is recommended to expose in open vessels to the air of a sick-room, or to diffuse in the form of spray throughout the atmosphere. The theory is, that these yield up oxygen to the disease-poison, and, altering its chemical constitution, impair its morbid properties. Now it must be remembered, in the first place, that these agents are entirely non-volatile. There can be, therefore, no commingling with the air. The particular portions of air which happen to come into immediate contact with the surface of the solution, no doubt have their contained organic particles oxidised; but how feeble a proportion do these bear to the atmosphere of an apartment! The nauseous products of putrefaction, the permanganates have a remarkable power of oxidising, and thus rendering inodorous; they are excellent *deodorants*; but I have shown them to occupy a very low place both as arresting putrefaction and as killing the low forms of life. A little consideration must show that agents which operate by oxidation only can have but little effect upon the specific poisons of disease. Imagine the minute particle of disease-poison as it is after a long continued relation with large volumes of air, this air frequently containing its special oxidising constituent—ozone; or imagine it commingled with vast bulks of water: surely here are enough conditions for its speedy oxidation and destruction, if it be capable thereof. How insignificant must be the superadded effect of the oxidising permanganate! In whatever bulk employed, the permanganates do not destroy the microzymes inducing putrefaction existing in the air superincumbent upon them. From my view, therefore, of the nature of disease-poisons, I am justified in concluding that the employment of the permanganates as means for the disinfection of air is at once frivolous and futile.

2. Chlorine is also an oxidising disinfectant; but this stands on higher ground as an air-purifier, because its volatility allows it to come in immediate contact with the particles suspended in the air. It is of very high value as a deodorant; but its action on fermentation, putrefaction, and on the life of low organisms, is but feeble. I have seen fungi living luxuriantly in and amongst the particles of chloride of lime.

3. Iodine is much more efficacious. It is an oxidising agent, and hence a deodorant; but it is more—it destroys microzymes, and arrests decomposition. It is of very easy application. If placed in open vessels about a room, it evaporates spontaneously, and is a very useful agent for disinfection of air.

4. Sulphurous acid has also a double action; it is a deoxidiser, and hence a deodorant; and it is extremely powerful in destroying the life of low organisms. It has been used (the method of its evolution being merely burning brimstone from a metal plate), and, as the records seem to show, with much advantage.

5. Carbolic acid is a volatile agent, easily diffused throughout the air. It exerts no chemical action thereupon, and thus is not a deodorant; but in my opinion it holds the highest place as a disinfectant proper, for it kills the low forms of life existing in the atmosphere even when it is present in but small proportion.

Starting with the view that the poisons of spreading diseases are minute particles of living matter, I will now turn to some experimental evidence bearing upon the question of the efficacy, positive and relative, of air-disinfectants. Observation of the effects of different agents, when commingled with the air, upon the low organisms met with in putrefactions, must for the most part offer *à fortiori* evidence; for in

many infective liquids the presence of the minutest bacteria cannot be detected. Dr. Sanderson has, however, observed bacteria as the characteristic inhabitants of the infective fluids which transmit pyæmia, "and therefore probably the carriers of infection." Without assuming, however, anything further than that the poisons are *living*, we can, I think, obtain valuable analogical evidence; for the influences which kill bacteria, monads, and germs of fungi, could surely with great probability kill also the minuter particles of living matter constituting the infecting poison.

EXPERIMENT I, *showing that Bacteria and Monads are killed by Air which contains Carbolic Acid*.—A maceration of hard-boiled egg in cold water was observed on the third day after preparation. Multitudes of cylindrical and filiform bacteria and ovoid monads were observed in active movement (magnifying power, 500 and 750 diameters linear). A small drop was placed on a slide, and held for thirty seconds over the open mouth of a flask which contained a little carbolic acid. This was compared with another drop uninfluenced. At first, movements in each case were equally active. In about two minutes in the former, movements became more languid, and soon ceased in many instances. Some, however, continued perfectly active. Experiment was repeated with exposure to carbolic acid for one minute. Monads, at first active, began to move in smaller circles, then merely to revolve on their axes, and finally manifested merely a peculiar vibration. A very marked difference was shown between the exposed and the test-drops; in the former, a large number of bacteria were perfectly motionless. Experiment repeated with exposure for three and five minutes respectively: in the latter case, nearly all were dead. It was evident that the superficial portion was so affected as to render motionless all the bacteria; but in the deeper layer, some, though comparatively a very small number, manifested active movement.

Observation has shown me that, whilst the effect of carbolised air upon a fluid capable of putrefaction is to prevent the formation of the usually dense follicle formed by the dead bacteria, and to kill those which are superficial, it has no influence upon those below the surface-level, which continue to manifest active movement.

EXPERIMENT II, *showing that the Germs in the Air, which develop into Fungi, are killed by Air which contains Carbolic Acid*.—Two precisely similar glass flasks were taken, and into each was poured some well boiled paste made from wheat-flour. Each was provided with a cork perforated and fitted with tubes for the entrance and exit of air. Over the surface of the paste in A, 500 cubic feet of air were blown by means of a bellows, and then the flask was closed with India-rubber tissue. B was treated precisely similarly, except that the air first traversed the surface of six drachms of liquefied carbolic acid contained in another small flask. B was subsequently sealed. The loss of the liquid carbolic acid was half a fluid-drachm. The flasks were then kept in identical conditions. In flask A, after a few days, islands of mildew appeared; the paste fermented, and disengaged gas-bubbles; and now (thirteenth day) green mould covers the sides, and large masses of white and green mould are on the surface of the paste. In B, the paste remained perfectly unchanged, and now (thirteenth day) presents not a trace of fungoid manifestation. These flasks were exhibited to the meeting, and it was manifest that, although more than three weeks had elapsed since their preparation, the paste over which carbolised air had been passed remained without any sign of decomposition; the other presented a mass of mildew.

I have formerly shown that the appearance of penicillium and aspergillus can be entirely prevented by the presence of carbolic acid in the air supplied to the soil.

EXPERIMENT III, *showing that, whilst the presence of Carbolic Acid or Sulphurous Acid in the Air prevents Putrefaction and the concurrent Development of Living Forms, the so-called Oxidising Disinfectants fail to prevent either*.—Four small wide-mouthed glass bottles, of similar shape and size, were filled with small cubes cut from a hard boiled egg. They were then placed each in a glass trough, into which was poured the following disinfectant agent in each case: A, commercial permanganate solution (red), 1½ drachm; B, commercial chloride of aluminium, 1½ drachm; C, pharmacopœial sulphurous acid, 1 drachm; D, crude carbolic acid, 11 drops. Each was enclosed under a glass cover, so as to allow free communication of air both with the open bottle and the free surface of the disinfectant agent; but the cover itself was imbedded in cement, so as to exclude external air. At the end of seven days, the covers were removed, and the bottles containing the pieces of egg were each filled up with distilled water which had been well boiled and then allowed to cool. The covers were then re-applied, and the contents were examined three days afterwards. A, (permanganate) was extremely fetid, so turbid as to be absolutely opaque, and with a thick pellicle covering its surface. It teemed with small bacteria, and presented many fungoid cells; and the portions of

egg were disintegrated; they were in a stage of advanced decomposition. B (chloride of aluminium): very foetid and turbid, rather less so than A. Every drop examined swarmed with small monads and bacteria. The egg-cubes were broken up, and presented signs of advanced decomposition. C (sulphurous acid). Fluid presented no foetus; was perfectly transparent. The cubes of egg appeared to preserve their shape and condition exactly as when first introduced. On microscopic examination, many fields presented no trace of motile organisms; but occasionally a few active bacteria were met with. D (carbolic acid). Fluid appeared almost clear, and the egg-cubes distinct. Very few bacteria presented themselves, usually five or six in a field; they were of unusual length. Decomposition was almost, but not entirely, arrested.

The evidence which I have adduced, I think, fully shows that the presence of certain volatile or gaseous antiseptic agents in the air is sufficient to poison the lowest forms of organisms, to prevent the appearance and development of fungi, and to arrest the putrefaction of organic material. I hope it will be allowed that we who counsel the employment of gaseous or volatile antiseptics for the disinfection of air do so with the clear understanding of a purpose to fulfil, and a train of analogical evidence that the means are adequate to the end. We believe the subtle poisons of disease to be minute particles of living matter; and that these, given off from a diseased person, can be contained in and wafted by the air. We do not pretend that they are equally numerous with the harmless germs of living things which the air normally contains; but they are with them and among them. We show that the presence of antiseptic agents in the air destroys the harmless germs; and we contend that it is probable that it also destroys the disease-germs, which have strong analogical relations with the former, which certainly do not exceed them in bulk, and are probably far more minute than those which are obviously destroyed. As regards the nature of an efficient air-disinfectant, we find that it must be volatile or gaseous, and therefore capable of equable diffusion throughout the air. The non-volatile agents are inert. It is not the action of a chemical agent upon an organic chemical compound which constitutes disinfection, according to our view; but the action of a diffused poison upon the living particles which are suspended in the atmosphere. The agents which I myself believe to be most efficient are sulphurous acid, iodine, and carbolic acid. Future experience will point probably to many others, but we have these at present to rely upon.

A few words as to the methods of practically employing these various agents.

1. *Sulphurous Acid*.—If the chamber to be disinfected is (a) *uninhabited*, all articles capable of being bleached should be removed; orifices communicating with the external air should be closed, and crevices pasted over with paper. A vessel containing burning sulphur should then be introduced, and the door closed. For the sake of safety from the chance of fire by the overflow of the molten sulphur, it should be kindled upon an iron plate, and floated upon a large vessel containing water. It is convenient to place glowing embers on the plate, and then dust over them flowers of sulphur. If the room is (b) *inhabited*, the sulphurous acid must be disengaged in less proportion. Dr. Hjaltelin, who has employed it in small-pox wards, considers that its power of exciting bronchial irritation has been exaggerated, and that patients may be accustomed to it in a high degree. It may be employed in the manner before described; the flame of the burning sulphur being extinguished by submersion of the iron plate in the water, if the fumes become too powerful. Or, as employed by Dr. A. W. Foot, flowers of sulphur may be dropped upon a heated shovel, and carried about the room. The generation of the gas should be repeated three or four times in the day. It is certain, however, that some people feel it difficult to tolerate the sulphur fumes.

2. *Iodine* may be used as an air-disinfectant in a very simple manner—first suggested, I believe, by Dr. B. W. Richardson. Solid iodine is merely exposed in glass or porcelain vessels in different parts of the room. The iodine vapour is given off at ordinary temperatures. This is a very efficient mode of attaining a constant disinfection.

3. *Carbolic Acid*.—To employ this agent when the room is (a) *unoccupied*—communication with the external air being closed—a quantity of the crude acid should be poured into a strongly heated metal cup, or upon hot bricks, and left to vaporise. Subsequently, the floors, ceiling, and, if practicable, the walls, should be irrigated or sprayed with an aqueous solution; and the floor scrubbed with carbolic acid or coal-tar soap. Or Savory and Moore's excellent vaporiser may be employed, whereby large volumes of carbolic acid vapour will be disengaged. If the chamber is (b) *occupied* by the sick, the vaporiser just mentioned, which is so constructed that the liquefied acid falls drop by drop upon a heated plate, should be put in action at

intervals twice or thrice in the day. The objectionable odour of the carbolic acid may be greatly masked by its admixture with oil of wild thyme. It is obvious that this method gives off the carbolic acid too powerfully for continuous use. The agent, however, is so volatile as to render itself readily available for maintaining a constant antiseptic atmosphere. It has frequently been used in combination with inert powders for strewing about the room, or has been sprinkled upon cloths or other absorbent materials which have afforded surfaces for its volatilisation. These measures, however, have their inconveniences and even dangers; for the strong acid is irritant and caustic, and may inflict serious injury on those who inadvertently touch it. To obviate the difficulty, I have requested Messrs. Savory and Moore to construct for me an instrument consisting of a piece of canvas in the form of an endless band stretched between two rollers, and dipping into a tin trough to be charged with the acid. By turning a handle at the top, the roller is drawn through the trough, and thus moistened in its whole extent. After it has become partially dry from evaporation, a turn of the handle lifts up a fresh moistened surface. I have used this in several cases, and have found it to act most satisfactorily. I believe, from the data we possess, that in carbolic acid we have the most efficient and the most manageable of all agents for the disinfection of air.

THE GEOGRAPHICAL DISTRIBUTION OF PHTHISIS.

By ALFRED HAVILAND, ESQ.,

Lecturer at St. Thomas's Hospital on the Geographical Distribution of Disease.

THE doubts raised by Mr. Armstrong in his recent communication to the JOURNAL call for discussion. Mr. Armstrong has used Dr. Crisp's figures, and not mine, in comparing the mortality from phthisis in the Great Ouseburn district during the "decade (?) 1861 to 1871," with that which occurred during the previous decennial period 1851-60. In January and February last year, I published my lectures on the Geographical Distribution of Phthisis, which I delivered at St. Thomas's Hospital during the winter session 1870-71; and I beg to refer your correspondent to them. They will be found at pp. 5, 6, 57, 58, 140, and 141, of the JOURNAL for 1871, vol. i, accompanied by a photolithograph map of the distribution of phthisis in England and Wales, reduced to one-eighth the size of the original, in which, of course, the lettering is too small for practical purposes; the names, however, of the districts can be read by the aid of a magnifying glass; and the colouring will give a general idea of the distribution of phthisis, if the reader will bear in mind that *red* indicates the low, and the different shades of *black* the high mortality districts, a guide to which will be found at p. 5. The black tints represent the *blue* in the map used for my lectures.

On referring to the above map, it will be found that Great Ouseburn belongs to the sixth or lowest degree of mortality, which ranges from below 17 to 20 deaths annually to every 10,000 females living. Although, however, this is the case, this district is far from being so exempt as Dr. Crisp states—viz., 1 in 88, or the lowest in the phthisis death-rate scale. In fact, the figures of the Registrar-General, who gives the annual average rate of mortality from phthisis to every 100 living, show at least ten districts which have a lower mortality from phthisis than Great Ouseburn; and, if we arrange them in the order of their low mortality, beginning with the healthiest district as regards this terrible cause of death, we shall have the following list, the numbers after the name being the annual death-rate to every 10,000 living: Ongar, 12.3; Easington, 15; Atherstone, 15.2; Belford, 15.4; Scarborough, 15.8; Tenbury, 15.9; Guisborough, 16.3; Sleaford, 16.3; Meriden, 16.4; Wheatenhurst, 16.4; Helmsley, 16.7; Great Ouseburn, 17.6; and *Whitchurch*, 20.8. We therefore see that, out of a dozen of the lowest mortality districts, Great Ouseburn exhibits the *highest*, instead of, as Dr. Crisp states, the *lowest* mortality. I have introduced Whitchurch in order to show how the discrepancy has arisen. This district, too, occupies in Dr. Crisp's list an unmeritedly distinguished position; its mortality from phthisis being represented as 1 in 62, which would make it rank above Meriden, 1 in 60; Wheatenhurst, 1 in 60; Guisborough, 1 in 61; Helmsley, 1 in 61; Sleaford, 1 in 61; and equal to Scarborough, 1 in 62. The Registrar-General's figures, however, have spoken for themselves. The fact is, Dr. Crisp has assumed that the number of deaths from phthisis placed to the account of Great Ouseburn and Whitchurch was the aggregate for the *ten* years 1851-60; whereas he will find, on referring to the Registrar-General's supplement to his Twenty-fifth Annual Report, pp. xciii and cv, that the figures in the first district represented only six and a half, and in the second seven and three-