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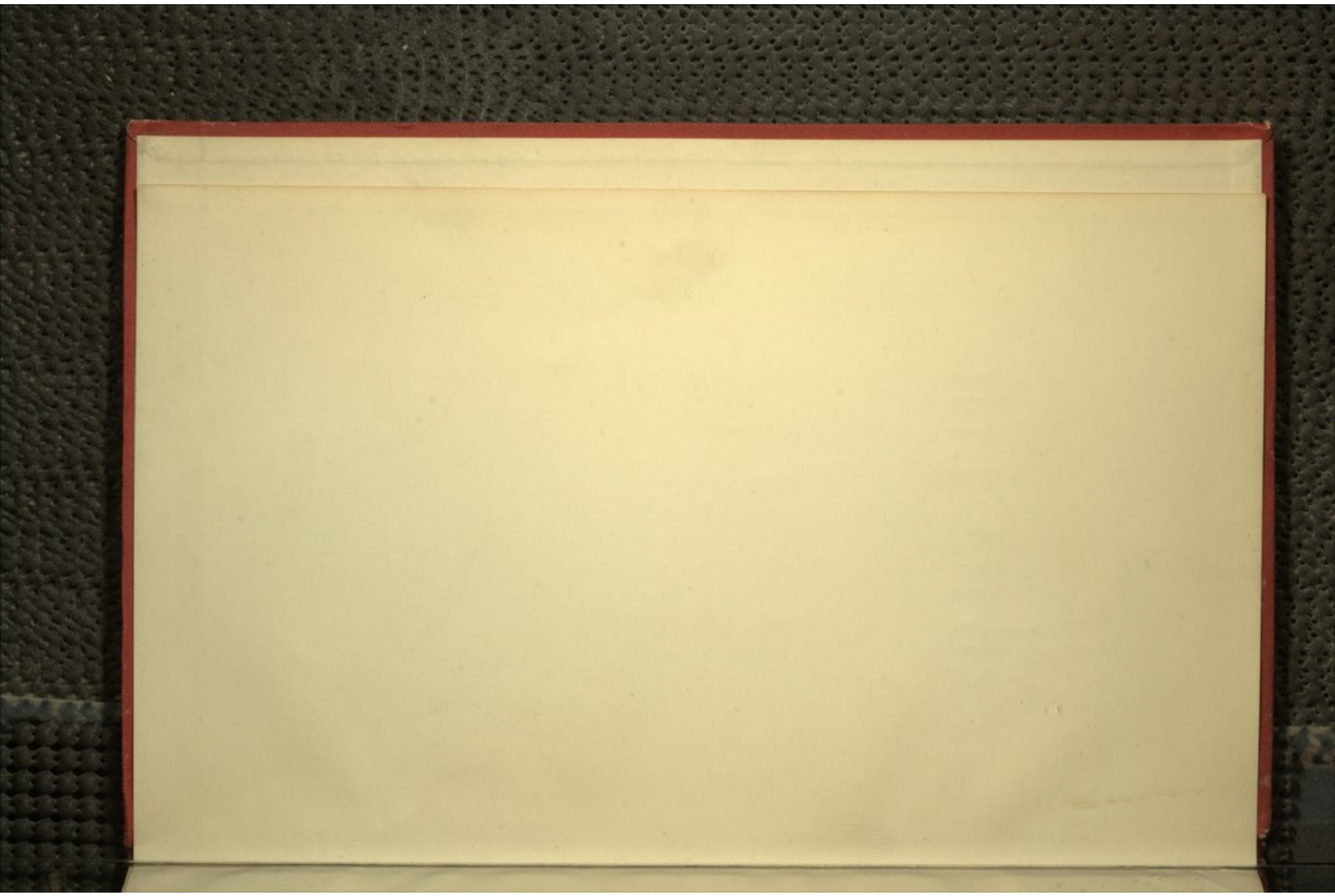

BAD AIR AND BAD HEALTH

BY

HAROLD WAGER

AND

AUBERON HERBERT

Dedicated to Professor Clifford Allbutt with the esteem and regard of the writers.

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"It is but too common for men to treat that which is their best friend as a dangerous enemy."

WILLIAMS & NORGATE

14, HENRIETTA STREET, COVENT GARDEN, LONDON;

20, SOUTH FREDERICK STREET, EDINBURGH.

1894.

BAD AIR AND BAD HEALTH.

THE purpose of this paper is to utter a warning against the careless way in which the mass of people, poor and rich, ignorant and learned, allow the air of their living-rooms to be in an impure condition; and to point out the great sacrifice of energy and health which results from this carelessness. We shall try to show that there is a strong ground for believing that not only a large part of the ever-increasing trouble of bronchial and lung affections, but also a very large part of that vague and subtle ill-health, which troubles our modern lives in varying forms, are to be placed to the account of the impure air which we so habitually breathe.*

As we wish to make the paper plain to every one, we shall occasionally go back to the A B C of certain matters involved. The air which we breathe is made up of two gases, one active, one indifferent. The active gas, oxygen, on which life depends, is in pure air in the proportion of about one-fifth (nearly 21 per cent.) of the whole; the indifferent gas, nitrogen, which tempers and dilutes its active partner, is in the proportion of four-fifths (just over 79 per cent.), and with these two gases is found a small quantity—continually varying according to circumstances—of carbonic acid, about three to four parts in 10,000 parts, or ·04 per cent., and in addition a minute quantity of a peculiarly active form of oxygen, called ozone, which is said to be rarely found in the air of towns. Of this gas-mixture (which we call air) we breathe enormous quantities. Of it we breathe in the twenty-four hours, according to Professor M. Foster, over 2600 gallons, that is about 425 cubic feet. As it returns from our lungs, the proportions

* Another article will follow the present article. At the end of this article is a list of the books referred to, with explanation as regards the manner of reference, and a list of medical terms employed, with translation of their meanings.

of the mixture are changed, the oxygen being reduced, and the carbonic acid increased.* But in all ordinary cases the quantity of oxygen in a room in which people are meeting is not greatly decreased, whilst neither this decrease, nor the increase of the carbonic acid, is sufficient to account for all the bad effects. How, then, arises the mischief?

The truth is that in taking air into the lungs and breathing it out again, we breathe out with it an organic poison. About the existence and presence of this poison there can hardly be doubt, though but little is known about its nature. Of it Dr. Foster writes (p. 552) that it may be formed in the lungs, or it may be a product of putrefractive decomposition, allied to a class of poisons known as ptomaines, which are found in the system. Dr. A. Ransome ("Health Lectures," 1875—76, p. 160) says:

"The aqueous vapour arising from the breath, and from the general surface of the body, contains a minute proportion of animal refuse matter, which has been proved, by actual experiment, to be a deadly poison. . . It is this substance that gives the peculiar, close, unpleasant smell which is perceived on leaving the fresh air and entering a confined space occupied by human beings or other animals. . . Air thus charged has been fully proved to be the great cause of scrofulous or tubercular diseases, and it is the home and nourisher of those subtle microscopic forms of life that have lately become so well known under the title of germs of disease, or microzyms. It is probably the source of a large part of that increase of mortality that seems inevitably to follow the crowding together of the inhabitants of towns."

Aitken says (27): "It has been found that air spoiled by the breathing of human beings contains small quantities of one or more extremely poisonous substances, which Du Bois-Raymond has named 'anthropotoxine.'" Gautier (214) sums up the changes that take place in air that has passed through the lungs:—Increase of carbonic acid, slight diminution of oxygen, increase of nitrogen and water vapour, presence of poisonous vapours, or at least of matters that are putrid, or in a state of gas, and giving rise presently to putrid gaseous (putrescibles gazeuses) matters, or matters in a state of fine division and suspension in the air; whilst the causes of these changes are—"the complex organic products of human or animal respiration,

* It must be remembered that the act of breathing consists in bringing the blood of the system in contact with air, through a delicate membrane in the lungs. Here an exchange takes place—oxygen being yielded up from the air to the blood, and carbonic acid from the blood to the air.

and of the breathing through the skin; the gases that escape from bodies; the consumption of oxygen, &c."

Galton says ("Our Homes." p. 497): "This organic matter" (given off from the lungs), "on an average, may be estimated at thirty or forty grains a day for each adult;"* and both Dr. Carpenter and Sir Douglas Galton notice that if breath be passed through water (and then kept in a closed vessel at a high temperature), putrefraction is set up, and an offensive smell is given off.†

Now let us take the case of a person who sits in a perfectly closed room, ten feet high, ten feet broad, and fifteen feet long, for five hours. At the end of that time he is breathing air which contains 1·2 per cent. less oxygen than it ought to contain. Now this is serious enough, but besides this, he is breathing some air which has already entered into and passed out from his lungs, and is therefore charged with this special poison. Here seems the great secret of the fatal mischief. Nature has got rid of the poison, thrown it out of the system, but the perverse occupant of the room insists on thwarting Nature, and, by means of his closed doors and windows, breathes in again,—it may be a second time or a third time,—the poison that has been once safely got rid of. Say that in twenty-four hours 425 cubic feet have passed once through his lungs, then in six hours our friend will have vitiated one quarter of that quantity, or 106 cubic feet—*i.e.*, about one-fourteenth of the whole air in the room in which we have supposed him to be sitting, and which contains 1500 feet of air. If he still goes on sitting in his study, at the end of nine hours he will have vitiated 159 cubic feet, or about one-ninth of the whole; or if he has been unfortunate enough to have had a friend sitting with him, then in six hours they will have vitiated one-seventh of the air; and of every mouthful of air they breathe after that time, one-seventh part of such air must be supposed to be charged with poisons that have been already once got rid of, but are now

* We do not know by whom this calculation was made.

† Foster (p. 552) states that "when the expired air is condensed..the aqueous product is found to contain organic matter, which, from the presence of micro-organisms....is very apt rapidly to putrefy." L. P. writes to us: "If a globe be filled with ice and taken into a close, badly ventilated room, the dew which forms outside is found to be contaminated with these organic impurities." L. T. writes: "It is more than likely that it is this animal poison which is the *direct* cause of typhus fever, as that follows overcrowding with mathematical precision."

being retaken into the system. Of course this proportion of one-seventh will not remain constant. Each breath expired will make the matter worse.* That we do inspire such impurities of the air, we know, not only from the consequences that follow the breathing of impure air, but from a common experience referred to by Professor Beale (S.A., 125) that a person may breathe in a putrid smell, and then breathe it out again—the taste and smell persisting for some time.

As a matter of fact, the supposed study does not strictly conform to facts, and the oxygen would not be reduced to this very serious extent in any ordinary room, since some air enters under doors, by the side of window-frames, and even through brick walls, when dry. Quite apart, however, from the question of the poisons which we breathe out into the air, a loss of 1·2 in the quantity of oxygen (*i.e.*, 1·2 per cent. of the whole air, or a reduction in the amount of oxygen itself from 20·96 to 19·76) would be a very large and hurtful loss. Probably any loss of oxygen amounting to two or three tenths of 1 per cent. is hurtful. Angus Smith records (p. 25) some reductions of oxygen: after a lecture at the Sorbonne, 19·86; a public elementary school, 20·65; an English law court, 20·49—end of sitting—(p. 67) and some low amounts in mines under special circumstances. Indeed, much lower figures have been given for mines, but they seem doubtful, since whenever a reduction in the amount of the oxygen of the air takes place from 20·96 (natural quantity) to 18 per cent. (*i.e.*, nearly 3 per cent. of the whole air), being accompanied with an increase in the carbonic acid from ·04 (normal quantity) to 3 per cent., the candles in mines

* In order to keep the air of a room in thoroughly pure condition, the large quantity of about 3600 cubic feet of outside air should be admitted per grown-up male per hour (Parkes, p. 179). Large as this quantity is, it will not keep the room pure, if those in it are engaged in active work. In work, more carbonic acid is evolved from the body than in repose, and the larger amount of 4750 cubic feet of fresh air per head p. hour is required. This, however, is light work. In hard work, nearly 10,000 cubic feet would be wanted. In hospitals again, very large quantities should be supplied. It may be considered ideal to seek to make the air of a room as pure as the outside air; and we should have reason to be only too grateful if care were ordinarily taken to supply something a good deal less than the quantities of air just named.

It should be noticed that in these cases the vitiation of the air is indirectly measured by the quantity of carbonic acid, which, resulting from the breathing of the persons in the room, is in excess of the normal quantity (4 in 10,000 parts). It is a convenient and probably fairly accurate test, since the impurities generally increase proportionately with the carbonic acid, and carbonic acid is easily ascertained, the organic impurity only with difficulty.

cease to burn (p. 81). This extinction of the candles, however, is due to the presence of carbonic acid as well as to the loss of oxygen. The influence of both can be fairly measured by the fact (stated by Dr. Angus Smith in another place, p. 165), that when air contains only 18·5 of oxygen, with about 2·5 of carbonic acid—a point at which the candles went out—(the figures quoted just above are apparently intended to leave a margin) if the carbonic acid be removed from the air by chemical means, the candle still burns, though with a little less than half of its full light,—the light being only ·45 per cent.; and we might add to this statement the fact that a candle will burn with as much as 10 per cent. of carbonic acid in the air, if the normal quantity of oxygen be supplied (Quain, i., 208). It is interesting to remark here, that a man can live in air where neither candle nor lamp can burn, just because the venous blood has stronger affinity for oxygen than has candle substance or oil (Angus Smith, p. 75), and life can be sustained until oxygen drops to 10 or 12 p.c. of the total air; but at the same time the effects of diminished oxygen must be very hurtful. If the light of a candle be reduced by one-third when the oxygen is only reduced by ·8 (*i.e.*, from 20·96 to 20·16 per cent.), we may be sure that we too must suffer much from diminished oxidization in the same fashion as the candle. It must be so, since any diminution of oxygen, and any increase of carbonic acid, in the air that we are breathing, means that less work of blood purification can be done in equal times,—each cubic inch of such air, carried to the lungs, presenting less oxygen for the blood to seize and to make use of. Dr. Angus Smith, who performed some very interesting experiments on himself, on his friends, and on candles, in a lead chamber, believes that very small reductions in the amount of the oxygen in the air affect us prejudicially. He points out (p. 69) that in nature the reduction of the amount of oxygen in the air is very limited; and that such reduction—marking the difference between healthy and unhealthy places—is only about the 1-25th of the reduction that took place in an English law court (200 parts in nature, per million, as against 5,000). Gautier (i., 218) also thinks that any decrease in the oxygen of the air is more hurtful than an increase in the carbonic acid. Moreover, Dr. Angus Smith points out (29) what is of great importance, that when the air is impure, by that very fact, the proportion of oxygen is still

further lessened. We should, indeed, naturally expect this to be the case, as the oxygen would be taken up by the impurities in the air.* Of course it is quite possible — as in the case of excessive alcohol taking, or other unhealthy habits — that we may not feel for months, or even for years, the effects of slight oxygen starvation, but the great and expensive labour that nature undergoes, in every human body, to supply the blood with oxygen, is an eloquent fact that we should never allow ourselves to forget. Professor Foster (p. 254) calculates that the total work done by the heart in a day is about the equivalent of a journey up Snowdon, or the lifting of 75,000 kilograms up the height of one metre. If we credit half this work as done for the purpose of bringing the blood to the lungs, and there discharging carbonic acid and taking in oxygen, and if we add to it the continual and costly movement of the muscles which are concerned in respiration (the contraction of the chest cavity takes place about 17 times a minute, and is stated by Professor Haughton—Carpenter, p. 324—to be equal to the lifting of 21 tons one foot in 24 hours), we can fairly realise how imperative is our physical duty not to waste or defeat any part of this great labour—undertaken for the sake of blood purification—by our own carelessness as regards the quality of the air that we are breathing in our houses. Nature has done her part; it is but fair that we in turn should do our part also.†

Before leaving this part of our subject, we ought to say some words on carbonic acid. We have three things to consider as regards the air of our living rooms, (1) as we breathe, we lessen the oxygen in every confined space; (2) we increase in proportion the carbonic acid—oxygen being taken into the lungs, carbonic acid being given

* The writers found in Scotland that the test paper showed ozone in the air at a slight distance from the house, but would not show it in the house, though windows were always open.

† It is right to refer here to the experiments of Dr. Marcet and Mr. Russell. They found, we believe, that the result of breathing air with an excess of carbonic acid was to increase the quantity of oxygen inspired—not having the papers before us, we presume through quickening of respiration—and to decrease the carbonic acid expired. (Proceedings of Royal Society, June 4, 1891.) This decrease of the carbonic acid expired (which would be still greater, as we should expect, but for the increase of oxygen inspired) shews the depression of certain vital functions—such as the changes connected with the getting rid of waste—following upon the breathing of an excess of carbonic acid; just as Müller found in the reverse case that more carbonic acid was expired—*i.e.*, certain vital functions were quickened—when excess of oxygen was inspired.

out; (3) we breathe out a certain organic poison. Leaving the other two points for the moment, we wish to call attention to certain facts affecting carbonic acid.

First of all, it is necessary to distinguish between the effects of pure carbonic acid, and carbonic acid accompanied by those organic impurities which come from skin and lungs. It is true that pure carbonic acid has in itself, when inhaled in sufficient quantities, "a distinctly toxic narcotic effect" (1 Quain. p. 208); and it is stated (see Parkes p. 157, and Angus Smith), that when (in a pure state, apart from organic emanations) it amounted to 3·84 per cent. of the whole air, it tended to produce disturbance and slowing of pulse with quickening of respiration—the quickening of respiration being more marked than the slowing of the pulse. When Dr. Angus Smith introduced this quantity of pure carbonic acid (3·84 per cent. of the whole air) into the lead chamber, his two friends suffered after a few minutes from headache; and he himself was affected with feverish activity "of body and mind," his breathing being increased from 20 to 26 per minute (p. 142). But 3 per cent. or 3·84 is a very large quantity. Even 1-10th of one per cent. (or ·1) is a large amount when compared with the normal quantity (·04 per 100) that is found in the air. This quantity (·1 per cent.) of pure carbonic acid was found in the air of a well-ventilated soda water factory (windows wide open) in Manchester, which A. Smith visited (p. 409), and was believed to produce no bad effects.

But quite different from pure carbonic acid is the carbonic acid which results from respiration and has very "evil companions" in the shape of organic impurities. Though ·1 per cent. of pure carbonic acid may be nearly harmless in itself, De Chaumont and Parkes (Parkes, p. 177) believe that when once the carbonic acid of respiration amounts to about ·08 (as against ·0401 of the natural air), or about double the normal quantity, an odour (resulting from organic emanations) becomes perceptible; and when it amounts to about ·1 per cent. (or 1 in a thousand) that the odour becomes disagreeable. They would therefore impose ·06 per cent. (or about 1-17th of 1 per cent.) of carbonic acid as a limit, which, in their opinion, should not be exceeded in living rooms, when it results from respiration. How much this limit is constantly exceeded, may be seen by some figures of carbonic acid given by Dr. Angus Smith (p. 54): Chancery Court (near ground), ·20 per cent. (by vol.; or

1-5th of 1 per cent. instead of the 1-17th allowed); different theatres from ·10 up to ·32 per cent. (or in the worst cases 3-10th of 1 per cent. instead of 1-17th). It should be remembered, to avoid confusion, that in some cases the figures of those, who write about the carbonic acid present in crowded rooms, include the normal quantity of carbonic acid in the air, while other figures exclude it. In the limit of ·06 per cent. it is *included*, and it is easy to remember this limit by remembering that organic odours become perceptible (and therefore, as we must presume, distinctly hurtful) when the carbonic acid, resulting from respiration, about equals the normal quantity of carbonic acid already in the air, and thus forms a double supply. The limit lies half-way between the natural quantity and the double supply, at which last point (·08 per cent. of total air) the organic emanations of skin and lungs become perceptible to the smell. This should never be tolerated.

It is, perhaps, well to add that Dr. A. Smith (194) has proposed a very simple way of testing the amount of carbonic acid (and by inference the organic impurities) in the air. Carbonic acid brought into contact with lime water or baryta water, forms a precipitate. Where the air is of ordinary purity, a bottle of a certain size holding ½oz. of lime water and so many ounces of air will give a certain amount of precipitate. Now if a bottle, also holding ½oz. of lime water but only half the quantity of air, is found to contain a precipitate of the same amount, it is plain that in this second case the air contains twice as much carbonic acid as in the first case (pure air). Thus, by bottles of different sizes, any person can test easily for himself the air of different rooms. Reduced to the simplest rule, there should be no appreciable precipitate, when the air of a room is shaken up in a 10½oz. bottle containing ½oz. of clear lime water (202). If there is, the air is impure. At the same time we think that possibly a still simpler test might be found. Might not a special candle be made—for test purposes—by mixing some substance with the wax, which is unsuitable for combustion, and which would show by the decreasing light when there was a hurtful diminution of oxygen with a hurtful increase of carbonic acid.

We must now leave this part of our subject, but in leaving it, it is right to say that a new discussion has lately arisen as regards the respective parts played in bad air by carbonic acid and by the organic poisons. For details, see Appendix A.

A few words seem necessary here for those who have never followed the changes going on in the body. We know that we are constantly building up new tissue of different kinds, and that this building up makes it necessary that the old tissue should be got rid of. The larger part of our food measures this change which is always going on. If we take our daily food, liquid and solid, for twenty-four hours, as weighing about 5 lb. 8 oz. (Hermann, p. 233) — a large proportion being water — we may consider about 5lb. 3oz. of this quantity as taking part in the formation of fluids and tissues, the other 5oz. forming exhausted ferments, as they are called, which, passing along the alimentary canal, are eventually rejected. Now, all the suitable part of the food, after undergoing various changes, which are necessary to prepare it for its passage from dead food into living tissue, finds its way into the blood; and when by means of the larger blood-vessels, it reaches the very minute blood-vessels, called capillaries or hair vessels, it pours a part of itself out through the permeable walls of these minute vessels, bathing and feeding the whole surrounding tissue. Thus, as somebody has said, the whole of the new living body is in solution in this wonderful food-stream of the blood, which, by a very subtle mechanism of nerves, distributes its good gifts in proportion to the needs of each separate part. But the blood is not simply a food-stream, it is also a sewage stream, and it is as such that we are specially interested in it. Where no growth or storing of flesh material of any kind is taking place in the system, it is evident that such part of the daily food which is turned into tissue measures not only the daily construction that is taking place within us, but also the daily destruction or waste. In fact—if one may so speak of the particles of which he is composed—we are for ever living and dying within ourselves—making a new self, and getting rid of an old self; and just as the new living body is in solution in the blood, so also is the old dead body, that has done its work and has to be got rid of. Now, of this dead body such part, as does not escape through the kidneys, has to escape through lungs and through skin.*

About this process of waste, that is, the getting rid of the old tissue which is being replaced by new tissue, but little is known.

* We do not take notice here of certain other slight losses, such as loss of dead outer skin by friction, &c.

We know, whilst certain temporary forms of waste are found in muscle, such, for example, as kreatin (Gr. kreas, flesh) which, whether again made use of or not, has been supposed to be eventually changed in some complex manner into urea in the liver, or an acid called lactic (Gr. gala, milk) which is also supposed to be decomposed in the liver into carbonic acid and water (M. Foster, p. 827), that all our dead tissue is—with certain slight but most important exceptions—got rid of safely at last in the three forms of urea, carbonic acid and water.* These are the final forms which the waste, that passes from the tissue into the blood, takes—the urea being separated from the blood and got rid of by the kidneys, the carbonic acid both by the skin and the lungs, and the water by all three channels of separation.†

But we said that urea, carbonic acid, and water did not account for quite all the waste tissue; and amongst the part not so accounted for are the very hurtful poisons which escape from lungs and skin. What are these poisons? Have they a connection with, a relation to, the poisons which, as we know, exist at all times within the system on a large scale. Broken-down or waste tissue passes through many forms before it reaches the safe final forms of urea, carbonic acid and water, and there are reasons for concluding that some of these forms are highly poisonous. We see this by what happens to a man when he is drowned. A drowned (asphyxiated) man is in reality a poisoned man. The waste which is going on everywhere and at every moment in his tissues is producing poisons of so deadly a character that when they cannot be oxidised by receiving oxygen from the blood (as happens under ordinary circumstances by means of the two gallons—nearly—of air which he breathes in a minute) death ensues in a very short space of time. In such a case, the poison produced all over the system has been no longer rendered harmless by oxygen, and goes as poison to the brain ‡ Now, this poisoning does not appear to be

* We are not taking into account certain substances discharged from the skin in minute quantities, as chloride of sodium, phosphate of soda, oxide of iron, &c.; or other substances got rid of by the kidneys.

† "The natural waste of the body appears in two simple forms of carbonic acid—the gaseous form having the chemical formula CO_2O, while that, which is got rid of in solution, is urea, that is, $CO_2(NH_2)2$ in which the second atom of oxygen in the carbonic acid is replaced by a nitrogenous body termed amidogen," writes L. P.

‡ It may affect the brain, directly through the blood, or indirectly, by poisoning the local nerve centres.

primarily or necessarily due to an excess of carbonic acid, which must accumulate in the blood when a man is drowned. As Professor Foster shows, even where the carbonic acid is got rid of, and no oxygen is available, the same result follows (600). Thus we have a pretty clear indication that the poisoning which results is the non-oxidisation of certain active poisons. Other indications point to the same conclusion. When a man faints from loss of blood, he probably faints because the diminished stream of blood does not carry a sufficient quantity of oxygen with it to neutralise the poisons which reach the brain.* It is also noticeable that this desire for oxygen is emphasised by the convulsions that take place in such cases as drowning,—or when the inhalation of nitrous oxide is continued without air (Quain, p. 42); or after such a loss of blood as proves fatal (Watson, vol. I., 66, 286). In these cases, oxygen being denied, the poisons (carried by the blood, and retaining all their virulence from being non-oxidised) act at first as a powerful stimulant to a part of the nervous centres, which, in their turn acting through the local nerves, throw one set of muscles after another (connected with the respiratory system) into action, in order to obtain the oxygen that is so sorely needed; ending at last in that general violent movement which is called convulsions. After a short time, when no oxygen responds to the muscular effort made to obtain it, the poisons overpower the nerve centres and death ensues.†

Both fevers and violent exercise seem also to illustrate the same action. In fever, the tissue rapidly wastes, and great quantities of waste-poison are poured into the blood. These poisons in like fashion act on the nerve centres, and are the cause of the quickened respiration and circulation,‡ which are necessary to get

* One of the writers was informed by a friend in Africa, that he was present when a man cut himself badly with a bill-hook, and was carried into a cabin. Each time the door was closed, the man fainted; each time the door was thrown open, he came back to his senses, indicating pretty clearly that the supply of oxygen, which was unduly diminished by the loss of blood, was increased when the door was open, and was just sufficient to neutralise the effect of the waste-poisons and prevent unconsciousness.

† It is interesting to remark here that this reaction of the nerve centres under the effect of the poison, seems to be of that "protective character" which occurs so often, and to which Professor Foster more than once has referred; that is to say, that it produces a violent movement of the muscles in the effort to obtain air, which can alone neutralize the mischief.

‡ The nerve centres, however, of heart and respiration are differently affected. In certain cases, the circulation is slowed, not quickened. This is the case, Professor Foster says, in drowning, after a slight quickening has

the excess of poison oxidised; and, therefore, when delirium or unconsciousness supervenes, we may say pretty confidently that the rapid circulation and the rapid breathing have not been sufficient to oxidise and render harmless the mass of poison which is being carried to the brain.† So again, in pneumonia, the quickened breathing shows both the effort of Nature to make up for the loss of that part of the lung which is ineffective, and shows also the stimulus, which the increased waste-poison in the blood (increased, owing to diminished lung capacity, and therefore diminished oxygen) exerts upon the respiratory machinery.‡ So again, when less blood is carried to the lungs, owing to the artery which leads

taken place. May this be explained—whether by means of the increased difficulty of passage through the small arteries and capillaries by impure blood, or the stimulation of the nerve centres [which restrict the bore of the arteries and thus slow the circulation] by impure blood, or by other machinery—by the supposition that, where oxygen is denied, an increase in the rapidity of the circulation would carry the poison quicker to the brain, and therefore hasten the end? It is plain that the quickening of the respiration may be safe in many cases where the quickening of the circulation would involve danger to the nervous centres, owing to the mass of poison in the blood. A similar effect in a slight degree seems to occur in the case of vitiated air. It has been stated that in such air the circulation is slowed. Angus Smith's experiments on himself in the lead chamber seem to confirm the statement—the breathing being quickened, the pulse being a good deal disturbed, but tending to be weakened and slowed (211), especially when one person was alone in the chamber, and therefore, perhaps, less subject to excitement. In fever, on the other hand, the circulation is, generally speaking, quickened; in exercise, again, when oxygen is freely available, and is being pumped to every part of the system by the action of the muscles, the effect is the same as in fever; both respiration and circulation are quickened in order to increase the supply of oxygen required to meet the large increase of waste—the quickened circulation probably not being due to carbonic acid, which, as is remarked by Professor Foster, is not found on analysis in excess in the blood. Perhaps it is well to add that there are three ways in which the circulation may be affected: by action of the nerve centres which regulate the heart; action of the nerve centres which regulate the bore of the arteries, and thus affect the circulation by increasing or diminishing the resistance to the passage of the blood; and changes in the condition of the muscle of the heart. In the case of those persons who habitually breathe impure air, and whose blood is in an impure state, it seems likely that the condition of the muscle of the heart is affected, as well as the nerve centres, by the normal impurity of the blood. Something could be learnt by very simple observations. Those who attend crowded concerts or meetings should notice at the time and also next day, the effect upon their pulse and rate of breathing. There is evidently not only stimulation of certain nerve centres, but also depression of nerve action resulting from these waste-poisons (see p. 26).

† This indicates very clearly that the purest and freshest air should flow through the room of a person suffering from fever. It would be almost as necessary to him as to the person suffering from loss of blood. Such treatment is confirmed by experience,—see case of Austrian army, further on.

‡ Unless in this case it be attributed in part at least to increased carbonic acid.

from the heart to the lungs being partially blocked with a clot, the same effect is produced. We might also compare with these conditions of imperfectly oxidised waste the condition which arises after hard work,—to which a person is not accustomed—either in old age or in a feeble state of health. The tissue, not being in the firm condition of the tissue of a vigorous person accustomed to daily work, breaks down in undue quantities, whilst at the same time the circulatory and respiratory machineries being no longer at their best, the "unburnt" waste remains in the tissues, being insufficiently supplied with oxygen brought by the now enfeebled blood-stream. On the next day the over-worked man is poisoned by this unusual quantity of waste in the system, and feels discomfort in many parts of his body or limbs. So also the discomfort acutely felt by some persons during east winds probably arises from the poison, which ought to have been got rid of by the skin, but owing to the closing of the pores, has been thrown back into the system. It is different with the ordinary violent exercise taken by men in the vigour of life. In this case there are no after pains, because when men are young and healthy they are capable of oxidising successfully large quantities of waste, which are got rid of at once, and do not remain in the system to cause trouble. The successful athlete is therefore, first, the good oxidiser (see M. Foster, p. 628),—the person who has good lung capacity and — what is more important—a powerful heart to drive the blood swiftly; and, secondly, the person who trains well, whose tissue is healthy and firm and does not break down rapidly into waste—waste in his case not outstripping the powers of oxidation, and thus causing distress. On the other hand, the untrained man, who breaks down in the race with every symptom of distress, is the poisoned man — the man who formed waste quicker than he could oxidise it.* It is hardly too much to say, that if we

* In such a case, it may be asked, why are not the waste-poisons passing into the blood from the tissues safely got rid of in the form of carbonic acid and water by the time that the blood reaches the lungs? It seems difficult to escape from the conclusion (see Foster, p. 603) that imperfectly oxidised waste products must, on occasion, pass the lungs without being got rid of. In the case of violent exercise, it would seem that the quickened heart and quickened breathing come from the action of waste-poisons, which, passing the lungs, reach the medulla (nerve centre at base of brain, regulating respiration) and stimulate the nerve centres; and that in many cases there is not time, owing to the excessive quantity of waste in the blood, to reduce all the waste to the safe final products of water and carbonic acid. As regards

cannot oxidise vigourously, we cannot, physically speaking, lead a successful life.

Reviewing, then, what we have said, we seem to see three things: first, that so long as our working machinery remains good, and we are able to supply ourselves plentifully with oxygen, we can get rid of a large amount of daily waste in safe and harmless forms; secondly, that when oxygen is withheld from us there are poisons in every part of our tissue of so deadly a character (either abnormally formed because oxygen is absent, or formed under ordinary circumstances but normally neutralised by the supplies of oxygen constantly carried to the tissues) as to take life in a few minutes; thirdly, that even when all is well, and our system is functioning under healthy conditions, we are still always breathing out from ourselves, through lung and through skin, certain dangerous poisons, which poisons, when we are living in bad air, we perpetually reabsorb into ourselves, to our own great hurt.

Nothing, however, that we have said, satisfactorily explains the presence of these poisons which escape from the lungs and the skin. It seems hard to explain why, when Nature so successfully breaks down the great mass of waste into harmless products, there should be this comparatively slight residue left over—reminding one of a lawless fraction of people in an orderly society—which cannot be got rid of on the same easy terms. As we have seen, we have about 5lbs. 3ozs. of daily waste that is nearly all safely got rid of as urea, carbonic acid, and water, by means of kidneys, skin,

the poisons we rebreathe from the air, it seems rather a surprising thing, as they enter the circulation, that they should not be at once oxidised in the arterial blood, when we remember how they must be surrounded by the oxygen that the blood has just received from the air. But active as oxygen is—in its "nascent" state, just released from hæmoglobin—in the tissues after leaving the blood, there are reasons for thinking that this activity does not exist in the blood itself (Foster, 580). Thus we are told that pyrogallic acid, which is an easily oxidisable substance, may pass through the blood without undergoing any change; and fresh blood, as we are told, has little oxidising effect. This powerlessness of the oxygen in the blood is important as regards these rebreathed poisons. If they were oxidised in the blood, they would at once, we may presume, lose their hurtful character, but such an arrangement might interfere with the delicate adjustments by which more oxygen (by means of more blood) is distributed to those organs where there is special need of it at special moments. Were the blood liable to lose its oxygen on its way from the lungs to the organs, greater mischief of other kinds might result than from the existing failure to directly oxidise those poisons, which we breathe into the blood, when we take vitiated air into our lungs.

and lungs; but accompanying this safe discharge we have a few grains of poison—a sort of surplus of evil—which in some way or other escapes the oxidation to which all the other mass of waste has been subject. What, then, is this poison? How far is it the same, how far does it differ from, the normal poisons of the tissues, which as we see, in a few minutes destroy life when oxygen is withheld? Where and how is it formed? Are we to look upon it as a putrefactive poison formed at the surface of the lungs and the skin; and if so, why should it be formed in this irregular fashion? Dr. Klein tells us (p. 241) that septic bacteria* (*i.e.*, the authors of putrefactive change, not of disease) are to be found in those parts of the body into which air penetrates, as the mouth, the air-passages, the whole alimentary tract. Are we then to look upon these expired poisons as derived from putrefactive decompositions taking place in the air passages, and therefore, either as matter left over after the bacteria of these tracts have taken from waste substances — escaped from the blood—such elements as they require; or as matter excreted by these minute organisms in their own growth? At present, both within and without the body, the nature of these poisons is surrounded with mystery, and many are the interesting questions that remain to be solved about them. In whatever manner these expired poisons are formed, are they—when they have passed outside the body—the food of the bacteria which are found so plentifully in foul air?† If so, are these ordinary bacteria (excluding the case of certain bacteria producing disease) friends rather than enemies; do they render this expired poison itself less harmful; or do they themselves produce an excretion which is of a poisonous character; or should they be looked on as neutral, destroying one poison and producing another? So also we should like to ask, are the poisons themselves removed by simple currents of air, or are they oxidised in the air; if so, are they oxidised only when ozone is present (see "Our Homes," p. 495); and if oxidised in the air, are they

* For reference to a different view, see De Bary on "Bacteria."

† *Bacteria* (Gr. Bakterion, a staff) are the smallest living organisms known, and now included in the vegetable kingdom. They are fungus-like; possess a very simple structure, are capable of free movement, and may multiply very rapidly. Some kinds play a part in putrefaction; others in certain diseases. It has been calculated that not uncommonly we inhale 300,000 of these germs in the day.

oxidised also in the blood, after we have rebreathed them, when they are surrounded with oxygen,—the oxygen being in loose combination with hæmo-globin ; or are they only oxidised—in common with other waste in the tissues—after they have passed from the blood into the tissues?

Another interesting light is thrown upon the bad character of the waste-poisons, which are always present in the tissues, by the statement that they exhaust the power of muscle to contract. Muscle taken from a freshly killed animal, if fed with arterial blood, or blood supplied with oxygen, may retain for some time its power of contraction. But if venous blood (blood that has lost its oxygen and is charged with waste-poisons) be injected into it, the power of contraction is lost quicker than if no blood be supplied to it. In the same way the power of the muscle is soon exhausted if a solution containing substances, which can be extracted from muscle (such as kreatin, lactic acid, &c.), be injected into it (M. Foster, p. 150). These facts help us to see the local mischief which must often arise from these poisons, as well as their effects on the nerve centres. Many an ache and pain are probably due to the local action of these waste-poisons, whether they are the normal waste-poisons of the system, of which, under unhealthy conditions of life, we are not properly getting rid, or these special poisons of skin and lungs that we persist in re-breathing into the system. When it is said that "pain is the cry of a nerve for healthy food," it might often be said with equal truth that it is the cry of the nerve to be relieved from waste-poisons ; and a human body, the tissues of which are blocked with waste, may be fairly compared to a town, whose system of sewage from some cause or another has been arrested.*

* Where Nature does not get fair-play, where, for example, the blood is vitiated by our constantly rebreathing poisons that have been already once got rid of, other dangers must exist. In the delicate chemical translations which take place either when food is being changed into tissue, or worn-out tissue into harmless waste, it may happen that the process goes wrong, and an abnormal poison is formed. We have a great capacity for forming poisons and abnormal substances, both in illness and when health is slightly deranged. Thus, under certain circumstances, instead of urea, uric acid is formed ; thus in uræmia, or retention of urea in the system, various secondary compounds are formed which act on brain or spinal cord as narcotic poisons ; thus a highly contagious poison is formed in inflammation both of the conjunctiva and of the peritoneum, and in "other inflammatory and febrile diseases" (Beale, S. A., 343) : thus pus may be formed from an alteration in normal bioplasm and may assume the most poisonous character (94-5) ; thus, in acute yellow atrophy, where liver cells lose

We now pass to other evidence affecting the poison that escapes from lungs and skin. We all know that a room is offensive when many people are crowded into it; we know the unpleasantness of a bedroom before the air has freely entered it; we know how disagreeable the breath and the clothes can be; we know that animals die when submitted to air that has been breathed, even when the carbonic acid has been removed;* we know how necessary

a part of their activity, a substance called leucin is manufactured to a considerable extent instead of urea (M. Foster, p. 755); thus gall-stones are formed instead of gall, and certain changes take place in the bile, by which some of its constituents cease to be dissolved in it (M. Foster, p. 431); and thus when the liver is diseased, various abnormal compounds appear in what passes from the kidneys (Brown, 194). Thus also in digestion we may manufacture an acid called butyric, which when absorbed into the blood is stated to act as a nerve poison (L. Brunton, 146); or an improper compound called hemi-albumose (L. Brunton, 37); thus Valerianic, Acetic, Formic, and other acids may be formed when digestion is much deranged (Beale, S. A., 151); or to take an example of common experience, in cases of indigestion, we may fail in manufacturing a true gastric juice, which in its proper state should be acid, but may have an opposite (alkaline) character (L. Brunton, 22), thus "losing its digestive power." Thus, again, there are poisons, to which we shall refer in a later paper, of a very interesting character, which are formed in the system both during life and after death. [It is curious to notice in connection with these ptomaines (poisons formed after death) that a dispute arose during an important Italian trial as to whether a poison detected in a body was strychnine, or a naturally formed ptomaine. We give in the second part of this paper a sketch of Dr. A. Brown's and Sir W. Aitken's account of these ptomaines.] Thus, too, Blyth ("Poisons," pp. 468-470) describes cases in which narcotic poisons have been formed by synthesis of substances in the tissues or in the blood. So also we might refer to the speculation of Dr. Carpenter — though, if modern views are correct in assigning a bacterial origin to cancer, the matter should be stated in rather different terms — that a cancer is an excretory organ, formed to get rid of poisons in the system, illustrating once more "the protective nature" even of that which finally brings pain and death; and to the case of certain pathogenic (disease-producing) microbes, which, as seems likely, are not able to affect healthy living tissues, but only unhealthy tissues—the unhealthiness implying alteration of the tissue. Most of these cases are, doubtless, of an extreme kind; they imply the abnormal formation of poisons to a serious extent, sufficient to constitute illness; but there are many less serious formations of abnormal poisons, which, though not sufficient to produce illness, yet cause much discomfort, and which are the consequence of the vitiated state of the blood,—often and often arising, as we believe, from the evil habit of breathing impure air.

* If we remember rightly, both Parkes and D. Galton ("Our Homes") refer to these experiments—a mouse dying in forty-five minutes when submitted to air treated in this manner. Dr. Richardson also refers in one of his works to experiments, which were conducted by himself, and which are more fully described in a report to the British Association. Dr. Richardson had formerly a theory of "devitalised oxygen," but we suppose he would probably consider now that it was a truer statement to say that this special poison had not been removed from the air which the creatures breathed. Experiments of the same kind have also been made on rabbits in Paris. One of our number

is the continuous flood of pure air in hospitals—we have heard it stated that a much freer admission of air may render unnecessary the antiseptic treatment of wounds; we know how by treating

(A. H.) adds the following remarks: "Though I think it would be quite misleading to speak of the experiments upon the mouse, and the experiments conducted by Dr. Richardson as in any sense cruel, yet, expressing my own personal opinion, I remain opposed to all such experiments. Whilst I admit the neat and convenient evidence often supplied by them, and the ready test that they seem to offer in the case of new hypotheses, and also admit that difficulties of method would at first exist, were they renounced, yet I venture to think, speaking generally, that the wealth of material—consisting of the facts of health and all the delicate gradations between ill-health and disease—which exists on all sides of us for pushing forward knowledge, is so great, that however convenient these experiments may be, they are not really necessary and might be replaced. After all, a method of verification is much easier to replace than a method of discovery; and, indeed, it seems probable that a keener perceptive sense in tracing out the meaning of the things of common life, which are of such vital importance, a closer alliance between lay observation [now unguided and wasted] and scientific enquiry, and a more careful examination into the causes of that modern ill-health, which does not amount to disease, but which is so instructive from a pathological point of view, would be developed, as investigators consented to renounce this particular method. In writing this, however, I admit grave difficulties as regards new methods, and am simply governed by the moral side of the question. Whether, therefore, for the moment we gain or lose in knowledge, I think we—who disapprove—ought to seek out other methods. No legal compulsion, however, of any kind should be employed. All of us must be left free to follow our own conscience and judgment in the matter: and those of us who disapprove of such experiments should recognise that upon us is placed the burden of putting our shoulders to the wheel and showing that we can produce equally good practical results by employing other methods. Doubtless a great deal has been learnt through inoculations of animals,—uncertain as some of them are; but we have yet to see whether other reactions from the bacterial virus could not take their place. I should like to see physiological schools founded—especially at the Universities—for the purpose of developing methods differing from the present method. Why are we, who differ amongst ourselves, always to be in servitude to one uniform system and one uniform school of teaching? Let the schools founded on experiment pursue their own way on their own responsibility; and let others amongst us oppose other schools to them. Progress consists in these practical oppositions more than in denunciations of each other,—though I admit that we might find life a little dull, if the denunciations on both sides came entirely to an end; and, perhaps, a certain amount is required for all causes. Personally I find myself indulging in a fair amount.

"A few last words. The physiologists have the right to claim freedom of judgment and freedom of action in the matter, and they must have it. On the other hand, not one penny of State money or one fraction of State privilege should be conceded to them. It must be a perfectly fair field between us. There must be no State power of any kind placed in the hands of the medical profession. Like other bodies, they may adjust the conditions of their own service, or the conditions of entrance into their body, to their own liking, but they must have no power of interfering with or repressing any kind of medical practice or teaching outside their own ranks. We are finishing up with our established churches; and we will build no secular imitations upon their ruins. Professor Horsley will recognise the justice of

men in the open air and in tents recoveries have been made quicker and better than in hospital; and how in the case of the Austrian army "the most severe maladies ran their course much more mildly" in the free air, while the recovery was quicker and more perfect (Ransome, "Health Lectures," 1875-78, p. 151). So during the French evacuation of Mexico it was discovered with much surprise that the wounded, having to be transported in open conveyances during several weeks, did much better than if treated in hospital (Gautier, 213); so also in the Crimean War the mortality in French hospitals in Varna was 60 per cent. in buildings, in tents 26·5 per cent. (213); so also the tent hospitals during the siege of Paris, notwithstanding the winter season and scarcity of fuel, gave the only good results; and in consequence of these facts, both Germans and Americans have established, as a regular thing, tent hospitals, placed in gardens, as soon as the winter is over; so "erysipelas is somewhat frequent in fixed hospitals, but is exceedingly rare in tents and huts" (Russell, 171); and "overcrowding in hospitals and want of ventilation" are amongst its causes (174); so hospital gangrene " . . is prevented by perfectly free ventilation . . . It not only does not occur in tents, but patients removed to tents at once commence to improve" (172); so Dr. Collie recommends in acute infectious diseases "the windows being open, as a rule, by night as well as by day,"—the patient, however, not to be exposed to draughts; so also the loss by puerpural fever has been largely reduced in maternity hospitals by purifying the atmosphere and improved hygienic surroundings (Russell, 246). So also Dr. Parkes says (p. 181) in cases of blood poisoning, the best treatment is complete exposure to open air; so also in typhus, [in a less degree in enteric fever] and in small-pox and plague. "This complete exposure," he adds, "of patients

this claim. He has taunted those who disapprove of experiments upon animals with availing themselves of knowledge gained by these experiments. He will at once see that if we owe him freedom to act upon his own judgment, he equally owes us freedom to organise such medical schools, and to take such medical help as we like, orthodox or unorthodox. Lastly, some of us esteem and like the profession too much to wish to quarrel with it. If the State give it any kind of monopoly or privilege, then it forces upon both sides perpetual bitter war; for some of us will never acquiesce in any form of State privilege and power. Let the State stand wholly aside. In that way alone shall we be able to remove artificial and unnecessary obstacles to a continual growth of trust and liking between the public and the medical profession, towards whom, even if we must at times quarrel with them, we cannot but have warm feelings of gratitude."

to air is the most important mode of treatment, before even diet and medicines."* So "all the common highly infectious diseases in England, except measles, have a high rate of prevalence in January," indicating the fatal effect of shut-up rooms and want of ventilation; so "well ventilated depots of typhus patients are not dangerous even to the attendants" (Russell, 342, quoting Sir J. McCormack); so, as regards diphtheria, "dirty, unventilated buildings and bad nourishment" (Russell, 135) increase the liability to it; so want of ventilation and crowding favour that terrible disease, the plague (Russell, 237); so on the other hand light and air are safeguards against cholera (76); so also even in natural positions, where "hills or jungle" impede ventilation, malaria is favoured (224); and so in Liverpool "the open courts remained on the whole healthy, and this even in districts smitten with fever" (Thorne Thorne, 18). In the same way, the deaths of the Black Hole of Calcutta add their evidence, though it is evidence of an extreme kind. Whilst out of the 146 persons shut up, 123 died (Carpenter, p. 357), of the remaining number many afterwards died of putrid fever—that is, were poisoned, owing to an insufficiency of oxygen to neutralize the poisons breathed out on all sides of them, and rebreathed by themselves. So also a contagious disease similar to typhus has been developed amongst animals crowded on ship board (Aitken, 30); so at Portsmouth when the carbonic acid in the cells did not exceed ·7 per 1000 the convicts "were robust and healthy," when it rose to 1·0 per 1000, then they "suffered from anæmia, lung, and other diseases" (Russell, 96); so Collie writes (128) "disease of some sort almost invariably attends large aggregations of individuals"; so shearing-shed fever, which is very like influenza, arises when a large number of men and sheep are crowded in the shearing-sheds in Australia in hot, dry weather (Russell, 472); so "Dr. Madden has noted that trismus nascentium and spasmodic croup are very largely reduced by ventilation or removal to country

* "When our Health Commissioners were sent out to the Crimea to examine the heavy mortality among soldiers in the hospitals, their first act was to use their sticks to break some hundreds of glass panes in the windows, so as to admit air freely. After that the wounded recovered rapidly," writes L. P. In the same way Dr. Clifford Allbutt reduced the mortality in a heavy epidemic of typhus fever in Leeds by fastening the windows in the fever hospital with screws, so that they could not be shut. He remarks that in Ireland those attacked with typhus, who were put out to die under hedges, would often recover.

air" (Russell, 376). So again Mr. Russell writes: "The decline of robustness is plainly visible in persons living in bad air"; so "during the prevalence of influenza and colds the chances of escape are almost directly as the air admitted" . . . If statistics were procurable, it would be found that the daily travellers by train in winter suffer from colds and lung troubles in much larger proportion than the engine drivers and guards who get more of the outside air. All statistics of the influenza epidemic prove that those living in the stuffiest conditions were most attacked" (Russell, 478); so the death-rate increases as the density of people increases per acre (399), and again as the density increases per room (418); and so (Gautier 220) soldiers and sailors, confined in too small spaces, may suffer terribly—"then appear fevers of the typhus type, affections of the skin, such as herpés, zona, purpura, scurvy, and endemic typhus"; so bad air (and sedentary life) to some persons (as east winds to others, (Beale, S. A., 211) by checking skin action and so poisoning the system) may be a cause of a lesser trouble,—constipation (Beale, S. A., 175), but a trouble which brings with it after a time much serious mischief,—such mischief itself being specially likely to result where the nervous centres are depressed by the breathing of impure air, and where in consequence the great purifying organs are doing their work less effectually; so "the spread of diphtheria is favoured by schools, especially through the closeness of the breathing organs to each other" (Russell, 143); so typhus is a disease of bad air, crowded towns, and crowded rooms, and it begins in the most crowded part of a town. . . . Typhus may be greatly limited by securing abundance of fresh air" (Russell, 338); so typhus and houses built back to back, where ventilation is much impeded, are related to each other (Thorne Thorne, 21); so "offensive and evil-smelling drains are much less likely to produce typhoid, than covered unventilated drains which have access to the interior of the house. In the free atmosphere typhoid is rarely caught, even at an open cesspool" (Russell, 294); and so also one of the new diseases of the century, cerebro-spinal-meningitis (80), is believed to be favoured by overcrowding. A simpler piece of evidence, however, is presented to us daily by our own eyes. Who is not struck by the pasty anæmic look of our city children and of the larger number of those who follow sedentary occupations, as contrasted with the looks of those who live in the country, and are

much in the open air? What is that pasty anæmic look? It results from the absence of red corpuscles in the blood, and appears to indicate that where oxygen is deficient in the blood* the red corpuscles are not produced in their proper quantity. So also the effects of living in rooms in which sewer gas has penetrated illustrate in their own stronger degree the effects of living in unventilated rooms. The one is the lesser form, the other the more serious form of the same evil. In both, bacteria thrive and multiply, and in both, meat and milk rapidly taint.† Both atmospheres are full of putrid organic matter, and the symptoms of headache and feverishness are common to both, though, of course, the case of sewer gas in a house is the more serious form.‡ Again, we all know the wonderfully restoring effect that hill air with its ozone has upon us after town life; showing how the poison has depressed all our functions, and how the pure air restores their energy. We see the same effect in the lives of workpeople. Sir D. Galton, like many others, tells us of better work done, more energy, more appetite, when air is introduced into unhealthy workrooms. Dr. Parkes tells the same story. Dr. A. Ransome, speaking in 1875, quotes the case of the Guards, picked men, highly cared for, yet who died quite as fast as the civil population. Why? he asks. Mainly from defective ventilation of the barracks ("Health Lec-

* But why is oxygen deficient in these cases? Is it, once more, because so much organic poison is breathed in with the air of the shut-up rooms, that the functions are depressed and imperfectly performed; that, for example, the act of respiration, though at first stimulated, is gradually impaired? Or does the poison—unoxidised in the blood—directly affect the formation of the red corpuscles?

† The number of microbes is much greater in town than country (Russell, p. 405, following Miguel); at Montsouris the number of microbes per cubic metre of air was 75, in the Rue de Rivoli, 750; in rooms there were eight times as many microbes as in the open air, and in hospitals twelve times; M. Miguel also found, according to Russell, 3,000 germs in some Paris streets per cubic metre, 45,000 in an old house, and 90,000 in one hospital in winter (440); whilst in a crowded railway carriage 3,120 microbes are said to have fallen per square foot of surface per minute (411). This extraordinary increase requires verification; but railway travellers will do well to observe that this enormous quantity was, as it is stated, the result of a full carriage and closed windows. When one window was open and there were but four persons in the carriage the number was only 395. There can be no doubt we think that far more lives are lost in railway travelling by closed windows than by railway accidents.

‡ Sewer gas in a shut up house may be much worse than sewer gas in a sewer. It has been shown recently, by Carnelley, that the air in a well-ventilated sewer is, so far as organic matter and micro-organisms are concerned, purer than the air in a small crowded and badly-ventilated room.

tures," 1875—78, p. 150).* Again, we find disease attacking country districts for the first time, where houses had been improved, and the ventilation, which used to take place through porous walls and less well-fitting windows, had been done away with.† So also it is stated in one of the Manchester Health

* "Sir Lyon Playfair, one of the Commissioners for inquiring into the state of barracks passed a couple of nights with the soldiers in their crowded sleeping-rooms, and found the air saturated with organic effluvia which discoloured permanganate of potash. The mortality among soldiers is now greatly reduced by the better ventilation enforced by the Commission," writes L. P.

† A case of this kind is reported to us by Mr. Alexander Campbell, of Auchindarroch, Lochgilphead; and we believe that the same thing was observed in a Westmoreland district. In an interesting letter Mr. Campbell writes: "Some years back I was asked by a medical officer of large experience in the Highlands regarding a phenomenon which had puzzled him. He had exerted himself much and with great success, to have improved cottages built, but in proportion as the cottages grew better did the health of the people grow worse. I gave him my opinion that in the old, uncomfortable-looking cottages, built maybe of dry stone, and open to the roof, the people were kept healthy in spite of themselves by the wind blowing through them, whilst the new cottages, tightly built, and with well-fitting doors and windows, excluded the air, and the windows being seldom or never opened, the inhabitants were poisoned. He said he fully agreed in this, and would ask for no more new cottages until the people had learned how to live in them. I have found a considerable amount of ill-health amongst the paupers in the Island of Tiree, which, from its situation, exposed as it is to the free action of breezes from the Atlantic, should be one of the healthiest islands of the Hebrides. I attribute this to the mode in which the houses are built, with two walls two or three feet apart, the interval being closely packed with sand. The air is thus hermetically excluded, and unless the windows are made to open, and are freely opened, the inhabitants are constantly, when within their dwellings, breathing vitiated air." In the same manner the natives of Labrador, living in imperfectly covered tents and subject to much hardship, are free from consumption; when they come down the St. Lawrence, and live in well-built houses, they take the disease readily (Ransome, 51); thus also, the Bedouins who "exchange their tents for stone-built houses suffer from consumption" (see 41); thus in Algeria the nomad Arab is free from consumption, whilst "amongst the captives many die from the disease"; and thus Cornish miners, owing to the impure air of the deeper mines, have three times as much consumption as other Cornish men (Russell, 400). It is also worth while quoting, as regards the effects of buildings, which exclude the air, from a review of Major Fisher's book (the book itself we have not read) in *Spectator*, May 2, 1891, "Through the Stable and Saddle Room"—"Everybody knows something of the importance of ventilation, both for man and horse; but it is not so widely known as it ought to be, that while horses seldom or never take cold, through being exposed to cold, they are often made ill by being too warm. [It is not the warmth; it is the impure air.] It is the inside, not the outside, air that gives them coughs, sore-throats, congestion of the lungs, and sundry other ills to which horseflesh is heir. For this reason, old ramshackle stables, full of cracks and crevices, are healthier than brand-new buildings with tight doors and windows, and impervious roofs. Our author, who never generalises rashly, and supports his theories with copious instances, mentions one or two curious 'cases in point.' Remounts for cavalry regiments, which are

Lectures that in the old crowded lodging-houses people sleeping on the floor would escape fever, whilst those sleeping on the bedsteads would be struck by it. The explanation is that those on the floor got ventilation from the door and fireplace. The colder and purer air, being heavier than the heated impure air, followed the line of the floor and thus protected those sleeping on it.

Animals furnish the same evidence. Cows and horses both suffer grievously from want of ventilation in their stables; and cattle, though they require warmth for fattening, still put on flesh better in a colder but well-ventilated place than in a warmer place which is unventilated (Parkes, p. 180). So also Parkes tells us about the French cavalry. Before 1836 the mortality among the horses varied from 180 to 197 per 1000 per annum. With the enlargement of the stables and increased quantity of air, the loss was reduced to 68 per 1000, and finally to 28½ per 1000, and of officers' horses to 20 (130).

Then we have the evidence of the ordinary tests for ascertaining the purity of the air. Air fouled by respiration discolours permanganate of potash and robs it of a portion of its oxygen; the amount of organic matter is then measured by the number of volumes of oxygen required to restore the lost oxygen to the permanganate and bring it back to its former condition. Another test is the presence of bacteria, which are found in large numbers in foul air, increasing out of proportion to the moulds (fungi) found in the air, which appear to be less favoured by the presence of impurities than the bacteria. The significant fact is their number in badly ventilated places, which seems to show that they prosper just because they have discovered their proper food — the organic poison poured out into the air from our lungs and skin. On

mostly of Irish extraction, have often to travel in severe weather part of the way in cattle-trucks, with no other protection from the cold than their own coats. Nevertheless, the remounts nearly always arrive at their destination in perfect health; yet they are no sooner placed in stables, however well ventilated, [so very few stables are 'well-ventilated' and well-trapped, as regards drains, that we feel pretty sure that an error in observation has crept in here], than they begin to suffer from coughs and colds, which generally end in strangles. During the autumn manœuvres of 1875, Major Fisher's regiment was encamped near Aldershot, and though it rained almost incessantly, and the horses were picketed in the open, without so much as a blanket to cover them, colds and coughs were unheard of, and the favourite charger of one of his brother officers, which at the time she left the barrack-stable suffered from a severe cold, was made whole by a few days' exposure to the elemental strife." The book should contain some valuable facts.

this point, Dr. A. Ransome makes an interesting speculation. Impressed with the belief that consumption is communicable in foul air, and non-communicable in good air, he believes that the tubercle-bacillus (one form of disease-bacteria) which is believed to convey the disease, becomes more virulent in foul air than in pure air, and is thus better able to make a lodgment in the human system. Such speculation however should not make us lose sight of the cardinal fact, that, as the result of living in bad air, there is a change of tissue, which is the direct preparation for disease.*

* This speculation of Dr. Ransome leads us to consider the preparation for disease. Just as the malignancy of the bacillus would be increased by a vitiated atmosphere, so also it would be increased by vitiated blood, or deteriorated tissues. Dr. Klein (pp. 238-248) believes that in the interior of healthy human tissue no bacteria, which cause putrefaction, are found. They are found abundantly in those parts of the system to which air penetrates, as, for instance, in the mouth, or in the alimentary canal; and from the alimentary canal they pass easily, as the food itself does, into the diminutive blood-vessels or the diminutive lymphatics (a system of vessels employed in manufacturing the blood) that line the walls of this canal. But if the blood is in healthy order they seem to perish, dying for want of food. Dr. Klein goes on to state, that if at some point they are carried to tissue that is in an unhealthy condition, they may obtain a footing there and begin to multiply. He does not actually state, as we understand, that the unhealthy condition of the blood keeps them alive, but it would seem to be implied; for it must be probable that the unhealthy state of the blood—for example, blood charged with poisons, which having once escaped from the skin and lungs, have been re-breathed into the system—would have the same favouring effect in their case as the unhealthy tissue. Both are likely to present them with the food they require. If this is so, then just as bacteria *that cause disease* are favoured by the external poisons they find in vitiated air, so also they would be internally favoured by the unhealthy state either of the blood or the bronchial and lung tissues of those persons who habitually breathe the poisons of shut-up rooms. Thus, these organic poisons, both within and without a man, would tend to make him a prey to those illnesses in which the success of the germ depended upon its proper food being supplied to it; and it would seem probable that by constant attention to the purity of the air which we breathe, we might do much towards securing individual exemption from the danger of infectious diseases. It is worth quoting Professor Nussbaum as regards cholera (see an interesting article by Mrs. Priestley, *Nineteenth Century*, May, 1891, p. 825): "It is known with certainty that the cholera bacillus is dangerous only to those persons whose stomach is not in a healthy state, and jeopardises life only when it passes into the intestines. A healthy stomach will digest the bacillus, and therefore it does not reach the intestines in a living state." It is, perhaps, right to refer also to a much-quoted theory that in the blood the white cells (leucocytes) act as protective cells (phagocytes), whose office is to overpower invading bacteria of a dangerous character; and, according to Metschnekoff ("Ann. de l'Institut Pasteur") these can, in case of need, migrate to the point which is invaded by parasites, even leaving the blood to do so. On this point—the defence given by healthy blood and healthy tissues against infectious diseases—we have written more fully in the second part of this paper; and here it is sufficient to say that the growth of any disease-bacillus in the human system must be looked upon in the light of an agricultural

It should be noticed that exercise, as well as pure air, helps us in our constant struggle against the poisons that we either manufacture or store within ourselves. It does this by driving the blood charged with oxygen, by means of the pressure of the muscles called into play, more thoroughly through every part of the tissue; and thus it would help to quicken the breaking down of dead tissue into its safe and final waste-products (water, carbonic acid, and urea), and shorten the period during which the dead tissue was passing through the various dangerous forms which it temporarily assumes. From this fact we may infer that the man of sedentary life, above all others, requires pure air. The stimulus of moving air, says Gautier (220), is wanted to whip the skin, and excite the lungs to their proper action. Such action, and the action of light, are necessary for the formation of healthy blood.

In truth, pure air and exercise are equal forces acting in the same direction. They both get rid of waste, and with it of the poisons in the system which are depressing various organs. We need not therefore be surprised when we are told by Sir D. Galton, that after barracks were better ventilated the rations of the men had to be increased; or by "the pathetic story" of certain seamstresses whose workroom was ventilated, and who then begged that the old state of

operation. The bacillus, like any other form of vegetation, requires to be supplied with its proper food, if it is to grow rapidly and vigorously; and there is much reason for believing that it does not find this proper food, so long as the blood and tissues are healthy. As in the case of all other plants, it must have its prepared seed-bed; and it is this seed-bed which we prepare when we breathe impure air, or live under any other unhealthy conditions likely to favour the accumulation of improper materials in the tissues or the blood. We should perhaps add that the quantity of germs which enter the bloodstream in breathing impure air has also to be considered. The dead germs probably form excellent manure for the fatal germ which at last one day survives within us and finds itself able to grow. In this manuring of ourselves—and there are many ways of doing it—in preparation for the germ, which thus at last is enabled to grow, lies the secret of the infectious diseases, both of men and animals. Eventually we may get rid of these diseases, not by barricading out the germ, but by living under such healthy conditions that there is no seed-bed within us for the bacillus when we breathe it into the blood. We have written fully on this point in the second article, and have tried to show that these infectious diseases—like other forms of evil—have also a useful side, and that any attempts to suppress them violently—any mere system of "stamping out"—will produce greater evils than the diseases themselves. They are to be strenuously fought, and perhaps they may be finally banished from human existence, but only in one way—by teaching and helping men to conduct their daily life under more healthy conditions. They must be starved out, not stamped out. Higher levels of general health offer the only security against them. The same truth applies equally to animals and animal diseases.

things might be restored, as their appetites had increased beyond their earnings. Sir D. Galton gives another experience, which illustrates the depressive effect of these poisons upon the functions of life. A New York medical man—some of us may think, rather cruelly—shut up some flies without food, some in foul air, others in pure air,—the pure air being constantly changed. To his surprise, the flies in the pure air died first,—these dying from simple starvation; whilst the flies in the foul air died from poison, and with the tissue of their bodies unexhausted, indicating that the functions of life were carried on to the last where oxygen was available, but had been slowed and depressed by the presence of the poison,—so that life was actually maintained longer in the foul air than in the pure air. To take one more example. Parkes tells us that it was found in the case of miners that they required 6000 cubic feet space per man per hour (this included the air necessary for horses and lights) to be able to work at their best. When this quantity was reduced to one-third or one-half, there was a great reduction in their working energy. In other words, the poison within their system, being imperfectly oxidised, impaired their faculties.*

We could wish that it were possible to write the whole of the noble story of oxygen from a physiological point of view. It is a manifold service that it performs for us. It not only, as we have seen, neutralises the deadly poisons resulting from waste, but it provides heat, and is necessary for the production of the labour-energy stored in our muscles. All through animal life the consumption of oxygen, serving this double purpose, is the measure of activity. Just as reptiles and cold-blooded creatures consume small amounts of oxygen and develop little activity, so birds and insects consume immense quantities of oxygen and exhibit immense activity. Each animal has, as Professor Foster believes (p. 812), its own

* We may also take the case of races living in hot and cold climates. In hot climates we breathe a smaller quantity of oxygen (owing to the expansion of gases) than in cold climates. Thus, taking two climates, one of 32° F. and the other of 80° F., we should inhale about 2164 grains of oxygen per hour in the one climate (the cold), and only 1971 in the other climate (the warm), or a difference of about 10 per cent. (Galton, "Our Homes," p. 498). This might in part account for the difference of energy that exists in the races of hot and cold climates, just as our own energy, as Galton remarks, varies considerably on hot days and keen frosty days, though on the other hand some allowance must be made for the more open-air life that is led in warm climates. The bearing of these facts upon crowded rooms should be perceived. As the room gets hotter, not only are we breathing more poison, but also less oxygen, which is the only remedy for the poison. We are therefore doubling the causes of evil.

peculiar quantity, its co-efficient, so to speak, of oxygen, which it consumes—an amount which, judging from the few instances he gives, seems to vary with intelligence; thus the dog consumes more than the rabbit per lb. of its weight, and a man more than the dog. In the same way, a waking man consumes more oxygen than a sleeping man, a man at work than a sedentary man, a young man than an old man, a young child (relatively) more than the young man. The restless activity of children marks both their great consumption of oxygen and the pressing need that exists in their case that they should be allowed to possess it abundantly by breathing pure air. Rapid and extensive waste is going on in every child's body. Tissue of every kind, including bone, is being constantly broken down in order that it may be built up anew on a larger scale, and it is therefore the greatest cruelty in their case not to provide them in fullest measure with the purest air. Unhappily, very little thought is given to this matter; and with quite young children —whose need is the greatest of all — our nurseries are only too often mere slaughter-houses. It is noticeable, that out of every four deaths of infants, as it is stated,* one takes place from lung collapse,—a condition that often follows bronchial inflammation (see Symes Thompson, "Lungs"; Quain, p. 861), and thus indicates the ordinary source of mischief. Dr. Symes Thompson significantly says: "All causes that interfere with respiratory efficiency favour the occurrence of the condition named."

It is now right for us to look at the subject of these waste-poisons in special reference to the skin. Without referring here

* So it has been stated. At the same time it is right to remember that lung collapse follows many different kinds of illness. The villainous state of our nurseries, however, is shown by the statement from the Registrar-General's Report for 1889, that there were in that year 71,056 deaths of male infants (i.e., not over twelve months) in England, and out of this number, 13,805 (roughly speaking, nearly 1 in 5) died from diseases connected with the respiratory system. It is perhaps well to repeat here that bad air lessens the supply of oxygen for the human body in three ways (1) It slightly lessens the proportion of oxygen in the air of the room and increases the carbonic acid: (2) the poisons which are re-breathed in bad air must be oxidised in the blood or in the tissues, and therefore must take some of the oxygen required for other purposes; (3) owing to the depressing effect of the poison, some of the functions of life are less vigorously performed, and therefore more waste would accumulate in the system. Add heat, and the oxygen is again diminished, owing to the expansion of gases. On the Continent the unventilated nursery seems to slaughter children in even more wholesale fashion than with us. If we remember rightly, the *Times* correspondent reported that 37 children [under the year] per 100 died at Kiel from tuberculosis.

to the different calculations made on this subject, it is enough to say that much less carbonic acid escapes from the skin than from the lungs; more water (if we are to follow Prof. Foster—who differs from other authorities, who again differ amongst themselves—we may say roughly, 1·5 lb. of water from lungs, and 2·5 lbs. from skin per day), and a larger amount of solid matter. The solid matter (from the skin) is put at 1 or 2 p. c. of the whole 2·5 lbs. and two-thirds of this 1 or 2 p. c. is organic matter containing the poisons in question.* We can see the importance of the skin, as an organ of excretion, in various ways. In the first place, the enormous number of sweat glands under the skin, supposed by Krause (Baker's Kirke, p. 427) to be between 2 and 3 millions in number—in the parts where they are least abundant they are over 400 to the square inch — offers evidence of a physiological character as regards the work which is thrown on the skin, even if, as is stated, some small part of skin perspiration takes place independently of these glands. Then we have the evidence of the disagreeable odour from the skin and clothes where cleanliness is not observed; again, we have the striking facts of death having both actually and nearly occurred in cases where the body had been covered (the mouth having been left free) with gold-leaf or plaster of Paris. Thus, also, a case has come under the notice of one of the writers in which quite recently a farmer lost a large number of sheep owing to a preparation used, when they were dipped, containing a resinous element, which interfered with the breathing through the skin. Thus, too, chimney-sweepers—probably from deficient action of skin owing to constantly unclean linen "have eight times their due of malignant disease, especially cancer" (Russell, 401). Various explanations have been given, but Prof. Foster seems to think (p. 697) that the retention of poisonous matters—"constituents of sweat, or the products of some abnormal metabolism" (changes through which tissue passes)—which would have been discharged through the sweat glands, is largely concerned in the matter. Independently of certain physiological experiments, this conclusion rests upon much interesting evidence.

Indeed we have a most remarkable case bearing on this point recorded by Sir D. Galton ("Our Homes"). Some men in the Horse

* Thus we should have from 118·3 to 236·6 grains of organic matter excreted by the skin in twenty-four hours.

Artillery had left their bedding rolled up for two months, without having it opened to the air. When first used again, man after man, who had slept on this bedding, came into hospital with "a suspicious fever." It would be difficult to find a case that more vividly illustrates both the poisonous character of the emanations of the body, and the necessity of free exposure to air in order to render bedding harmless. Again, when serious consequences result from a chill—owing primarily to the constriction of the blood vessels of the skin and disturbance of the action of the sweat glands—such as a dangerous affection of the kidneys (Richardson, p. 283), or a congestion of the spleen (Richardson, p. 307), or the more rare inflammation of bone (Richardson, p. 323), it seems that the great cause of mischief in all these cases is either the retention of normal poisons that ought to have escaped through the skin, or the formation of abnormal poisons during the inaction of the skin. [We think Dr. Richardson as well as Professor Beale suggests the formation of abnormal poisons.]* Again, the fœtid exhalations from lungs and skin in starvation, arising from the breaking down of tissue, which is very rapid in these cases and results in a larger discharge than usual, through skin and lungs, of putrid matter, show how these organs play their part in relieving us from the waste-poisons.

From what has been already said, we ought not to feel surprised that those who live in foul air are not only lowering their health, but are carefully preparing themselves either for lung and bronchial affections, or for such infectious diseases as scarlet fever, measles, diphtheria, small-pox, typhoid, cholera, &c.† As regards cholera, we extract the following interesting account given by Dr. Carpenter. He states (p. 360) that in the fatal autumn of 1849 there was at Taunton an exceedingly badly ventilated workhouse. In the schoolrooms there were only 68 cubic feet or less per head. The fatality of the cholera attack — thus carefully prepared for—was awful. Within 48 hours after the first attack 19 deaths and 42 seizures had taken place. In the course of a week 60, or 22 per cent. of the whole number, died, almost all the others suffering badly. Fewer boys died as compared with girls, because, as it was stated, having even less air than the girls, they used to break the windows.

* In such cases, however, the result will be principally dependent upon the previous state of the blood, as explained further on as regards a cold.

† This dependence of infectious fevers upon the unhealthy condition of blood is discussed in the second paper.

In the gaol of the same town, where each prisoner had over 800, and, in some cases, over 900 cubic feet, and where a system of ventilation kept renewing the air, there was not "the slightest indication of the epidemic influence." In August, 1849, the cholera raged severely in London, the mortality having increased from nearly 1 per 1000 in June and July to 4½ in August and September. It happened that at this moment a large number of male prisoners were transferred from Millbank Prison—which was in one of the bad districts—to another part of the country, the numbers being thus reduced from over 1000 to about 400; whilst at the same time the female prisoners were slightly increased in number in Millbank Prison, from 120 to 131. The consequences were remarkable. The mortality of the female prisoners (who were attacked) went up from a little over 8 to a little less than 54 per 1000 (which was very much above the rate of increase in the outside districts), whilst the mortality of the men fell from slightly over 23 per 1000 to nearly 10 (the June and July rate of mortality). Carpenter gives other interesting examples, and also remarks upon the fact that the special centres of cholera existed, before the invasion of that disease, as fever nests; and that cholera followed the footsteps of other diseases, not only in the same district, but in the same streets and houses, and even rooms.*

As with cholera, so with other diseases. At Secunderabad, in India, in old days, the barrack accommodation for the Line was unusually deficient, and the average annual mortality of the men was nearly double the average of the Presidency; whilst at the same station both the officers, who were well quartered, and the detachment of artillery, who had roomier barracks "at no great distance," did not share in the heightened mortality (Carpenter, p. 363). Barrackpore furnished an even worse example as regards troops; but the worst of all was to be found in the Indian

* Of course it would be unfair to put all such cases simply and exclusively down to the effects of vitiated air, as we might, perhaps, in the special case of the prison quoted above, since overcrowding in towns occurs amongst the poorest part of the people, living on the worst food, badly clothed, and therefore for these reasons specially exposed to attacks of disease; but with all such deductions, the evidence is of a very striking character. Dr. Richardson writes to the same effect. Speaking of relapsing fever, he says:—"The disease (1847) followed where the habitation was most crowded" ("Our Homes," p. 7); and, again, "Certain it is that homes which are charged with impure atmosphere are the places in which septic diseases are most likely to be intensified and most likely to spread" (Our Homes," p. 21).

gaols, where, in some instances, 70 cubic feet only of air was the average allowed; in no cases did it exceed 300 cubic feet. The mortality was,—as might be expected,—1 in 4. It was a fair imitation of the Black Hole of Calcutta. So at the end of the last century, in the Dublin Lying-in Hospital, the mortality from trismus of the children was 1 in every six born; by better conditions of ventilation, it was reduced to 1 in 19½ (Carpenter, p. 365); and this number of deaths was again reduced. So in the London workhouses of last century, 23 out of 24 children died in their first year. By reforms, especially by improved ventilation, the number of deaths was reduced from between 2000 and 3000 to between 400 and 500 (Carpenter, p. 365). So with our soldiers. When barracks were improved, especially in the matter of ventilation, deaths from zymotic diseases fell from 4·1 per 1000 to 0·96 per 1000. So in the case of our sailors on board the *Rattlesnake*, a case which came, as it is stated, under the notice of Professor Huxley. The crew (Carpenter, p. 256) had acquired by confinement (this seems to have been one special cause, though not the only cause) a predisposition to disease. No malady appeared, however, until one of them slightly wounded his hand; then disease appeared, and ran through the whole ship's company. They had carefully prepared themselves for disease with the poisons of impure air.

We suspect, however, that no class of human beings suffers so much from the poison of foul air as infants. Hirschberger is stated to have declared that 25 per cent. of all children who die under one year of age die from tuberculosis. Older children and grown up persons are seldom so much shut up, and the other principal diseases by which so many infants die, diarrhœa, convulsions, atrophy, debility, teething, bronchitis, and pneumonia,* all of them strongly suggest the general irritation, or the special local poisoning, produced by re-breathing these waste-poisons, though improper food must often bear a large share of blame. Of all the evil consequences of foul air—as already seen—none can be traced more surely than phthisis or pulmonary consumption, to which disease nearly half the deaths between the ages of 15 and 35 are due in this country (Ransome, 35). Wherever men are crowded

* According to Dr. Vernon, "Health Lectures," 1877, p. 218, seven out of ten infants die of these diseases (and premature birth).

together without care and proper means taken to supply them with fresh air, there pulmonary disease relentlessly destroys life. Parkes, Dr. A. Ransome, Sir D. Galton, and others have collected many interesting examples, bearing on this matter. Sir D. Galton tells us ("Our Homes," p. 502) that after our barracks were improved—ventilation being one of the leading improvements—chest and tubercular disease, which had been fatal to 10·1 per 1000 soldiers, were only fatal to 4·2, and in the same way with proper ventilation (and other improvements) of the stables of the horses, coughs and catarrhs disappeared. He also quotes Dr. Leeds, of New York, to show that the supposed cure of sending a consumptive patient to a cow stable was in reality the cure of sending him into somewhat purer air than that of his own room (p. 502). Thus Dr. Ransome tells us (65) that wherever air is excluded, where courts and alleys are closed, there tubercular disease is favoured; thus in proportion as people are attracted to indoor trades, so the death-rate rises by lung disease (60); thus Dr. Greenhow concludes that the same constant proportion exists between indoor life and deaths by lung disease (Russell, 106); thus Dr. Farr shows that the same constant proportion exists between deaths from diseases of the respiratory organs and density of population (Russell, 106); thus the wives of agricultural labourers, employed at home, die at twice the rate, compared with their husbands, from consumption; thus out-door occupations give immunity,—thus "the poor fishermen of Iceland, the hunters and trappers of North America, the nomad tribes of Asia and Africa, the wretched natives of Australia," and "the ill-fed, ill-clothed fishermen of St. Kilda and the Hebrides" hardly ever contract consumption (Ransome, 50); thus also comparatively escape consumption "soldiers on campaign, fishermen, hunters, gipsies, engine-drivers, gardeners, and agricultural labourers"; thus also escape, "blacksmiths, charcoal-burners, forge-men, iron puddlers, sailors, and coachmen"; thus while the comparative average of all persons dying (between certain ages) of consumption is 220 in England and Wales, that of fishermen is only 108, or not quite half (Russell, 94); thus in breezy Westmoreland the deaths from consumption were 2·27, for all England 3·54, for Manchester township 7·7 (Russell, 98, quoting Dr. Ransome, quoting Mr. Baxendell); thus the deaths from consumption, between certain ages, of weavers compared with spinners in cotton-mills increased as the foulness of

air increased;—the deaths of weavers being 11·4 per cent., when the carbonic acid (resulting from respiration) in weaving sheds ranged from ·7 to 1·4 per cent., whilst the deaths of spinners were 6·4 per cent., when the carbonic acid in spinning rooms was ·55 per cent. (Russell, 95); thus it is stated that where the cubic feet in printing-rooms fell below a certain number per head, 12·5 per cent. of the printers (compositors) had consumptive symptoms; with larger space the number fell to 4·35; and with further enlargement to 2 per cent. (Russell, 98, quoting Dr. Ransome, quoting Dr. Guy); thus in Canada the deaths in barracks from consumption were, at one time, 23 per 1000; as the barracks were improved and "better ventilation introduced" the deaths fell to something over 9, and again subsequently to 6 (Russell, 105); thus the deaths from respiratory diseases were twice as great in proportion to the population in metropolitan Surrey than in extra metropolitan Surrey (82); thus a bright sunny climate is good for the consumptive patient, just because it tempts him out of shut-up rooms into the open air (see Ransome, 47); thus even in the most favourable positions, such as high altitudes, those who live crowded together, or in shut-up rooms are not free from consumption (see 43); thus Baudelocque writes of air made foul by breathing:—"This is the true cause,—perhaps the sole cause,—of the disease of scrofula" (quoted by Ransome, 63); thus Sir J. Simon, when examining the causes of lung disease, writes:—"Probably none is so effective as the bad ventilation of the work-place" (quoted by Ransome, 62); thus Dr. Welch showed that consumption increased in the army with length of service owing to the long-continued breathing of impure air (see 64); thus Dr. Ransome thinks that oxygen disfavours the bacillus of consumption, and that in an open-air-life "it is robbed of its power for evil"; thus Gautier writes (220), "people living in bad air, which, from not being sufficiently changed, is poor in oxygen, rich in carbonic acid, in moisture, and in hurtful miasmatic exhalations, pass successively to anæmia, to scrofula, and often to consumption. These effects show themselves specially in women and children, still more in children on account of the delicacy and impressionability of their constitution. Moreover, among children . . different eruptive fevers, thrush and diphtheritic affections show themselves"; and thus Sir J. McCormack (quoted by Ransome, 63) writes:—"Wherever there is foul air, unrenewed air, impure air, we meet with consumption, we

meet with scrofula, and untimely death." Thus also Dr. Richardson quotes a case where no less than nine members of a family following the occupation of Cheap Jack, were in succession the victims of consumption from sleeping in a travelling van, their life in the open air during the day being insufficient to counteract the poison breathed in the night ("Our Homes," p. 11). Parkes also tells us that in the Royal Navy and in the Mercantile Navy, bad ventilation and phthisis, occasionally amounting to a veritable epidemic, have gone hand in hand; and he quotes many authorities insisting upon the close relation between foul air and pulmonary consumption. On the same point—the slaughter produced by unventilated barracks—Dr. Richardson tells us that the mortality in the Army before Sebastopol was during twenty-two weeks ending May 31, 1856, at the rate of 12·5 per 1000 as against 20·4 of the Guards *quartered in England* ("Our Homes," p. 13). Dr. A. Ransome reports a case as late as 1861, where fearful lung disease broke out in some of the ships of the Royal Navy. The arrangements were actually such that only 14 inches space was allowed to each hammock, and the air above the hammock was 8° to 10° hotter than below.*

The same evidence comes from the sedentary trades, some of which "afford experimental conditions for the development of disease"; from the cases of phthisis (or some destructive lung disease) amongst cows in unventilated sheds (Parkes, p. 162); from the higher rate of consumption in town as against village, and city as against town (Hirsch, p. 213)—in each case the dearer lodging implying more over-crowding; from the outdoor treatment now recommended for consumptive patients; and from many other classes of facts.†

* The recent violence of influenza has been probably the result of that breathing of highly impure air, which is so common in our own country, and even more in other countries. We suspect that this disease deserves a leading place among the many forms of trouble which appear where people live in constant disregard of the purity of the air of their living rooms. They do not yet see that it is just as wrong to live in filthy air as it is to drink filthy water.

† There are many interesting points—such as Sir G. Buchanan's views as regards the effect of dampness of soil, and Hirsch's theory as regards the high Mexican plateaus—which have to be considered; but nothing yet written in any way shakes the great fact that impure air is found in the closest alliance with pulmonary consumption, and is the special favouring cause. As regards damp, we venture to believe that it greatly increases danger where there is a tainted soil, or matter liable to putrefaction; otherwise, apart from any taint, and as merely affecting pure air, to be nearly harmless in itself, except

When we come to pneumonia, it is still the same poisons, we believe, which are at their mischievous work. Just as in pulmonary consumption the bacillus finds its food prepared for it by the unhealthy state of the blood and tissues—altered by the poisons that have been rebreathed from foul air—so also must it be in pneumonia, if we are to accept the theory, that pneumonia is directly caused by a special bacillus of its own ("Crookshank," p. 273). Secondary pneumonia, which is a lung attack resulting from the poison in the system from such a fever as typhoid, throws light upon this matter, and seems exactly to explain the origin of ordinary pneumonia. Where ordinary pneumonia is not preceded by some violent exposure and chill,—in other words by violent poisoning through the skin—we believe that it would be almost always found that the person attacked had been living in rooms where the air was impure, had breathed consequently, again and again, the exhaled poisons, until these poisons had so altered the tissue as to allow the bacillus to obtain a lodgment; in other words that he was as much "poisoned" as the person suffering from secondary pneumonia. Of course any slight chills, by arresting the action of the skin, by thus increasing the poison in the system, and by diverting the blood that has been poison-laden, perhaps for many months, from the surface of the body—where it undergoes a certain aëration, with a consequent mitigation of the mischief—to the internal organs, are likely enough to be the immediate precursor of the attack by rendering the conditions still more favourable for the germ. Again, latent pneumonia in quite young children is sometimes masked (Quain, p. 880) by considerable nervous disorder which precedes it. This nervous disorder tells the story. It is caused by the poisons which are acting on the system, poisons which solely and simply result, as we believe, in far the majority of cases, from the villainous state of air that is common in nurseries, and which prepare the system for every

perhaps so far as it may affect skin action in certain persons, and thus lessen elimination of poison by the skin. It has also certain bad indirect effects,—the wet bricks of a house, for example, allowing less air to pass than the dry bricks. The moral of this is,—that we should not be afraid of letting pure damp air freely through open windows into a room; but that we should take every precaution against damp rising from the ground and affecting floors, walls, &c.; or against floors, walls, &c., left continuously in a damp state, as these almost always have some organic impurities about them, and the damp favours the decay of these impurities. "Shutting up" seems to us the worst and most dangerous method of fighting damp.

kind of disorder, especially those affecting the respiratory organs.* The same thing happens after poisoning by drink.

It might, however, be urged that a person leading a healthy outdoor life might, after severe exposure, be attacked by pneumonia. Certainly; and in his case the attack would mean violent momentary poisoning (whether direct poisoning or a sudden alteration of the state of tissue so as to allow the growth of the germ) through the skin; just as in the case of the man living in bad air, it would mean gradual slow poisoning through the bad air taken into the lungs. But in his case, the attack, if the life has been lived under really healthy conditions, should be more safely and easily got over.

The case of a common cold is exactly analogous, but simpler and clearer. It should not be called a "cold," but, in more exact language, "throat poisoning." What really happens is this:—A. B. lives in unventilated offices and rooms, breathing bad air, until his blood assumes a poisoned condition. During this time the impure blood flows through the small blood-vessels of the surface of the body, as the result of the hot rooms, and of the tendency of impure blood to relieve itself by respiration through the skin. Then some slight chill—so slight, perhaps, that it was imperceptible to him at the time—acts upon his skin; the flow of blood is diverted from the surface of the body to the internal organs, and the minute blood vessels, that line the mucus membrane of the air-passages, become full and congested. As this happens, the walls of these little blood-vessels become stretched, and in consequence thinner, and as a second consequence allow their contents to transude easily. As the contents transude, the poison that is in the blood escapes also, acts probably both upon the local nerves and the small local nerve-centres, and by affecting these nerve-centres still further paralyses their nerve-fibres which go—as Beale has

* If on the other hand it is believed that pneumonia can arise without the intervention of the bacillus, we must regard it as a case of direct instead of indirect poisoning; that is, that the organ was directly poisoned by poisons discharged into it from the blood, instead of the tissues of the organ being altered by these same poisons, so as to afford the special food which the bacillus requires for its rapid growth. That there is such direct poisoning we know from those attacks of the liver and kidneys, which follow a chill—itself following a long-continued poisoning of the blood—and in which the poisons (which had accumulated before the skin failed to act owing to the final chill) are thrown back on to those organs. Parkes (164) believed that bronchitic affections are often produced from the breathing of foul air.

shown—to the minute blood-vessels.* The effect of this paralysis is still more to relax the minute blood-vessels and thus to favour an increased transudation of the contents so that the poisoning of the part is increased, with the usual accompanying symptoms of poisoning,—the pouring out of mucus, which marks both the irritation that exists and the protective effort to render the poison harmless, and the loss of sensation and contraction in the part. Professor Beale points out (S. A., 122) when a cold is coming on, how a part of the throat loses its contracting power. The muscles of the pharynx, generally so sensitive to any stimulus, contract "very slowly," or "not at all," and the familiar difficulty in swallowing shows that the nerves are partly paralysed and no longer able to fulfil their functions. We have an example of the same paralysis from poison in the case of the common gnat-bite. As Professor Beale (S. A., 307) points out, the little red spot surrounding the bite is the result of the paralysis (by the poison) of the local nerves or the small local nerve-centres, and marks the dilatation and gorging with blood (congestion) of the minute blood-vessels that surround the spot bitten.†

It is of importance to notice one point carefully in this matter. Mr. Erasmus Wilson (150), in writing about "a cold," describes how, as the small blood-vessels of the skin contract, under the influence of cold, the skin circulation comes to an end, and the blood is thrown either upon the throat or lungs, causing throat or lung disease, or upon the membranes lining nose, eyes, or ears, producing a cold in the head, or upon stomach, producing stomach disorder, or upon the kidneys, producing pain in the loins, or on the joints, producing rheumatism, or on the nerves, producing neuralgia, &c.; and Mr. Russell gives much the same account of a cold. But surely the mere transference of the blood from one part of the body to the other cannot be responsible for all these evils. Unless the exposure to cold is sufficiently violent to lead to the formation of abnormal poisonous substances in the blood at the moment itself, as the blood begins to stagnate in the skin-capillaries,—a formation that probably takes place only when either the chill is very violent, or the blood is very impure,—there can be

* A certain amount of poisoning of the tissue might have gone on for some previous time; but the sudden violent poisoning brings matters to a climax.

† Speaking of this paralysis he says, "mainly due to poison expelled," and also suggests another cause.

no reason why the flow of blood directed from the surface to the interior should be hurtful. On the contrary, it is in itself a preservative and most necessary process which is constantly taking place to regulate the temperature of the blood in a greater or lesser degree. The truth is that the mischief depends upon the previous state of the blood. It is the sudden flow of *vitiated* blood (vitiated, it may be, from many different causes, from over-eating, from drinking habits, from drinking impure water or taking impure food, from over-fatigue, from deficient exercise, from failure of any of the great purifying organs, from old age and impaired functions, but above all and in the great majority of cases, from breathing impure air) which, thrown upon some organ—itself from the same cause in an unhealthy state—and escaping through the distended capillaries, creates the disturbance and does the mischief. That very mischief, however, is preservative in its character, as we shall try to show in another paper, and is in the general interests of the body.

There are many other evidences that the common cold—like its more serious congeners, bronchitis, pneumonia, and consumption itself—is a case of poison in the blood from which the system is relieving itself by discharging the poison into some special organ. In the first place in some of the infectious diseases, when the system is struggling to get rid of a specific poison, the respiratory tract is affected, just as if it were an attack of ordinary sore throat or pneumonia or bronchitis. Thus, in measles one of the early symptoms is "a short dry cough" (Collie, 43); thus measles is "often mistaken for a cold or cough" (Russell, 227); thus in severe cases the cough is "frequent and distressing," "the lungs greatly congested" (Collie, 205), whilst "the most formidable and most frequent of all the complications of measles is broncho-pneumonia" (206); thus, too, in typhus "the complications are chiefly pulmonary" (112) and "congestion is so frequent that it should be regarded rather as part of the disease"—a fact indicating only too clearly—when we remember that typhus is the disease of over-crowding—that the respiratory system is specially liable to be attacked, whenever trouble comes from living in bad air; thus, too, congestion of the lungs is a common complication in typhoid; thus throat symptoms play an important part in scarlet fever, and sore throat in many cases leads up both to scarlet fever and diphtheria (Russell, 135),—

"mild throat cases were the connecting links between successive outbreaks of diphtheria" (141); just, indeed, as colds lead up to consumption itself (116)—the frequent return of common cold evidently indicating that the system is fairly poisoned, and that unless the conditions of life are changed some more serious form of poisoning will be presently developed.

Many more similar examples might be given; but perhaps these are sufficient of their kind to show that troubles in some part of the respiratory tract are constantly arising when from various causes poison is circulating in the system; and therefore cases of cold, influenza, bronchitis, pneumonia, and indeed consumption itself, must be looked upon as cases of one common family, as cases of poison, first accumulated in the blood-stream —in far the larger number of instances due to breathing bad air—then discharged at some point or other of the respiratory tract, in order that the system may be rid of the poison that is embarrassing it. We shall discuss the matter again in the second part of this paper, and here it is sufficient merely to say that all these outpourings of poison from the blood-stream into various parts of the body—however painful or even dangerous in themselves—are protective in their nature. When the poison is poured out into the upper air-passages, it is for the sake of protecting the lower air-passages and the lungs; when it is poured out into the lungs, it is to protect the great nervous centres on which the maintenance of life depends from minute to minute, and which must be safe-guarded even at the expense of an important organ like the lungs. Thus there is a sort of hierarchical order existing among the organs; and Nature, like a skilful general, sacrifices—as the need arises—a valuable outpost to save the citadel.

We may, moreover, appeal to some evidences of another class to show that throat and lung attacks are essentially cases of poison discharged from the blood at certain points. When seventy-two persons were partially poisoned at Welbeck, in 1880, by eating beef-and-ham sandwiches (Klein, 122), pneumonia [and enteritis] were found "most prominent" as post-mortem symptoms; in a similar case at Nottingham in 1881 the post-mortem disclosed "intense pneumonia" (124), whilst in both instances the animals which were inoculated with the same meat exhibited the same symptoms; then also poisonous alkaloids are found (Brown)

in what passes through the kidneys of pneumonic patients; and animals dying of swine plague are found to have inflammation of the lungs (Klein, 134); and thus—to take a lesser fact of a different order but equally significant—in pneumonia, as Lauder Brunton points out, the temperature falls, when an aperient is successfully given, and remains high when constipation exists,—indicating that the poisons which result from constipation (owing to absorption of putrescent matter through the intestine) increase the sum total of poison in the system, and maintain the fever. Thus also in a severe febrile attack in an orphanage, caused principally by too much sewage being distributed on insufficient land, "pneumonia often supervened. . . Dr. Bridges thought that pneumonia was present in a large proportion of the cases, but was sometimes abortive" (Russell, 366),—an instance bringing into close relation with each other the previous poisoning of the blood and the resulting pneumonia. Perhaps, however, of all the facts which connect diseases of the respiratory machine with a poisoned state of the blood—and especially with that poisoned state which arises from breathing impure air, is the case of persons with gouty tendencies in advanced age. These persons are apt to suffer from atheroma, that is, the channel, or bore, of the arteries becomes smaller, and consequently smaller quantities of blood are aërated in the lungs, and therefore the waste of the tissues is less efficiently disposed of. As a result, bronchitis is apt to supervene,—the aëration of diminished quantities of blood owing to the diminished channel of the blood-vessels almost exactly re-producing what takes place in the case of the ordinary healthy person who lives in impure air. [If it is right to interrupt the argument to draw a moral,—such moral would be that persons in advanced age should be as much out of doors as possible, should eat moderately so as to lessen waste, and be exceedingly careful about changing the air of their living rooms. Pure air is as vitally important to them as it is to those who are affected with some specific fever and are fighting for their lives against the poison which has taken hold of their system]. Thus, again, "senile pneumonia" that shows itself "in old persons, especially if broken down," (Fothergill, S. and A.), tells exactly the same story. Much the same thing, again, happens with kidney disease. Waste-poisons circulating in the blood, from whatever cause, seem specially liable to affect the air-passages. Campbell (21) speaking of kidney disease, writes: "The circulation of nitrogenous sewage

renders the tissues more apt to inflame ; hence the tendency to bronchitis, and [inflammation of the serous textures]"; thus Prosser James writes :—"Gouty people are prone to suffer from chronic inflammatory or congestive sore throat, which is greatly aggravated at intervals" (157) ; and thus, again, it is held that asthma may be due to improper substances circulating in the blood and irritating the muscular fibres or nerves of the larger air passages, and thus causing their contraction (see L. Brunton, 40). It is also interesting to note that a drug (iodide of potassium) may produce in some persons the symptoms of a cold (Collie, 211 ; "a violent coryza," Robinson, 2) ; whilst in others it may produce a bullous rash,—indicating that the system sometimes gets rid through the air-passages, sometimes through the skin, of what is poisonous to it.

There are some interesting analogies to be noticed in this matter. Just as the mucus membrane of the air passages may take "cold" or to speak more correctly, may be affected by an outpouring of poison, so also may the mucus membrane of the stomach and intestine. In Professor Beale's words (S. A. 350) "It becomes red and less moist than in the normal state," "the secretion of gastric juice is interfered with, and its qualities changed." In truth, a stomach or intestinal attack is often exactly parallel to an affection of the respiratory system,—poison being poured out into these tracts for the sake of purifying the blood-stream and getting rid of the poison,—as in the case of a cold, at the cost of considerable inconvenience and suffering to the part poisoned. One other fact makes the comparison more interesting. The same cause, the same poison present in the system may affect either or both of these tracts (the respiratory and the digestive). Thus in parts of Leicester, of which we are told that "its soil has been much polluted from insufficient and defective sewers," there has been much trouble, says Mr. Russell, from summer diarrhœa,—in this case the poisons of the infected air attacking the digestive rather than the respiratory tract. Thus again there is a connection between dysentery—just as there is between sore throat—and bad ventilation (Russell, 169) ; "it appears probable," writes Dr. Ransome (66), quoting from report on back-to-back houses, "that the want of thorough ventilation" favours a rise not only in diseases of the respiratory organs, but in diarrhœa ; in India, writes Mr. Russell, there is a prevalence of dysentery from over-crowding

and want of ventilation in barracks ; thus, as we all know, sewer gas, which has found its way into a house, may produce either sore throat or diarrhœa, or both ; thus we see enumerated amongst the causes of diarrhœa some of the very same causes which favour disease of the respiratory organs, such as chill, "damp, cold, dark, unventilated buildings" and emanations from decaying organic matter (Quain's article Diarrhœa, referred to by Russell, 126) ; thus the influenza-poison "in cold weather and cold countries largely attacks the respiratory organs" (Russell, 437)—a fact which results not from the cold but from our shutting ourselves up in bad air—whilst "in warm weather and warm countries" (where sanitation is often bad and drinking water is often polluted) "it largely attacks" the intestines ; and thus the eating of meat in an improper state may produce either the early symptoms of a cold or a disturbance of the digestive system. A case of a boarding school was brought to the notice of one of the writers where cod in a wrong condition was eaten. From the first symptoms which occurred, the mistress of the school thought that a cold and sore throat were running through a part of the school. So also in the case of boils [a case, where the poison in the system seeks another outlet in the place of the air-passages] "the inhalation of infected air" may be, like eating diseased meat or over-eating, a cause of the trouble (Beale, S. A., 357),—indicating pretty clearly how many different methods there are by which we can produce similar states of poisoning, and provoke the same remedy or similar remedies ; so mosquito-bites, in the same manner as impure air, may favour boils (Beale, S. A., 357),—implying that in both cases, just as with the eating of diseased meat, the common cause of mischief is the poison taken into the blood ; and so also "sewer gas has been proved to be a cause of erysipelas" (Russell, 172)—showing again how the same poison taken into the blood may alike affect the skin, respiratory tract, and digestive tract, and be discharged from the system at one or other of these outlets. If one more link is wanted, it is to be found in the fact stated by Mr. Russell that sewer gas "has now been shown to be the cause of much pyæmia in hospitals." Thus we have the poisoning of the blood and the resulting affection of different organs, just according to circumstances, by the same agent. When we look at all these facts taken together, it is very hard to escape the conclusion that the diseases

of our respiratory organs are cases of blood-poisoning, and—in far the great majority of such cases—of the poisoning which results from living in impure air. Nature is not a fool, though we often like to treat her as such. She did not elaborate for us that most costly apparatus for purifying the blood, which we call the lungs, and leave it a matter of indifference whether we breathed again or not what had been already cast out of the system by her efforts. As Professor Foster has shown, the force which we expend daily on the internal machinery and internal work of our bodies is much greater than the force we have at our command to expend in labour outside the body; whilst—as we have already seen—the labour of the heart alone represents for a day in foot pounds (*i.e.*, the raising a pound a foot high) a walk to the top of Snowdon. We can thus see clearly how deliberately we thwart the intentions of nature and the elaborate efforts she has made to endow us with good health, when we refuse to give our lungs a fair chance by offering them through many hours of the day impure air to breathe.

From what we have said it must not be supposed that chill plays no part in producing cold. As a fact it often pulls the trigger; and brings on the cold that is due. But though chill is a thoroughly bad thing in itself, as affecting the action of the skin and its excretion of poison, to all those who are susceptible to it,* its real harmfulness almost always depends upon the poisoned and unhealthy condition of the blood which precedes the chill, whether such condition has been produced by living under unhealthy conditions, or by weakness in some organ on which the purity of the blood depends. The slight causes of chill, which then become hurtful, ought to have hardly any effect upon naturally healthy persons living in good air; though for all that, as long as they have the slightest effect, they must be most carefully avoided.

A few words should be added as regards those diseases which are closely associated with certain bacilli. As we have already

* When blood is stagnating in the capillaries, writes Beale (S. A., 162), substances may be formed "which, re-entering the blood, may poison . . the system." This would probably only take place, as we have said, either in the case of blood in a vitiated condition, or of feebly performed functions, or of severe chill. Few persons under ordinary circumstances and with ordinary care ought to take such a chill in waking hours. The time when there is far more danger—to those who are susceptible—is at night with open windows, when the temperature may fall suddenly.

said, and shall try to show later, the intervention of the disease-bacillus—for example, in consumption or in pneumonia—in no way alters the essential conditions of the case. In a state of true health and pure blood, the inhaling of chance disease-germs, as we believe, will not produce disease,—infectious disease requiring that the blood should have been previously altered or poisoned. But on this matter a good deal has to be said.

Reserving, then, many matters for discussion in our second paper, we can only say here, in conclusion, that we are convinced that very grave issues are dependent upon the question of breathing pure air in our houses. We suspect that not only liability to cold, but common troubles like gout, rheumatism, lumbago, neuralgia, some forms of headache, and of dyspepsia, and many forms of nervous irritation, are generally to be conquered by constantly giving lungs and skin a fair chance of getting rid of these poisons, unless indeed either the digestive organs, or an eliminating purifying organ, like the kidneys, are failing in their duty;* we feel sure that the irritable temper that so often accompanies severe literary work, and at last ends in the "break-down," must largely be put to the account of the impure air breathed through long hours; and we suspect that much of the intemperate drinking in towns results from the depressed feeling which follows work done under similar conditions. We think a great society† might be formed to arouse the interest of all classes in this subject, and that friendly enquiries should be made—the answers being published—as to the provision for fresh air in hotels, concert-rooms, theatres, schools, examination rooms, churches, &c. We are, both of us, opposed to action being taken through State-inspectors. The present evil will never really be overcome until individual interest is aroused;

* Living in pure air is not sufficient in itself to keep the blood pure, if the digestion is imperfectly performed. The difficulties of diet must be satisfactorily arranged by each person for himself, and constipation avoided, if the blood stream is to be kept in a pure state. Constipation often means that some kind of food taken is disagreeable to the liver and is consequently throwing too much work upon it and impairing its action.

† A sketch of the proposed society is given in our second paper. A great society is in itself an evil as well as a good. It should be organised so as to develop individual action as much as possible, and to minimise official action,—indeed it should rather be a bond of encouragement existing between individual workers, than an organization, consisting of a small body doing everything, and a large body doing nothing. Meanwhile each individual should be doing his best in his own way. That in reality is worth more than any society.

and the State-inspector does not develop individual interest. We shall be glad to communicate with any persons anxious to take steps in the matter, and shall hope to draw up a short paper containing a few practical suggestions of a simple nature. Meanwhile, without discussing systems of artificial ventilation, we say to everybody: "Live as much as you can with open windows, wearing whatever extra clothes are necessary. In this way you will turn the hours of your sedentary work to physical profit instead of physical loss. The secret of health is to turn indoor life into outdoor life, by adapting your windows, so as to be able to open them as widely as possible in different kinds of weather, *then to open them widely*, then to get curtains and other impediments to air well fastened back, and then, as regards yourself, to wear a sufficiency of extra clothing that will make you thoroughly comfortable. If unfortunately you think you cannot bear an open window, even with an extra coat, and a rug over your knees, when you are sitting in a room, do the next best thing, which is: throw all windows *wide open*—not a poor six inches—whenever you leave your room, and thus get rid of the taint of the many dead bodies that we have breathed out from ourselves, and that hang like bad ghosts about our houses. Smuts, as we confess, may be bad, but they are white as snow compared with impure air. Pay special attention to the constant exposure to pure air both of clothes and of bedding. If susceptible, avoid chill, that is one very bad form of poisoning; but just as carefully avoid impure air, that is another and still more dangerous form of poisoning, because it gives no immediate warning of the evil that is taking place, and will at last produce the most serious results."

Our addresses are:—Harold Wager, Yorkshire College, Leeds; Auberon Herbert, Old House, Ringwood, Hants.

HAROLD WAGER,

AUBERON HERBERT.

Several gentlemen were kind enough to read the foregoing paper, when it was first published, and to express the following opinions upon it. We ought to say that it has undergone some considerable alterations and received some considerable additions especially towards the end, since it was submitted to them. We do not know how far any approval, previously expressed, would apply to the paper in its present form. The letters have been left almost in the order received.

Lord Playfair wrote :

" I return your proof with only a few suggestions. The paper is a good exposition of air in its relations to public health, and is likely to be very useful. You ought to follow it up with another paper on water, and conclude with one on cleanliness. Pure air, pure water, and cleanliness, personal and objective, are the three great factors of public health, provided that people are adequately fed. Napoleon, reciting his long personal experiences at St. Helena, made a wise remark :—' Life is a fortress which neither you nor I know anything about. Why throw obstacles in the way of its defence ? Water, air, and cleanliness are the chief articles in my pharmacopœia.' You and Mr. Wager have made an excellent beginning with air. Follow it up with essays on water and cleanliness, and then, as a veteran sanitary reformer, I will begin to think that my time for preaching is ended. I write this withholding my judgment on certain special theories you have advanced."

Professor Huxley wrote :

" When you insist upon the importance of fresh air—especially in combination with exercise—I go heartily with you. I have long been convinced (and to a great extent by personal experience) that what people are pleased to call ' overwork,' in a large proportion of cases means under-oxygenation and consequent accumulation of waste-matter, which operates as a poison. The ' depression ' of overworked nervous organization, is very commonly the ' oppression ' of some physiological candle-snuff not properly burnt.

" Furthermore, it is highly probably that the decaying organic matter given off from the whole free surface of animal bodies, taken in conjunction with its microbial contents, is a source of

danger, but whether directly or indirectly is a point about which I should not like to speak confidently.

"The fact is, while the virtues of fresh air and the wisdom of physical purity as a prophylactic may be very confidently justified by experience, the theory of the subject is full of difficulties, and the present views of physiologists must be regarded as merely tentative hypotheses. I should not feel justified in putting the theoretical points you advance as safely established truths before the public. I began to mark some paragraphs I thought specially open to objection; but I cannot go into the matter, as I am myself struggling out of the influenza poison, which afflicts one's brain with mere muddiness."

Dr. Clifford Allbutt wrote:

"Whether there be room for question in parts of your argument or not, it is in the main true, and your practical conclusions are as solidly true as they are impressive.

"If any one doubt, let him try the marvellous recreation of a few nights camped out *sub dio*, and be converted.

"Moreover, the marvellous effects of an open-air life in the cure of such maladies as consumption are known of all men. But is it kind to tell us these dreadful things when we are helpless to amend them?

"Your home solution of the problem is known to your friends, and is excellent in your circumstances, but is impossible in towns, where every inch of window means an inch of grime on walls, ceilings, and furniture. Not only so, but our big common dwelling-halls are gone, our high-backed chairs and settles are gone, our tapestry is gone, and air supplied in modern fashion *by slits or pipes* means 'draughts.'

"Now, 'draughts' will kill some of us as quickly as ptomaines and far more painfully.

"Please write another paper to tell us what is to be done!"

Dr. W. B. Cheadle wrote:

"I am sure that you are doing a valuable sanitary service in calling attention to the chronic poisoning by foul air which goes on so constantly without being realised, in the homes of both rich and poor, and in business offices, and in workshops.

"The poor suffer from the small, ill-ventilated cubic space avail-

able for either sitting-rooms or bed-rooms, and the crowding of work-rooms; the better classes partly from the close offices in which some of them work, but chiefly from defective bedroom space and ventilation. Few people, I imagine, realise the fact that *about one-third of their whole lives is spent in their bedrooms*, and that they pass this third part of their existence in an atmosphere so poisoned by organic matter that it would not be tolerated in a sitting-room for a moment. The amount of space allowed in bed-rooms and dormitories is frequently altogether insufficient. Doors and windows are tightly closed, and there is practically little ventilation going on for six or eight hours of sleeping time, whereas in sitting-rooms the admission of air is promoted by persons passing in and out.

"This steady nightly poisoning goes on in many public institutions, I am afraid, in the 'houses' of some public schools, and the dormitories of charitable institutions. They are well ventilated during the day, closed at night, and the allowance of cubic space is quite insufficient to supply fresh air enough with the very small influx which can take place.

"Night nurseries again, especially in large towns, are liable to be grossly overcrowded. I have seen a small, low room, in the attics of a London mansion used as a sleeping apartment for five or six children and a nurse, which had not space or ventilation enough for two persons.

"Without endorsing the whole of the pathology suggested in your excellent paper, I am sure you are right in attributing a large proportion of ill-health, contagious disease, and especially the increased virulence of this, to air fouled by organic matter."

Professor W. H Flower wrote:

"I am not sufficiently acquainted with modern physiology to know whether all the scientific details of the paper are correct, but I quite agree with you in the very great importance of the subject being pressed home upon all classes. How, for instance, could people travel in a railway carriage with perhaps six or more companions, shut up together for several hours, and insisting on *keeping all the windows closed*, as they often do, if they were made to realise that the air which they are breathing must necessarily be passing in and out of the lungs, not only of themselves, but of all their fellow-travellers as well, over and

over again in the course of the journey, and each time becoming more and more contaminated?

"I have always thought, though I have not medical experience enough to prove it, that the greater prevalence of tuberculosis and other lung disease in cold over warm climates is owing, not so much to difference of temperature, as to the fact that in the former there is a greater tendency to breath impure air for the purpose of warmth. My theories on the subject are, however, rather staggered by the thought of rabbits, sand-martins, &c., passing a considerable part of their lives at the bottom of burrows, where anything like ventilation seems absolutely impossible, and yet remaining perfectly healthy."

Mr. Lawson Tait wrote:

"What can I add to an article, so lucidly written, save that I agree generally with it, and hope that it may be productive of great good, as it well may."

Surgeon-Major George Paddock Bate, M.D., 5th R. B. Med. Off., Bethnal Green, wrote:

"I think you have (in an otherwise exhaustive article) made no mention of the fouling of the air produced by damp walls, floors, and foundations.

"Many houses in the district for which I am Medical Officer, are so badly constructed, that dampness more or less is always present, and patches of wall, where undisturbed, become rapidly covered with mildew, and the same condition obtains beneath the floor-boards where there is no ventilation.

"Of course you are aware that putrefaction is accelerated by moisture, and "dirt" on walls, and beneath floors, which in a dry state would be harmless, undergoes certain changes in the presence of moisture, and becomes a fruitful source of disease. In camp here (Shorncliffe), we find that if the floor boards of the tents are not frequently taken up, and the ground exposed to light and air, the surface becomes most offensive, and sore throats, and ultimately diphtheria amongst the men, may be caused by the fœtid emanations from beneath the boards.

"Doubtless you saw an account of a local enquiry recently, held in Bethnal Green by order of the Home Office, as to the immediate sanitary requirements of the District. I was exposed

to a good deal of mild chaff, because I held that dilapidations of houses were sometimes not the cause of unhealthiness to the inmates, but, on the contrary, were often an advantage, as they improved the ventilation, and thereby prevented disease. I see you have scored the same point in your article."

Professor Sir John Banks, LL.D., M.D., University of Dublin, wrote:

"I have read the article on "Bad Air and Bad Health" with very great interest, and I beg to assure you that I give my unqualified assent to nearly all the views on the subject which you have advanced. I have no doubt you have done good service to the public, and I join in the hope expressed by Sir Lyon Playfair, that you will follow it up with an essay on 'Water and Cleanliness.' No one can be more thoroughly impressed with the power possessed by fresh air in the prevention of disease, and its salutary influence on its progress when present, than I am.

"I have myself, like most Hospital Physicians in Ireland, whose duties involve frequent intercourse with fever cases, absorbed the pestilential effluvia, which if largely diluted with fresh air is comparatively innocuous. I was conscious at the moment that I had absorbed the poison.

"Many proofs I might adduce from my own experience of the fatal effects of bad air in the production and spread of disease. I may briefly refer to a few. A physician visited a person labouring under fever, who resided in a small low apartment wholly destitute of ventilation. Perceiving a most disagreeable smell, he observed that he had caught the infection, and he rushed to the window and forced out a pane of glass. Such a deadly dose had he taken in that he died on the fourth day. So concentrated was the typhus poison that he was overwhelmed, stricken down as it were "uno ictu." Many similar cases I might refer to. During the prevalence of some of the epidemics of typhus fever, which have devastated Ireland, the hospital accomodation being insufficient, tents were erected for the overflow of the hospitals. It was found that the mortality of the patients in the tents was much less than that of those placed as it was at first supposed under much more favourable conditions, attended with a care not always bestowed on the others. It may be noticed that many of the hospitals were ill-ventilated, and such

was the pressure on them, that double the number for which they were suited were admitted.

"At one time it was said that Ireland was the favourite habitat of typhus fever. Virchow in his work on 'Hunger Fever' thus describes Ireland—'Ireland ist noch heute das Land des hungers und der Auswanderung des Fleckfieber.' I am happy to say it no longer deserves the appellation. Cases of true typhus are becoming rare, owing to the improved state of the country in all respects. No need for 'entassement' of proofs of the evil influence of bad air in the causation of disease. I have only selected a few examples."

Mr. R. N. MacDonald, M.D., Gesto Hospital, Edinbane, Skye, wrote:

"I have read your article on 'Bad Air and Bad Health' in the *Contemporary Review* for this month, and agree with it *in toto*, barring some trifling details that might be difficult to carry out in practice. It has been arranged exceedingly well, and contains no more thunder than is necessary to awaken public interest in the matter. The writers have also shown an intimate acquaintance with all those physiological questions which have to be solved and understood before one can speak authoritatively on the vital processes that are brought into play in health and disease, and all the causes which may disturb the former and produce the latter."

Mr. H. S. Webb, M.R.C.S., of Welwyn, Herts., wrote:

"The paper entirely meets with my approval. From long experience, I am convinced of the necessity of pure air for the maintenance of health and for the cure of disease; for I see, day by day, the injurious and often fatal effects of the deprivation of it. I see the children of the poorer classes running about the streets and lanes healthy and happy, but if, unfortunately, they contract whooping cough, measles, or such like diseases of childhood, and are compelled to remain in bed in small ill-ventilated rooms, with several other persons helping to consume the poorly oxygenated air, they very frequently succumb, not to the disease, but to the deprivation of the lungs of their natural stimulant.

"As you are well aware, it takes a great deal of iteration and

reiteration to overcome popular prejudices. For years I have striven hard to impress on my patients and their friends the vital importance of free ventilation of the dwelling-house, with the response very frequently, 'It is one of the doctor's fads.'

"I am quite sure that many a dying person would again become a living one if, when the expected end appears to be approaching, the unwisely over-anxious friends would not crowd the sick room, depriving the invalid of pure atmospheric air, the one thing that could restore him to health.

"Again, often do I see sickly children of well-to-do parents ricketty and tuberculous from being shut up in dull close nurseries, because they are too respectable to be allowed to run about and caper in the public thoroughfares, and they have not space to do so at home.

"I inculcate to mothers of children that the best room in the house is only good enough for the nursery, but I find the best room is what they call the drawing-room, kept dark lest the furniture should be spoiled, dreary and smelling fusty; the guest room on festive occasions.

"I have no doubt that in time your exertions for the promotion of Sanitation will have the desired effect, but it takes a great many drops of water to wear away a stone. For twenty years I have been preaching on horse-shoeing and the repair of country roads, but I believe, so far, I have made few converts.

"As regards stable management, I have kept many horses with scarcely any sickness. I insist on free admission of air, night and day, with plenty of woollen clothing in the winter, and each fine day in the summer the horses not at work spend their time in the paddock."

Professor E. D. Mapother, M.D., late Prof. of Physiology and Hygiene, R. Coll. Surgeons, Ireland, wrote:

"It is much to be desired that this charming chapter in Physiology and Hygiene shall be followed by another in which remedial measures shall be as forcibly advanced.

"Having found adults quite unmindful of the harm resulting from rebreathed air and of other breaches of obvious natural laws, I have alone depended on the teaching of the pupils of primary schools in these vital points. The evil from want of ventilation which has lately come prominently before me is want of sleep; and

irrespective of temperature or grimminess, air should be let into every bedroom by an inch or two of the window."

Mr. Francis Warner, M.D., wrote:

"Your paper in the *Contemporary Review* will, I hope, lead to a better appreciation of the importance of good air. I have already visited 106 schools for the purpose of examining the physical condition of the pupils. Bad air is often a cause of mental exhaustion; overcrowding may effect this, so may the want of personal cleanliness, without which, ventilation in the school-room is ineffectual.

"I have been much impressed in visiting certain districts in London, with conditions in the children apparently, in part, dependent upon want of general illumination, i.e. in the neighbourhood of large block buildings and warehouses—but this matter is different to investigate.

"I think that also great noise, as many passing trains, may probably affect conditions of growth and brain power.

"One of the removable causes of chronic exhaustion among children is late hours, the effects of which are plainly marked in them, and are disastrous in their results.

"The physical surroundings of our population, and their effects upon development and brain power, are most important. Among 50,000 school children I found some abnormal points in considerably over 10 per cent., which points to the urgency of enquiry and consideration of conditions of healthy living as well as the rates of mortality.

"I hope you may be able to draw attention to some of these matters."

Sir Dyce Duckworth, M.D., LL.D., wrote:

"I thank you for your article in the *Contemporary Review*. I have taught and practised all, or much of what you advise, for a quarter of a century.

"I am bound to say that as I grow older, I can bear less cold fresh air than formerly, and you will certainly find the same. I generally observe that where scientific men mostly congregate the ventilation is worse than elsewhere. This is a sad reflection, but it is a true statement.

"I cannot agree to some of your pathogenic views. You are confident where I should hesitate to tread."

Mr. Symes Thompson, F.R.C.P., wrote:

"As Gresham Professor of Medicine, it has been my duty for more than 20 years, to expound the principles of Health preservation to the 'Citizens of London.'

"I rejoice to know that you have taken up the subject with such force and vigour.

"Every year, with advancing knowledge, new point and emphasis is given to the old teaching.

"For instance, the recent observations on the behaviour of tubercle bacilli when exposed (1) to foul air, (2) to pure air, (3) to pure air with diffused daylight, and (4) to pure air with direct sunshine, demonstrate with a definiteness previously lacking, the value of air and light in destroying these noxious organisms.

"The evidence collected in your article regarding stable air, and the air in cowsheds, is perfectly true, and might easily be amplified. It is strange how people will spend freely on the ventilation of their stables, whilst entirely neglecting the ventilation of their nurseries and sleeping rooms.

"The absence of catarrh at sea is indeed remarkable, as is also the frequent presence of catarrh on landing, until acclimatisation is established.

"The frequent relation of acute pneumonia to impure air is now recognised, the chilling of the skin, and consequent arrest of excretion being merely an incident in the determination of the attack. I have on several occasions been able to arrest the fever and other symptoms of pneumonia by sealing the waste pipe of bath or sink, through which drain air had previously been drawn into the sleeping room.

"In a recent case of influenza to which I was called in consultation, four 'old maids' were living in a fusty, frowsy, airless house, all windows and registers were firmly closed. On the day of my visit one sister had been buried, one had died, the third was moribund, and died on the following day, and the fourth had profound double pneumonia, and recovery seemed well-nigh hopeless. However, after opening the windows, and registers of the grates, she recovered; of the four servants who caught the disease,

one, an old nurse, died from the same type of pneumonia as her mistress.

"I was called to Mentone to see a case of typhoid fever. Dr. Marriott informed me that he had ceased to fear continued fevers, since he had adopted the plan of taking out the windows of the bedroom, and putting the bed in the middle of the room, and thus avoiding all chance of rebreathed air. In our humid climate, this plan of treatment is rarely feasible, but the 'hyper ventilation' treatment of many forms of chronic disease is of unquestionable value."

Dr. Bower, of Ivel Lodge, Sandy, wrote:

"I quite agree with all that is said on the subjects of ventilation, exercise, and cleanliness. They are matters of immense importance, and cannot be too frequently and too forcibly impressed upon all classes of the community. The article is likely to do a great deal of good, and I would like to endorse all that has been said by Sir Lyon Playfair and Professor Huxley."

Sir John Lubbock, Bart., M.P., wrote:

"I have read your article on Air with much interest, and, like you, am a great believer in pure oxygen. I do not, however, feel that I can add anything of value to what you have said so well."

Mr. Tom Smith, F.R.C.S., wrote:

"I am much obliged to you for sending me your paper, and I entirely agree with your main conclusions.

"If you can purify the polluted air of our houses without damage to the inhabitants you will remedy one of the most serious evils incidental to civilized life."

Mr. Thos. Bond, F.R.C.S., Westminster Hospital, wrote:

"The subject you write on is of great importance, but it seems almost impossible to find a satisfactory solution to the vexed question of 'ventilation.'

"In the case of the poor the necessity of keeping out the cold, especially in winter, compels them to shut up windows and doors, and the architects have not yet found a cheap and easy method of keeping out cold and letting in air.

"The most efficient method at present known to me is the system of ventilation by tubes called Tobin Tubes.

"If this system were generally carried out and perfected, I believe it would bring us nearer to the solution of this vexed question than any other method."

Mr. G. Fielding Blandford, M.D., wrote:

"With your article on Bad Air all must agree, but it leads me on to other questions. Sir Lyon Playfair suggests your following it up with another on water, and one on cleanliness, and I would suggest one on cold and one on damp. These two are fertile sources of disease, and they are intimately connected with the question of bad air, especially among the poor. You cannot expect people who have scanty food and coals, to open their windows in an English winter. For the same reason they burn gas to warm the room and use up the oxygen and poison themselves. But the well-to-do classes have not this excuse, and ought to read your paper and profit by it."

Sir J. Sawyer, M.D., Consulting Physician to the Queen's Hospital, Birmingham, wrote:

"The paper entitled 'Bad Air and Bad Health' is an able and popular exposition of a difficult subject, which is second to none in its importance to human health, and upon which there is much public ignorance. So far as I know, the writers are accurate in their chemical, physiological, and physical data, in matters of fact; in their opinions, they are in consonance with the teachings of medical experience. Oxygen is a food, which we take in breathing, which we can only take in that way, which is absolutely essential to the structure of our bodies, and it is a food which we cannot do without entirely for more than three minutes, without dying. Much of chronic invalidism is chronic sub-oxidation, and much of ill-health which is attributed to 'over-work' is due to work in wrong conditions, and one of the worst of wrong conditions is work in stale air. Whenever we doubt about our vitality we should doubt about our ventilation. From the discussion which this paper should excite I hope there may be evoked an enthusiasm for fresher air, which may result in the better ventilation of houses, of sleeping rooms, of public buildings—especially of places of public worship—of railway carriages—especially of those for first-class passengers—of workshops, and of those in which dusty trades are plied."

APPENDIXA.

Quite recently Drs. J. Haldane and J. Smith at Oxford have raised the question, as regards the chief source of mischief in badly ventilated rooms,—is it the increase of carbonic acid, the deficiency of oxygen, or the expired organic poisons (*Journal of Pathology*, Oct., 1892, Feb., 1893)? Having performed some interesting experiments of a harmless character upon human subjects, they seem to have ascertained from them that a large excess of carbonic acid in the air was the chief cause of quickened respiration; that a great deficiency of oxygen was also a cause, though in a considerably less degree, of quickened respiration; and that the excess of carbonic acid produced more immediate distress than the deficiency of oxygen. Having arrived at these results they seem to have founded upon them, and upon the results of some experiments upon animals, the conclusion that the effect of the organic poisons is of very secondary and but small importance. The human experiments are recorded with delightful clearness.

We now give in short form most of the experiments on human subjects on which their conclusions were founded. We do not propose to pass any remark upon the experiments on animals. As the experimenters themselves are well aware, these experiments are strikingly at variance with other experiments; and we venture to believe—one of us, be it said, being the victim of prejudices upon the subject—that the facts of health and disease are a safer guide in this matter than the experiments on animals. Unhappily in all civilised countries the larger part of the human race is unintentionally performing a whole series of experiments upon itself as regards the breathing of impure air; and an immense deal has to be learnt from a closer observation than has yet been given of common but slightly differing habits in every-day life.

The experimenters constructed a small wooden chamber with various convenient arrangements. They made it air-tight, and they analysed the air at stated intervals during the time that the subject of experiment was in the chamber. Of course after a

certain time the air became exceedingly impure, the carbonic acid being greatly increased, the oxygen greatly diminished.*

1. *Air vitiated by breathing.* The subject remained in the chamber until the carbonic acid rose to 3·9 p.c. *Results:* Some ill effects at the time, which ceased on leaving the chamber.

2. *Air still more vitiated by breathing.* The subject remained in the chamber till the carbonic acid rose to 6·39 p.c., and the oxygen was diminished to 13 p.c. *Results:* Quickened respiration (30 per minute); headache; on leaving the chamber headache and sickness. Results complicated by question: if food had been improperly taken? When first subject left, a second entered. Breathing quickened; only smelt paint.

Experiment repeated. Carbonic acid increased to 5·8 p.c. *Results:* Respiration much increased, up to 35; pulse slightly quickened, 76; slight headache, not persisting next morning. The observer, who entered, as the first subject left, only smelt paint. *Results*, after 15 minutes, breathings [p. min.] 30, pulse 96.

3. *Air greatly vitiated by breathing, but carbonic acid removed by chemical means.* The subject remained until the oxygen was decreased to 14·7; the carbonic acid being kept to a fairly low point (·6 p.c.) by chemical means. *Results:* Respiration quickened (30), pulse slightly lowered. No positive discomfort; slight occasional headache, which ceased on leaving; but "nausea and sickness" in evening. Results complicated by question whether sickness was due to having been experimented upon during 15 hours out of 48. The observer who enters has slight tendency to quickened respiration; respiration recorded as 11 (?).

Repeated. Oxygen falls to 13 p.c., but in this case carbonic acid rises to 1·4. *Results:* Respiration slightly increased (18); pulse falls (from 90 to 84); temperature of body falls over 2 degrees, though temperature of chamber rises 18 degrees.

4. *A large quantity of pure carbonic acid artificially introduced into the chamber.* [In this experiment it was apparently intended that the air should be normal except as regards the introduction of pure carbonic acid. The air, however, was not normal, as the oxygen was at starting 20·4 instead of 20·8, and fell to 19·8 before the end of the experiment. Perhaps the chamber itself

* It is well to remind some readers that ordinary respiration is about 18 per min., pulse about 70-75. The oxygen in the air should be 20·8 p.c.; and the carbonic acid ·04 p.c.

was tainted after previous experiments. At all events the air became impure during the experiment in question.] *Results :* Greatly quickened respiration (34); in one instance no headache during experiment, and only for short time after experiment; in another instance severe headache during experiment and persisting after experiment.

Experiments were then made by breathing air, the elements of which were mixed in different proportions in a bag.

5. *Common air breathed and re-breathed from a bag in highly impure state.* When carbonic acid reached 10 p.c., and oxygen was diminished in proportion, the distress became so great that the experiment had to be stopped.

6. *Large quantities of oxygen mixed with common air breathed from the bag.* When the carbonic acid reached 10 p.c., though the oxygen amounted to 58·6 p.c., great distress. The excessive quantity of oxygen, therefore, seemed unable to counteract the effects of the excessive carbonic acid.

7. *Results of breathing air* (1) *with great excess of carbonic acid and oxygen diminished in proportion; and* (2) *with great excess of carbonic acid and great excess of oxygen, compared together. Results :* Experimenters seem to have concluded that the excess and deficiency of oxygen were comparatively unimportant as regards quickened respiration. No record given of the time in which the breathing was quickened by each kind of air.

8. *Very large quantities of pure carbonic acid,* 18·6 *p.c., breathed for a short time. Results :* Experiment had to be stopped after 94 (?) and 110 seconds.

9. *Air, with oxygen greatly deficient and carbonic acid chemically removed. Results :* When the oxygen fell to 8·7 p.c. the experiment had to be stopped. Subject getting blue in face, but no headache, no marked increase in respiration. Another subject then breathed the same air. *Results :* Pulse rose to 131 in 5 minutes; respiration to 24. Experiment stopped after 6 minutes. The oxygen had fallen to 6·7 p.c.

10. *Effect of two different mixtures*—(1) *air greatly deficient in oxygen and with great excess of carbonic acid,* (2) *air greatly deficient in oxygen and only a trace of carbonic acid—compared. Results :* The air with excess of carbonic acid rapidly produced quickened respiration, which was relieved by breathing the air which had only trace of carbonic acid.

First of all we think it has to be remarked that the question of how much immediate distress is caused by great excess of carbonic acid and how much by great deficiency of oxygen requires a greater number of experiments, as the subjective element counts for so much in this matter. Even from these experiments it is plain that different persons, submitted to the same experiment, were differently affected. We must next remark that the experimenters generally subjected the person experimented upon to an enormous excess of carbonic acid and an enormous deficiency of oxygen,—as they themselves pointed out, far exceeding any normal excess or deficiency; that by these enormous quantities they were of course able to produce immediate effects; and that they seem disposed to look upon these immediate effects, resulting from this enormous excess and deficiency, as having some important bearing upon the question of the organic poisons. But have these effects any such important bearing? The net result of the experiments upon human beings seems to be that a marked physiological effect (quickened respiration, as attested earlier by Angus Smith) follows the breathing of a great excess of carbonic acid, and follows in a much less marked degree a great deficiency of oxygen. But this fact, interesting in itself and important as it is, like all other physiological facts, seems hardly to touch the question of the health effects, which in some cases follow quickly upon the three conditions,—the breathing of slightly excessive quantities of carbonic acid, of slightly deficient oxygen, and of certain organic poisons; or those other more remote effects which follow the same three conditions, when exerting their continuous influence through months and years. It seems hardly to affect the question—given a headache after a night of a crowded unventilated room; or given a case of tuberculosis after years of a sedentary occupation in unventilated rooms,—how much is to be put to the account of the respective factors—increased carbonic acid, diminished oxygen, and organic poisons,—to ascertain that carbonic acid, ten or twenty times in excess of the carbonic acid in an unventilated room, and oxygen, diminished some units per cent., produce in their different degrees quickened breathing and immediate distress. Like the related fact, that if the experiments had been pushed to a still further point, life itself could not have been sustained, the statement seems to leave the question pretty nearly

in the condition in which it was before. It is an interesting contribution to the material already collected upon the subject to know that quickened breathing is more readily provoked by excess of carbonic acid than deficiency of oxygen; but it is impossible to claim that such a fact—even when placed in the domain that lies beyond controversy—in any sort of manner settles what is the permanent mischief, arising from excess of carbonic acid, deficient oxygen, or the organic poisons.

As regards these poisons, the writers occasionally seem inclined to throw some doubt upon their existence. In one experiment it was observed that on entering the chamber after the subject had been shut up in it until the carbonic acid rose to the excessive amount of 6·39 p.c., that "there was no perceptible odour" to be noticed as the next person entered it. This was observed on two occasions by two different persons. We do not quite understand the purpose of this observation. Is it recorded for the purpose of implying that the organic emanations do not ordinarily leave a smell? But that is to challenge a fact that rests on very wide testimony. We think that most people who habitually live in rooms with fresh air, and accustom themselves to use their power of smell as regards ill-ventilated rooms when they first enter them, can have no doubt of the painful reality of this smell. It is true that, in the case of persons living generally in impure air, their senses are apt to become inefficient guides in the matter; secondly, that the sense of smell is so poorly developed in modern life, that it often requires training before it can be relied upon as a test-sense; thirdly, that with many persons it varies considerably in power from day to day, (generally in some relation with health), as perhaps might be expected from its low state of development in present modern life. Moreover, there seems in the case of the Oxford experiments to have been a special reason why the smell of organic emanations was not perceived. In two cases the second subject, who enters as the first leaves the chamber, smells the paint on the walls; and this smell may have overpowered or disguised other smells. The paint suggests other questions. The door, after being closed, was sealed up so as to be air-tight. What was the sealing material used; had it any special smell? Again, beyond these questions lies a more interesting one—when a certain excessive amount of carbonic acid and organic emanation is reached, and the oxygen is very largely reduced, is the power of smell itself rendered less acute? Parkes

has already observed that when a certain moderate quantity of carbonic acid, ·09 p.c., is reached (p. 177), the power of smell ceases to perceive shades of difference. Parkes also adds "Carnelly, *Haldane*, and Anderson, point out that the test by the sense of smell is liable to be influenced by many conditions, and that it not infrequently happens that a more overpowering odour is perceptible with a small than with a larger amount of carbonic acid" (179). We hope that Dr. Haldane will not quarrel with the authorities we have cited. Although the recording of the observation—no smell but paint—looks a little suspicious, we cannot believe that the experimenters desire to challenge the widely-observed fact that there is a smell to the emanations which come from skin and lungs. If it is necessary to make any appeal beyond common daily observation we may refer to Parkes, who quotes De Chaumont's four states of impure air which may be recognised by the smell,—each state containing a certain amount of carbonic acid (p. 177).

By excessive quantities of carbonic acid the experimenters produced quickened respiration. Can that fact be taken for a single moment as proof that other kinds of physiological disturbance were not being caused by deficient oxygen, or organic poisons, or by that very same excess of carbonic acid? A man may eat some indigestible food; may work longer than he is accustomed to; may pass through some agitating scene; may suffer a chill; and perhaps neither at the moment itself, nor in the time that immediately succeeds will there be any plain sign of the mischief that has been done, and the effects of which may be accumulating against him. But on the strength of these experiments (and of the animal experiments) the experimenters write (185)—we cannot help thinking without sufficient ground—"the immediate dangers from breathing air highly vitiated by respiration arise entirely from the excess of carbonic acid and deficiency of oxygen, and not from any special poison." We submit that this sentence would be safer, if limited as follows: "The immediate dangers, *as regards the respiration*, &c." What forms the whole body of immediate dangers we think are as yet hardly known; and it seems probable from certain cases, such, for instance, as the black hole of Calcutta, that persons may suffer more under close confinement from the organic emanations and deficiency of oxygen—for the two are closely co-related—than from excessive carbonic acid. This seems at

least implied by the fact that most of the survivors were ill afterwards with putrid fever, which can hardly be put down to the direct effects of carbonic acid. In another passage the experimenters write (181): "Our experiments in the chamber afforded distinct evidence against the theory that a poisonous volatile substance is present in air vitiated by respiration." Are there not at least two assumptions in this passage: that the effect of these breath-poisons is immediate; that their effect can be separated and distinguished when there is great physiological disturbance owing to excessive quantity of carbonic acid or excessive deficiency of oxygen; and that it is safe to form a conclusion, founded upon conditions which are violently abnormal, as regards conditions commonly existing in every-day life. Again they say (186): "If there be no special poison in air vitiated by respiration, it would seem to follow that (apart from the effects of heat and moisture and of infection caused by bacteria) the air of ordinarily close rooms is only injurious so far as it is offensive to the sense of smell. . . If, however, the deleterious effects are produced through the nerves of smell, it is evident that in order to secure wholesome air, efforts must rather be concentrated on the prevention of smell than on mere dilution of the products of respiration." It seems difficult to follow this line of reasoning. If there is a smell, from what does it come? It cannot come from excessive carbonic acid or (directly) from deficient oxygen. If there is a smell, and it is due to putrid particles or volatile poison, why is it simply to be hurtful by affecting the nerves of smell; why is it not to be hurtful when inspired? And if there is such a poison, can much be hoped from a continual disinfection of the air of our living rooms? Would that not mean—if the process were fairly successful in altering the most hurtful elements in these poisons—that we should be condemned to breathe for the rest of our lives the altered or partly altered poison+the disinfectant. The use of ordinary disinfectants has been described by an unfriendly critic as creating one bad smell to overpower another bad smell; and we hardly think that a combination of chemicals with our atmosphere will be the best thing to improve it for breathing purposes. Before leaving the question of the existence of these organic poisons, we wish to add a few remarks of a more general character. (1) In ordinary cases—we are not speaking of extreme cases—the effect of these organic poisons contained in the breath are slow in their action.

In many cases they produce an alteration of tissue which is the preparation for disease rather than disease itself, as, for example, the breathing of vitiated air, which precedes tuberculosis. It may be well to quote a sentence of Angus Smith. After speaking about "the overwhelming evidence" as to the hurtful effects of bad ventilation, he says: "The senses begin the argument, but it takes months or years to show the bad effects of that air which they dislike. At the other extremity the vital powers give way, and between these two we must have a gradation of effect" (p. 141). (2) Certain cases of sore throat, which arise either from breathing putrid organic particles (or volatile poison), or from the presence of various kinds of poison in the system, suggest that the sore throat of the common cold is due to some volatile poison or putrid organic particles; thus, some of the symptoms from breathing sewer gas which has entered a house—sore throat, slight fever, headache—have much in common with the severe feverish cold that so commonly follows living in impure air; whilst it might be added, the diarrhœa itself, which accompanies this introduction of sewer gas into a house, is only a cold, or inflammation, or poisoning, with discharge of mucus, of a different region of the same mucus membrane from that which is affected in a throat-cold. In the same way (as we have pointed out at greater length elsewhere) many other forms of sore throat, as in measles, scarlet-fever, poisoning from putrid meat, &c., are the results of poison in the blood, and therefore again suggest — as in the case of sewer gas, just referred to—that the ordinary sore throat or cold—which is so largely due to breathing vitiated air—is also caused (like these other sore throats) by the presence of its own special poison in the blood. Putting the two facts—if they are facts — together: that in air vitiated from breathing there are putrid organic particles (or volatile poison), and that colds, which are generally produced from living in bad air, are cases of poisoning—if such is the case, as we believe it to be, and as we have tried to show that it is—it is not easy to accept the suggestion that carbonic acid should be looked on as the chief cause of mischief, where ventilation is deficient. (3) The reality of these poisons is further attested,—as shewn in the text—by various evidence, such as the smell of badly-ventilated rooms, the impurities, though very small in amount, of water, through which the breath has passed, the test of "dis-

tillation with alkaline permanganate" (Parkes, 142), the evidence yielded by sulphuric acid, platinum, and nitrate of silver; the large numbers of bacteria in filthy shut-up and unventilated rooms,—presumably because putrid particles supply their necessary food*; &c. (4) It must not be forgotten that the quickened respiration caused by an excess of carbonic acid is a physiological adaptation and remedy to meet an unusual—but only, when a certain degree is reached, dangerous—state of circumstances. It is not necessarily an evil in itself. Exactly the same result is produced when violent exercise is taken, and yet we do not look upon the quickened breathing in such a case as a sign of grave mischief or danger. Of course in either case the process can be pushed so far as to produce danger and mischief; as in the case of a hunted animal, who though not caught by the hounds dies after the exertion; or the case of a person who breathes 6, 7, or 8 p.c. of carbonic acid out of a bag. But that may happen by pushing too far the most blameless physiological process. There is a considerable chance of a person retiring altogether out of this world who undertakes to eat 50 buns at a sitting. We call attention to this point, because we think that proving that carbonic acid quickens the respiration by no means exhausts the subject-matter. (5) The evidence of soda-water factories is, we believe, against the belief that carbonic acid is in itself the cause of mischief. This evidence—so far as we know—has never been of a very precise character; but there has been a certain amount of evidence to show that men might breathe, without apparent harm, large quantities of pure carbonic acid, considerably larger than that found in crowded rooms, where, at the same time, air was freely admitted. The inquiries by letter of one of the present writers, made some little time ago of the owners of a soda-water factory, seemed to confirm this statement (see also Parkes, 157.) (6) The analogy of the skin cannot be used as an argument, but, admitting that there are breath-poisons, it suggests how important is the action of the lungs in this matter. How deadly these organic poisons are, in the case of the skin, is shewn by the often quoted cases of the man, of whose body during life it was

* Bacteria are not always found in large quantities when the quantity of carbonic acid is high. In a hall—generally kept clean and open and fresh—where many people were temporarily collected—the carbonic acid would be increased out of proportion to the bacteria.

attempted to take a plaster cast, and of the child who was covered with gold leaf. Thus we have two organs—if the breath-poisons are admitted—both of which dispose of certain minute forms of waste not otherwise got rid of,—waste derived from the breaking down of worn-out tissue; and it is reasonable, when, in the case of the one—the skin—we see how deadly the poisons are, if by accident retained, that we should be led to suspect that the poisons got rid of by the other organ must also be powerful for mischief, whenever we are placed under conditions unfavourable for their elimination. (7) We venture to think that a good deal of the hurtful effect of an undue amount of carbonic acid is indirect, and that it sins by increasing the effect of the organic poisons. Apart from its direct mischief —of whatever kind that may be—its indirect mischief consists in aggravating the effect of the waste poisons that are in the tissues and in the blood. First, an increase of carbonic acid in the air means a decrease of oxygen, and thus the supply of oxygen taken in by the lungs is lessened—a fact that must count for much as regards the rendering harmless the waste poisons in the system; and, secondly, in proportion as an undue quantity of carbonic acid in the air enfeebles the pulse (A. Smith, 216) to that extent it diminishes the quantity of blood sent through the lungs, and therefore again increases the quantity of poison, remaining in the system, which would otherwise have been brought by the blood to the lungs, and thus got rid of. One beat of the heart (say, equalling 3 oz. of blood) less per minute means "a diminished circulation of many gallons of blood per day," and this means a large retention of poison in the system.* Thus, whatever may be the direct mischief caused by an excess of carbonic acid in the air, at all events it increases the mischief of the waste poisons in the body, by lessening the supply of oxygen, both as regards the amount of blood driven through the lungs (the circulation being enfeebled) and as regards the actual proportion of oxygen in the air that is being breathed,—the proportion of oxygen in the air being proportionately diminished by the increased carbonic acid. We might add that any diminution of oxygen in the air of a room probably still further diminishes

* On the other hand some allowance must be made for quickened respiration. But does quickened respiration persist where the increase of carbonic acid is only slight? We want observations on this point.

the supply of oxygen, because as the organic putrid particles increase, these again diminish the diminished oxygen. Angus Smith found that in the neighbourhood of organic corruption the proportion of oxygen in the air was sensibly less—the oxygen being taken up presumably in oxidising the putrid particles. (8) Though increased carbonic acid quickens respiration, yet other causes, producing the same effect, must be taken into account. As Professor Foster seems to remark, excess of carbonic acid cannot be held responsible for the quickening of the respiration in strong exercise, as on analysis it is found that the blood has no such excess (see 628, 663) of carbonic acid. It is also important in this controversy to remember another statement made by him: "The phenomena of asphyxia are in the main due to the former" (deficiency of oxygen); "the accumulation of carbonic acid in the blood has subsidiary effects only"—a statement which we think clearly shows that there are poured into the blood waste poisons of greater importance in their toxic effect than carbonic acid.

Books referred to. In the text the names of the authors only are given, with the number of page referred to. When only the page is given, the reference is to the author last named. Where two books by the same author are referred to, the name of the book, not mentioned in this list, is given in the text.

Aitken, "Animal Alkaloids"; Beale, "Slight Ailments"; Blythe, "Poisons"; Brown, "The Animal Alkaloids"; Brunton, "Disorders of Digestion"; Campbell, "Causation of Disease"; Carpenter, "Principles of Human Physiology," 7th edit.; Collie, "On Fevers"; Crookshank, "Manual of Bacteriology"; Foster, "Text-book of Physiology," 7th edit.; Fothergill, "Diseases of Sedentary and Advanced Life"; Gautier, "Chimie Appliqué, etc."; "Health Lectures"; Hermann, "Human Physiology"; Kirke, "Handbook of Physiology"; Klein, "Micro-organisms and Disease"; "Our Homes," by various writers, Galton, etc.; Parkes, "Practical Hygiene"; Prosser James, "Sore Throat"; Quain, "Dictionary of Medicine"; Ransome, "Milroy Lectures"; Richardson, "Field of Disease"; Russell, "Epidemics, &c."; Thorne Thorne, "Progress of Preventive Medicine"; Watson, "Lectures on Principles and Practice of Physic"; E. Wilson, "Healthy Skin."

GLOSSARY OF TERMS USED.

Alimentary tract: The food-tube of the body with its expansion (the stomach) employed for the reception of food and the earlier preparations which the food undergoes for becoming blood.

Alkaloids: Substances resembling alkalis. Alkalis, such as soda, unite with acids to form salts. "They have a soapy feel and taste." The alkaloids were supposed to be only vegetable products; they are now known also to be animal products. They are often in both cases poisonous.

Anæmia: A defect in the quality of the blood; "a deficiency in the red corpuscles."

Arterial blood: Blood as it comes from the lungs after receiving oxygen and giving up carbonic acid.

Asthma: A difficulty in breathing, "occurring in paroxysms."

Bacillus: A division, comprising in itself many subdivisions of bacteria, which latter word is the wider term.

Bacteria: Explained in text, see p. 15.

Bronchitis: Inflammation of the two large air tubes (bronchi) leading into the lungs. These tubes are more or less filled with mucus or some kind of secretion, "and thus impede the entrance of air to the lungs." The inflammation may be of the many small air tubes which descend into the lungs.

Broncho-pneumonia: Inflammation of the lung associated with, and generally following upon, inflammation of the large air tubes (bronchi) leading into the lungs. The inflammatory products of the bronchi help to fill up the air-cells of the lungs.

Bullous: Bulla is a vesicle or bag, which is formed by the outer skin and filled with watery fluid.

Capillaries: The minute blood vessels which supply every part of the body with blood. They lie between and connect the two systems of vessels, those which take the blood from the heart (arteries) and those which return the blood to the heart (veins).

Carbonic acid: A heavy poisonous gas, which extinguishes flame and destroys life when breathed. It is the same as choke-damp. It is produced by burning, fermentation, and the breaking down of waste matters in the body. See oxygen.

Congested: When applied to the minute blood-vessels, denotes fulness, the blood being torpid and stagnating, and certain of its elements having an increased tendency to pass through the walls of the vessels.

Consumption: (Phthysis) generally applied to lung-consumption. It is a wasting disease, in which the lung may be consolidated or filled up "by various kinds of growths and exudations" (*i.e.* escape of matters from the diminutive blood vessels in the lungs); or may be "occupied by cavities" of very varying sizes (see Quain),—such cavities in extreme cases eating out the lung substance, and leaving a mere empty bag.

Convulsions: A strong muscular movement, affecting a large number of muscles at the same moment, connected with the respiratory apparatus.

Coryza: Cold in the head.

Diphtheria: A contagious disease in which an exudation of bad character is poured out on various parts of the back of the mouth, the wind-pipe, &c., generally forming a false membrane.

Enteric fever: Another name for typhoid.

Erysipelas: An inflammation, the products of which can convey the same inflammation to other parts. Often affects the skin.

Gland: Generally denotes an organ composed of blood-vessels, lymph-vessels, nerves, secreting cells, &c. These secreting cells separate from the blood certain elements, and from these elements compound and store various substances required for the use of the body, such as saliva, gastric juice, &c.

Gramme=nearly $15\frac{1}{2}$ grains (Troy). 24 grammes make 1 ounce (Avoirdupois).

Intestine: That part of the food-tube or food-canal which extends from the stomach downwards. The useful part of the food—having been subjected to various processes—is absorbed into the lymph-vessels and blood-vessels to form lymph and blood,—the useless part being rejected.

Kilogramme=slightly more than $2\frac{1}{16}$ lbs. (Troy).

Kreatin: Probably, one of the earlier forms of the waste of muscle afterwards changed into urea.

Liver: A very important organ which purifies the blood; acts upon and renders harmless hurtful matters before they pass into the general circulation; assists digestion by pouring bile into the intestine: stores food in the form of fat or animal starch, thus supplying the system with sugar as required; and probably turns certain forms of waste into urea.

Lung: An organ with innumerable air-cells in which the air taken in at the mouth and descending the air tube (wind-pipe) is brought into close neighbourhood with the blood. The air and the blood are only separated from each other by the thin membrane of the air-cells and the wall of the minute blood-vessels which are imbedded in the wall of the air-cells. Through these membranes oxygen passes to the blood, and carbonic acid from the blood to the air. The carbonic acid is breathed out; the oxygen breathed in.

Lymphatic vessels: Carry the lymph, a colourless liquid, which helps to make blood. Are found all over the body.

Metre=3 feet $3\frac{3}{8}$ inches.

Microbe: Generally used now as another term for bacteria.

Micro-organisms: A term embracing the minute forms of life, whether plant or animal in their nature.

Nitrogen: A gas which dilutes the oxygen of the air. It is an element in all forms of animal and vegetable life. It is not poisonous, but when breathed cannot support life; nor can it preserve the flame of any burning body placed in it.

Nitrous oxide: A gas formed by a combination of oxygen and nitrogen, used as an anæsthetic.

Organic substances: Are substances produced by living things, animal or vegetable.

Oxidised: Acted upon by or combining with oxygen. In the great majority of cases, combustion is oxidation, or the union of some element of the thing burnt with oxygen.

Oxygen: One of the gases in the air, on which all ordinary cases of combustion depend. When wood, coal, &c., are burnt, oxygen combines with the carbon of the wood, and in doing so, produces heat and light, and forms carbonic acid gas. When it is breathed into the blood, it passes into the tissues and "burns" up,—*i.e.*, combines with, certain elements of the waste matters.

Ozone: A condensed form of oxygen, possessed of "intensely oxidising powers," and, therefore, a very valuable agent in destroying unwholesome substances. Exists in pure air, and can be produced by electrical discharges.

Periosteum: A membrane surrounding the bones.

Pharynx: The cavity at back of the mouth which opens into the food-tube leading to the stomach.

Plague: A fever accompanied by inflammation of the lymphatic (which see) glands, and of a tissue below the skin. Once extended over all Europe.

Pneumonia: An inflammation of the lung in which certain elements of the blood pass from the tiny blood-vessels and fill the air-cells of the lungs.

Puerperal: Connected with child-bearing.

Pulmonary: Connected with the lungs.

Pus: "A product of inflammation." Certain contents of the blood-vessels escape from the vessels, and, in combination with the white cells of the blood form pus.

Putrefaction: A decomposition of animal or vegetable matter, by the growth or action of extremely minute plants, called bacteria and found in earth, air, and water. Freezing arrests the growth of these minute plants.

Relapsing fever: Or hunger fever. It was first distinguished this century from typhus and typhoid fevers, with which it has much in common. It specially attacks the underfed. Is very contagious, and has a tendency to return (relapsing) "an indefinite number of times" after short intervals.

Septic: Connected with putrefaction.

Scrofula: A constitutional disease in which the glands develop in the later stages "a white soft cheesy matter mixed with a thick pus."

Spasmodic croup: Croup is an affection of the air-tube (trachea) and the upper part of it (larynx) which has the vocal chords. This tube takes air from the mouth down towards the lungs. A false membrane is apt to be formed on the affected part. The spasms affect the aperture which exists between the cartilages placed across the top of this air-tube.

Spleen: An organ in the left half of the body; has no duct (canal) of its own like the liver; manufactures no juice. Is believed to purify the blood, arresting and destroying old worn-out blood-corpuscles.

Tract: Used to denote part or region.

Trismus: A form of lock-jaw in infants.

Tubercle: A growth in certain tissues, the product of a specific bacillus. It is found in many different parts of the human system; but when only found in one part, or localised, it is generally in the lung; it commences so as only to be visible microscopically; after a certain growth it forms a nodule or lump of diseased matter.

Typhoid: A "continued" fever, *i.e.*, not placed amongst those fevers which have intermissions or those classed as eruptive. Marked by rose-coloured rash and ulcers in the intestines.

Typhus: A "Continued" fever (see Typhoid). Marked by great prostration, "cerebral (brain) depression," and dusky rash. Generally caused by over-crowding.

Urea: Is one important form of the waste which is always going on in human tissues. It is that part of the waste which contains nitrogen and which is removed from the blood by the filtering action of the kidneys. It is a solid, but dissolves readily in water. It is probably formed in the liver from antecedent forms of waste which are changed into simpler forms of waste.

Zymotic fevers: Generally employed now to denote certain fevers which are communicated "by matter derived from the human body (as in small pox), or from the earth (as in ague)." The term at one time covered other diseases which in some points resemble the process of fermentation (zumé Gr. ferment).

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APPENDIX B.

A medical friend writing on the subject, says:

"There is no doubt that limited and stagnant air is bad; that it depresses the bodily energy and concentrates contagion. And you shew abundantly that certain diseases vary inversely with the supply of fresh air. But when we ask *how* bad air acts, we have to be very cautious in answering. Physiology is a shifting science; many of its facts are but half-facts, and nearly all its conclusions but temporary theories. . . . There is, however, no doubt that pure air and plenty of it is the treatment for influenza; and I believe that much of the debility—though influenza is in itself a disease that leaves debility—which follows it, is due to the shocking way in which people poison themselves with bad air during and after an attack."

From Professor M. Foster, Cambridge:—

"I have been very much tied of late and have only just now been able to read your pamphlet. There is very much in it with which I agree, but it is almost impossible without writing almost a treatise to enter into details. I quite agree with you that in a well regulated economy the mere transference of blood from the skin to the internal organs ought not of itself to cause mischief, and the fact that cases of exposure to cold, quite apart from the intervention of microbes, give rise to disease is to be explained by something which we may call 'poisons' in the blood. The matter however seems to me too complicated to allow, with our present knowledge, a simple explanation. We must remember that, even in perfect health, the blood is full of 'poisons'—indeed 'health' is, from one point of view, the result of the nice adaptation of the effects of these poisons. Whether, when cold to the skin seems to cause a bowel attack, the result is due to the transferred blood being bad, or to the bowels, owing to their condition, being unable to cope with the extra supply of blood, is to my mind at present a problem. We must go steadily on working these things out. I am certainly more and more impressed with the view that we physiologists know very little about the functions of the *skin*. I'm sure it does many more things than we at present dream of. May not the ill effects of vitiated air have more to do with the skin than the lungs?"

"By the way that estimate of mine about the heart's work is purposely put as a very high one. The daily work of the heart of an average man is distinctly less."

Mr. R. Thorne Thorne, M.D., C.B., writes :—

"I am much obliged to you for a copy of your interesting article. If, as you suggest, it may contain 'heresies,' I can only say that you have contrived to mask them under a great array of facts and sound truth. You will see from the enclosed, that I approached the same subject in 1891, urging as regards one disease at least the imperative importance of living in a *moving air* and under circumstances admitting of abundance of light."

Mr. Mortimer Granville, M.D., writes :—

"Bad air, I take it, is air bad in itself, and has its badness aggravated by being made the medium for the dissemination of other bad things. The 'bad things' of which I am, at the moment, particularly thinking are the wretched 'microbes.' No one who has worked much at practical bacteriology can fail to have been struck with the absurdity of the accepted theory of 'disinfection.' I do not deny that if you fire a maxim gun into space you may hit something; but when it is remembered that the atmosphere of any ordinary room is really a highly concentrated medium through the whole of which *bacilli* and *cocci* capable of generating nearly all of the known diseases exist in crowds, it is difficult to set any high value upon the precautionary measure of 'disinfection.' The name of the enemy is Legion, and the mortality resulting from the most vigorous and sustained fire we can keep up on his heterogenous mass of forces is very small. To illustrate the fact that microbes take a lot of killing, let me tell you a laboratory story. The year before last I was greatly interested in an endeavour to discover 'the reason why' of some success I seemed to have obtained with papain administered in a certain combination for the cure of cancer. I have since found reason to believe that the *post hoc* was not the *propter hoc* of the particular *hoc* I was then thinking about; but that is a digression. In the course of my search for the so-called papain bacillus—which I now believe to be an *alter ego* of the bacillus subtilis—I boiled an infusion of papain and thereby killed off the parent bacilli, but behold in thirty-six hours I had a new crop even more vigorous than the first. This was repeated more than three times with the same result; and finally I succeeded in staining the last generation blue and kept them alive under my microscope for six weeks. Now if three boilings only issue in the production of a crop of bacilli so vigorous and light-hearted as to live six weeks under the ignomony of being stained blue, what sort of success are we likely to get in the extermination of a hardy race of disease disseminators by firing small globules of carbolic acid or any other noxious material into their midst? Simply as Voltaire said about the interchange of ideas between speakers of the Basque tongue—'Mais je n'en crois rien.' The only possible method of dealing effectively with the germs of

disease is the London policeman's remedy for obstruction,—moving them on. Plenty of fresh air, a healthy contempt of 'draughts' and admission of winds, even, if possible, of Kingsley's favourite 'north-easter'! If a tuberculous lung-cripple has passed a few hours in any room you may be sure that the walls and floors are dusted over with the bacilli of tubercle. So with all diseases. We never enter any home, or, for that matter, any crowded thoroughfare, without being peppered with 'seeds of disease'; and almost every breath we draw is full of them. Happily there is an army of Phagocytes maintained '*for defensive purposes only*' within us. The food of that army is fresh air. Supply it bountifully, and you do more to keep off 'bad health' than by any device the art of man has discovered under the sun. Did I say 'under the sun?' If only we knew how much those three little words mean we should think more kindly of the old Persian Sun-worshipper, if we did not incontinently lay aside some of the pride of our higher religious culture and enlightenment and bow our own heads as reverently and with as loyal devotion as he bowed his head."

Mr. J. Clement Dukes, M.D., Sunnyside, Rugby, writes:—

"Your pamphlet seems to me to be calculated to do a vast amount of good by calling attention to the fact of the deleterious effect of re-breathing pre-breathed air. It has never yet been realized, even by intelligent people, that it is just as nasty and injurious to re-introduce into the system the ærial refuse given off from the body, as it would be to re-introduce the liquid or solid excretions, yet this is perfectly true. If you can persuade people of the fact, you will have effected a great work."

Mr. J. Haldane, M.D., 11, Crick Road, Oxford, March 14th, 1894, writes:—

"I beg to thank you for the pamphlet by Mr. Wager and yourself which you kindly sent me, and for the offer of an opportunity of replying shortly to your criticisms. The paper has interested me greatly, quite apart from what you say at the end of it as to our experiments. I entirely agree with you as to the importance to the community of the whole subject. However doubtful I may feel as to some of the explanations put forward, and backed by authority and evidence, in the course of the paper, I cannot doubt that from some cause or other disease and death are constantly associated with the constant breathing of vitiated air.

"Your summary of our experiments is so clear and fair that I do not think I could add anything to it beyond calling more attention to the negative side of our results, and emphasizing the fact that never, even in experiments on animals lasting over twelve days, could we observe any ill effects produced by air vitiated by respiration to the extent of not more than three or four per cent. of carbonic acid. I

should like, however, to make a few remarks on your criticisms (pp 62-69) with regard to the bearing of our experiments on the questions discussed in your paper.

"We do not wish to throw any doubt on the existence of traces of volatile organic matter in normal expired air; but so far as we could obtain evidence this organic matter does not act as a poison. Our experiments strongly support the conclusion that the ill effects of breathing air very highly vitiated by respiration are due to excess of carbonic acid and deficiency of oxygen, and to no additional volatile poison. Moreover these effects are only produced by air vitiated to a much higher extent than is ever the case in ordinary rooms. We lay special stress on the experiments on animals, inasmuch as it was possible to make upon them far more thorough and prolonged observations than upon ourselves.

"In judging this question it must be borne in mind that the ill effects associated with living in vitiated air may be due to a number of other causes besides the vitiation of such air by the products of respiration. Among these causes we have emphasized, firstly, infection by bacteria, and secondly, the sensory impressions produced by evil-smelling air. The bacteria do not originate from the lungs or air-passages; nor, as a rule, does more than a small part of the unpleasant smell. The presence of both bacteria and smell is chiefly due to want of cleanliness, and can in most cases be far more effectually prevented by increased cleanliness, both of persons and rooms, than by increased ventilation.

"One of the chief practical outcomes of our investigations was thus once more to emphasize the importance of cleanliness, by which we mean the prevention of any accumulation of dirt, and not the mere application of disinfectants.

"In conclusion I must freely admit the existence of an unexplained conflict of evidence as regards the existence or non-existence of a volatile organic poison in expired air. We are inclined to think that there were sources of fallacy in the experiments (*e.g.*, those quoted at p. 18) which appeared to give an opposite result from our own, but this point has still to be cleared up."

We wish to submit certain considerations as regards the letter which Dr. Haldane has been good enough to send us, asking him at the same time to excuse occasional details—which are of the A.B.C. order—and explanations of terms, for the sake of those readers who are only able to give a small amount of time to these subjects.

(1). We believe that the ordinary circumstances, familiar to all of us, of unventilated rooms cannot at present be satisfactorily explained on the theory that the organic emanations are of small importance. We believe we are correct in stating that a shut-up bedroom, where all attention is given to cleanliness, both as regards the person using it, and the room itself, is disagreeable and offensive

to anyone entering it from the fresh air in the morning; and that an unventilated room, clean in itself, and filled only with persons, careful as regards personal cleanliness, becomes very offensive after a certain time. We also believe that the rapid *increase* in the offensiveness of an unventilated room, filled by an ordinary gathering of persons, is opposed to the supposition that the offensive odour is simply or principally due to dirty clothes and want of personal cleanliness. We have no doubt that the evil smell of a room filled with persons, who are careless on the subject of cleanliness, is worse than the smell of a room filled by persons careful in this matter; but is not this bad smell itself—so far as it arises from the clothes—principally owing to the previous saturation of the clothes by these very exhalations from the skin? Does not uncleanliness largely consist in negligence on this very point? In clothes merely stained by soil, &c., there would be no bad smell of the kind which makes a crowded room offensive, but there is a peculiar smell in clothes, in which a person has often perspired, and which have not been freely exposed to the air. We get a piece of indirect evidence on the subject by the warnings given that rheumatism is favoured by wearing clothes which have often received the perspiration of the skin, and have not been properly exposed to the air. In both cases, both when clothes, in which the wearer has often perspired, check the action of the skin and favour disease, and when they produce an offensive smell, must we not look upon the effect as produced by emanations from the skin? To what other sufficient cause can we attribute it?

(2). It may be well here to touch upon some of the statements made and evidence collected as regards these organic emanations from lungs and skin. (*a*) As regards the lungs,—Professor M. Foster says (552): "When the expired air is condensed by being conveyed into a cooled receiver, the aqueous product is found to contain organic matter, which, from the presence of micro-organisms, introduced in the inspired air, is very apt rapidly to putrefy." Carpenter says that the fluid from the lungs holds also "some animal matter which from the enquiries of Dr. R. A. Smith (Phil. Maga., xxx., 478) would appear to be an albuminous substance in a state of decomposition" († Carpenter 383). "A small quantity of ammonia is usually but perhaps not always thrown off." . . . Ransome estimates that an amount of ammonia representing about three grains of organic matter are eliminated by an adult man in twenty-fours hours."*

[*Note.—In Dr. Ransome's interesting paper it is stated that he found (using the water process of Wanklyn and Chapman) that out of 12 diseased persons, urea was present in the breath in the case of 3, (2 kidney disease, 1 diptheria); that in disease the total ammonia in

† In our references we have not distinguished between authors and their editors. Quotations are made under the names of the authors.

the breath varies considerably; that in certain cases it is as low as half the total ammonia found in health; in other cases of kidney disease it rises largely, being, in the cases he examined, in one case double, in another case more than double the healthy average,—which healthy average he puts at 0·2 gramme, or 3 grains in twenty-four hours; that in healthy persons the amount of free ammonia in the breath varies considerably, but that, as regards the total ammonia, there was "a remarkable uniformity;" and that the air of a railway carriage which was shut up (except ventilators) for fifteen minutes, with eight persons in it, was "strongly charged both with ammonia and organic matter." He adds the important remark that although 3 grains or 0.2 gramme of ammonia may seem a small quantity in twenty-four hours, "when it is remembered that the most impure water (examined by Wanklyn and Chapman) only contained 0.03 of organic matter per *litre*, it will be allowed that there is ample quantity to permit of putrefaction, and to foster the growth of the germs of disease." Ransome puts the moisture of the breath as yielding about 10 oz. of water in the twenty-four hours. As 10 oz. equals $\frac{2}{3}$ of a *litre*, we should have in the worst drinking water 0.03 gramme of organic matter in one *litre*; in the water of the human breath 0.2 gramme in $\frac{2}{3}$ of a *litre*. It is right, however, on this important question to keep back no fact, whatever may be the theory which it seems to favour. M. T. Lemaire (*Comptes Rendus*, Oct. 14th, 1867) asserts that the putrefaction that takes place in water that results from the breath, is not in consequence of organic matter, but depends upon the development of *infusoires* coming from the surrounding air, and from the mouth (le depôt qui s'est formé . . . tient au developpement d'infusoires provenant de l'air ambiant et de la bouche). He states that if the mouth and throat are cleansed first by water and tartaric acid (2 p.c.) and then by pure water, and then air is breathed in through the nose, the breath that is breathed out through the mouth from the lungs (care being taken to avoid any saliva) will not putrefy, if kept in a bottle with glass stopper. For reasons given above we hardly think that statement will stand. There are several questions to ask, and several things to take into consideration as regards such an experiment.]

Lossen estimates a much smaller quantity,—·014 grain. Wiederhold found chlorides of sodium and ammonium, uric acid, and urates of soda and ammonia. Carpenter goes on to point out that when tainted breath cannot be referred to decayed teeth, ulcerations in the air passages, diseased lungs, &c., "it must result from the excretion of odorous matter . . from the pulmonary surface. He also says that "some volatile organic compounds, which communicate an odour to the breath, are also eliminated by the lungs." On the other hand (see note p. 383) he states that Bachl—unlike other observers—was unable to find any traces of ammonia excreted by the lungs; whilst Schenck states

that a small quantity of ammonia is excreted from the lungs of dog, rabbit, and guinea-pig. Hermann writes: "Traces of ammonia are also excreted in the process of respiration (Thiry) but apparently in pulmonary respiration only (Schenck)." Ransome (71) found microscopically in the aqueous vapour of the breath "epithelial scales and other objects;" and also found that only one half of the amount of organic substance is in the breath of those suffering from lung disease as compared with the breath of healthy persons,—the difference being explained by the greater quantity of mucus excreted in illness which retains this organic substance. Landois and Stirling state (215): "An excessively small quantity of nitrogen is added to the expired air (Regnault and Reiset)." Segen found that all the nitrogen taken in the food could not be otherwise accounted for, and "assumed that a small part of it was given off in the lungs." They state (216): "A very small quantity of ammonia is found in the expired air—0·0204 grains in twenty-four hours. It is probably derived from the blood." They add: "The toxicity of the exhalations from the lungs of animals described by Brown-Sequard has not been confirmed by other observers;" but again (231): "To this (carbonic acid given off) must be added a certain quantity of organic matter which is extremely deleterious to health. While the CO_2 (carbonic acid) diffuses readily and is easily disposed of by opening the windows, this is not the case with the organic matter, which adheres to clothing, curtains, and furniture; hence to get rid of it, a room, especially a sleeping apartment, requires to be well aired for a long time, with a free admission of sunlight. . . The nature of the organic matter is not precisely known, but some of it is particulate, consisting of epithelium, fatty matters, and organic vapours from the lungs and mouth. It blackens sulphuric acid, and discolourises a weak solution of potassic permanganate. As a test, if we expire through distilled water, and this water be set aside for some time in a warm place, it will soon become foetid." Writing in 1847 Lewis Thompson finds rather more than three grains of bicarbonate of ammonia "constantly exhaled" per twenty-four hours from lungs of healthy persons (Philosoph Maga., xxx.) Dr. Cornelius Fox (232) quotes from Dr. Ransome's paper "on the organic matter of human breath in health and disease" (Manchester Philos. Society, Feb. 22, 1870) the statement—already referred to—that ten ounces of the fluid condensed from human breath would yield about three grains of organic matter—"a quantity sufficient to make the fluid highly decomposable;" and later he says (301): "M. Lemaire finds not only in the air that passes from the lungs, but also in the perspiratory fluid, abundant indications of animal and vegetable life" (Comptes Rendus, Oct. 14, 1867). Sir John Simon (II., 450) speaks of: "The foulness of air, due to the non-removal of the volatile refuse of the human body." Professor Louis Parkes says "it (expired air) contains a considerable larger proportion of putrefiable organic matters than air which is inspired" (197). "The organic matter

given off by the skin and lungs varies with the individual and his state of health. It consists partly of vapour and partly of suspended matters (epithelial and fatty debris); it is nitrogenous and oxidisable, and very rapidly putrefies. It is also absorbed by hygroscopic substances, such as wool, feathers, and moist paper, and is noticeable by smell, &c." Speaking of breathing and transpiring, Galton says (41): "There is an evolution of ammonia and organic matter. A considerable amount of suspended matter is set free, consisting of epithelium, and molecular and cellular matter, in a more or less active condition of putrefaction. . . The amount of organic matter has been variously estimated but there are hardly any trustworthy experiments on record. . As already mentioned this organic matter is highly poisonous." Dr. G. Wilson writes (96): "The organic matter given off (from lungs and skin) has never been accurately determined. It has a very foetid smell and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid of [in text "off"—misprint?], even after free ventilation has been resorted to. It darkens sulphuric acid, and discolorises solutions of potassium permanganate. When drawn through pure water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. It promotes the growth of micro-organisms, and milk, meat, or other food exposed to it becomes rapidly tainted." He quotes Angus Smith, who records 148·4 grains of ammonia (free and albumenoid) as found in a bedroom per 1,000,000 cubic feet. Professor Corfield (p. 15) attributes the ill effects of unventilated rooms to "foul, or putrescent, organic matter" that we expire. Dr. A. Carpenter (quoted by Dr. Fox, 310) speaks of: "septic matters given off from the pulmonary membrane, very manifest in some diseases to the sense of smell." In addition to these statements, it may be well to recall a few facts, which are evidence of the excreting function of the lungs as regards organic matters, and therefore when placed side by side with the facts just recorded strengthen the view that the act of respiration does not consist exclusive.y of expiring carbonic acid and inspiring oxygen. Carpenter (383) points out how turpentine, camphor, alcohol, and other odorous substances may be excreted from the lungs; and he also refers to the rapid way in which the breath may be affected when there is digestion trouble and the blood is affected by some mal-assimilated matter. In the same way phosphorus may be excreted by the lungs; so also the breath of excessive drinkers of alcohol may be luminous. Thus also Fothergill says: "I have tasted it (iodine) in the mouth on waking after its local application to the knees" (H. 72; and in another passage (369): "Many agents, especially the liliaceæ, are found in the breath after being taken by the mouth; they are thus partly given off by the bronchial membrane"; and we have Professor Beale's statement that a bad smell which has

been inhaled may be given off some hours later from the respiratory tract and perceived in the breath. All these examples seem of importance as evidencing the delicate excreting function which the lungs—at all events—can perform as regards removing substances from the blood. Then we have the evidence as regards the difference in character between pure carbonic acid and carbonic acid resulting from respiration. Parkes points out (160) that in the case of those who survive after very severe confinement in closed places "the symptoms are not those of pure asphyxia . . . a febrile condition is left behind, which lasts three or four days, or there are other evidences of affected nutrition, such as boils," &c. Carpenter (393) says: "Pettenkofer and Voit found that no discomfort was experienced from long exposure to an atmosphere containing ten parts of carbonic acid in 1000 parts, providing this had been added to the air in a pure state; but if the same quantity were present as a result of the respiration of several people serious inconvenience was soon felt." Parkes (157) writes about carbonic acid, that "no effect is produced by the air of the room (bath at Oeynhausen) in which the bathers remain for 30 to 60 minutes, although it contains a large percentage . . [Allusion follows to the belief that excessive carbonic acid in the air favours disease, which is however rejected by Parkes.] Hirt finds no symptoms of chronic poisoning by CO_2 (carbonic acid) even in trades where acute poisoning occasionally occurs;" and Professor Foster (552) re-affirms the doctrine that air in which pure carbonic acid amounts to one per cent. "has very little effect on the animal economy" whilst raised to one per cent. by breathing "it is highly injurious." Of course it should be said here that this hurtful character of air in unventilated rooms, as Professor Foster suggests, in the note which he is kind enough to send us, may be partly due to skin respiration as well as to lung respiration; and it is much to be hoped that Dr. Haldane and Dr. Lorraine Smith may be tempted to continue some of their interesting human experiments in order to throw more light upon this matter.

Then we have the indirect evidence, already referred to in the text, which is supplied by the fact that the effects of air vitiated by breathing are in many ways analogous to the effects produced, when sewer air enters a house,—the likeness of effect suggesting likeness of cause; and thus also if we put the two facts together that micro-organisms increase with (1) foul emanations; and (2) with bad ventilation (micro-organisms increasing with increased wall-space in badly ventilated schools, decreasing with increased wall space in well-ventilated schools—Ransome 123—), we have another ground for concluding that bad ventilation = organic emanations; or in other words, that what is expired by the lungs and skin furnish, like other foul emanations, those organic putridities which favour the bacilli; and to these two kinds of evidence we may add the third kind, that what are commonly called the zymotic fevers are favoured

by human exhalations as they are favoured by the air from sewers or other foul places. Carpenter (394) writes impressively: "It is impossible . . . to hesitate for a moment in the conclusion, that the fatality of epidemics is almost invariably in precise proportion to the degree in which an impure atmosphere loaded with putrescent miasmata may afford a nidus wherein a zymotic poison undergoes a marked increase in quantity and intensity, the putrescent exhalations from the lungs and skin of the living subject being at least as effectual in furnishing such a 'nidus,' as are the emanations from fœcal discharges or other decomposing matters, &c." If this line of reasoning is to be rejected, we must then fall back upon the supposition that this favouring of infectious diseases in overcrowded dwellings is due either to slight increase of carbonic acid, or slight decrease of oxygen, or to a general want of cleanliness. Can these explanations be looked upon as sufficient?

So also with the skin: In addition to what is generally stated in the text-books as regards the normal organic emanations from the skin, there is much evidence to shew the high capacity of the skin to take on the most active excreting functions when necessary. A few words first of all as regards the normal function. The sweat, consisting of two kinds, says Professor M. Foster (695) is excreted by two kinds of glands, the sebaceous and the sweat-glands, the sebaceous glands excreting "fats and fatty acids" and as it appears "some form or forms of proteids;" "we have reason to think that the sweat-glands secrete in small quantity some forms of fat and especially volatile fatty acids." Professor M. Foster's words are also significant as regards those cases where any substance like varnish prevents the action of the skin. The symptoms "seem to be due in part to pyrexia or fever possibly caused by the retention within or re-absorption into the blood of some of the constituents of the sweat, or by the products of some abnormal metabolism, [irregular formation of substances in the body], and in part to a dilation of the cutaneous vessels" (skin blood-vessels) —this dilation resulting in great loss of heat, and affording in itself, we think, evidence that it is the retention of poisonous substances which is producing the mischief,—the flow of blood to the surface being the natural remedial effort to get rid of these poisons by the action of the skin as well as to divert them from the internal organs. Carpenter (490) says of perspiration: "The acidity often observed appears to be due to decomposition and to the presence of certain volatile acids, &c." Amongst the constant constituents are fat, urea, and various volatile fatty acids. These are products of excretion, being separated from the blood by the sweat glands and must be distinguished from what simply transudes from any tissue. In disease, albumin, uric acid, biliary colouring matter, and various acids and other substances which have been taken with the food, may be excreted." So Fothergill states (H. 62) that urea is excreted by the skin not only under unhealthy but also under healthy conditions;

that it is found in the sweat of horses; that when the skin is very active a less amount of urea is execreted by the kidneys; and again that arsenic is eliminated by the skin as it is by the kidneys, intestinal canal, &c. (71); so also we have those remarkable instances in which the skin comes to the rescue of other eliminating organs when these are disabled or overtaxed. Thus as regards cases of kidney disease Carpenter writes (494): "Leube in particular has shewn that in certain affections of the kidneys the skin excretes urea phosphoric acid and chlorine in excess," just as we have the converse fact, that when the action of the skin is lost (Fothergill, H. 438) "we have great hyperæmia (excess of blood) of the kidney with increased functional activity." Of the active character of the excreting function of the skin at moments of disease there are many interesting examples. Thus in occasional cases of gout the skin excretes uric acid to so large an extent that "it is covered every morning with what is popularly called 'chalk'" (M. Granville, 41); so Fothergill writes (H. 62, quoting H. Wood): "The skin excretes urea freely during the advanced stages of Bright's disease, . . the urea in renal disease may even form a distinct crystalline powder on the skin . . "; so also we are told that: "The passage of a urinous fluid from the skin has been frequently observed in cases where the renal secretion was scanty; and the critical sweats by which attacks of gout sometimes terminate contain urates and phosphates in such abundance as to form a powdery deposit on the surface. It has lately been ascertained that in warm climates urea is an element of the perspiration of even healthy persons" (Fothergill, H. 57, quoting Carpenter, quoting Landerer); and thus both the kidneys and the skin excrete bile when the blood is overcharged with that substance, just as the gastro-intestinal canal on occasions can relieve the kidneys by excreting a urinous fluid (for other examples see Fothergill, H. 57). We also get examples of great functional activity on the part of the skin in the profuse perspirations which accompany lung disease, and which are said to have a delilitating effect owing to the loss of salts from the blood, but probably also bring great relief; so too we have a "sour perspiration" which with "the skin is bathed" in acute rheumatism (Fothergill, H. 69). Acting upon the knowledge of these facts, we see our doctors constantly turning this function of the skin to the advantage of the patient. When azotised waste (waste containing nitrogen which should have been got rid of by the kidneys) is causing mischief by its presence in the blood stream, it is sought to obtain depuration of the blood by provoking the skin to action (Fothergill, 439). So Beale writes (Liver, 204): "By sweating, excited by heat or medicine, noxious matters that have been accumulating in the blood may be removed . . "; so as regards acute kidney disease, he (U. D., 191) recommends sweating and the hot air bath; so also he writes (116): "When perspiration is suppressed, the bladder sometimes becomes irritable;" so also in the case of one specific poison a hot climate and hot baths are found very helpful

(Fothergill, 493), or in other words an increased excretion of the skin; so in congestion of the liver it is sought to promote the action of the skin (Fothergill, H. 149); so the common connection between taking a chill and upset of the liver and the evil effects of long continued east winds, of which Fothergill gives an interesting example, offer indirect evidence as to the healthy condition of the liver being maintained by the normal excreting action of the skin, after due allowance is made for direct chill of the liver by insufficient clothing; so again in some cases of anæmia, resulting from a defiled blood-stream, "promoting the action of the skin" prepares the way for other remedies (see Fothergill, H. 67); and so also "in bronchitis great relief is experienced when the skin acts freely."* In referring to these examples we admit quite readily that all these facts only supply indirect evidence; but they seem to point clearly enough in the direction that it is to organic emanations,—to that which is excreted and that which transudes from skin and lungs—that we must look for the cause of the hurtful character of the air where persons live in closed places.†

We think that we might add to these considerations the case of certain affections of the skin itself—these affections being "so notoriously associated with imperfect elimination, or, &c." (Fothergill, 73). We find these affections associated with digestive trouble (490), and the presence of "effete products" in the blood, suggesting—at all events to those who are inclined to see in most forms of disease remedial efforts of nature—that in these cases the skin is being used, not without suffering to itself, as a means for eliminating poison. "The skin," writes Fothergill (491), "has much to do with the elimination of these

* It is right to say that Fothergill believes that some part of the relief is to be attributed to the lowering "of the blood-pressure in the arteries" "by the refilling of the cutaneous vessels" as well as to increased functional activity of the skin (Handbook 439) in cases of remedial sweating.

† Other instances might be given, if it were necessary, of the action of both lungs and skin in eliminating noxious substances from the blood. Sir W. Aitken (Animal Alkaloids, p. 32), quotes from Murchison: "It is a common observation that a pungent ammoniacal odour is given off by the skin and lungs in typhus, while the presence of a large quantity of ammonia in the breath admits of actual demonstration;" thus also sulphuretted hydrogen when present in the intestine has been breathed out from the lungs (Animal Alkaloids, 41); thus also—though the instance is less directly in point—Dr. A. Brown, in his most interesting book on *The Animal Alkaloids*, following Gautier, describes (p. 141) the increase and accumulation of those alkaloid poisons (known as leucomaines) in the blood-stream, when liver, skin, or any other of the eliminating organs is at fault. Important as is the office of each of these eliminating organs in getting rid of these natural poisons—poisons which are always being poured into or formed in the blood-stream, and which—though probably not without their own useful office—are always threatening health, unless kept in check, or destroyed, or eliminated, it is interesting to notice that Gautier, in Brown's words, thinks that "their incessant combustion in contact with the oxygen of the blood" is even more important than their elimination,—in other words, if you wish to fight the battle successfully of keeping the blood-stream pure—the one great secret of all health—you must live in good air and feed the blood with the largest and purest supplies of oxygen.

matters (nitrogenised matter in the blood) and it seems probable that many of the skin affections, especially eczema, found under these circumstances, *are the direct consequence of this function of the skin*" (491); and he goes on to point out that reduction in the amount of nitrogen consumed (with taking of alkalies) "at once relieves these skin affections." So also Beale writes (U.D. 6): "An unmistakeable indication of the general disturbance of nutrition, and departure from the normal state of the blood, is often afforded by the presence of eczematous eruption, or of psoriasis in various parts of the body.* We think then that these affections indicate (1) poisonous or improper material in the blood, (2) the effort to get rid of the poison by action of the skin, (3) the poisoning of the skin itself by the excess of this poisonous material with which it cannot deal, (4) the sacrifice of this part of the system in order to avert graver dangers from the internal organs.

And now comes the great question, granted that both lungs and skin are organs with a high excreting capacity,—a capacity that can be almost indefinitely extended, as occasion arises,—granted that there are both normal and abnormal organic emanations from both organs, granted that it is to these organic emanations and not to the inodorous gas, carbonic acid, that we must look for the deadly mischief that arises from rebreathing air that has been already breathed, what can be stated about the organic poison, the "septic ferment" which we must assume to be present? Although modern chemistry seems unable as yet to return any sufficient answer to the question, we find some valuable indications offered to us by way of analogy. Few persons doubt about the evil qualities of sewer gas in a house,—in some cases as regards its direct action upon the human system, in other cases as regards its predisposing influence for certain diseases,—though the chemist as yet can only speak vaguely of the *causa causans*. Dr. Fox writes (313) that "of the chemical composition of organic emanations we know very little. Dr. Odling found that the vapours arising from sewage, were of a carbo-ammoniacal nature, similar to such bodies as methylamine . . . Beyond this point there is nothing but a *terra incognita* as to this very interesting subject." Mr. J. Parry Laws, who has been lately examining sewage and sewage-air for the London County Council, and, apparently, is impressed both with the small quantities of micro-organisms found in the sewer air, and with their harmless character, writes: "Although one is led almost irresistibly to the conclusion that organisms found in sewer air probably do not constitute any source of danger, it is impossible to ignore the evidence, though it be only circumstantial,

* A friend calls attention to the cases of "the absorption of nitrogenous waste products and their elimination by the skin when the kidneys are disabled or overcrowded with waste. Thus, for example, when the substance called skatol appears in what passes from the kidneys, urticaria (nettle-rash) is produced on the skin with toxic symptoms." In the same way one of the writers remembers cases in India where liver trouble was relieved as long as the patient suffered from the skin affection called "prickly heat."

that sewer air in some instances has had some casual relation to zymotic disease. . . . It (sewer air) may contain some highly poisonous chemical substance, possibly of an alkaloidal nature, which, though present in but minute quantities may, nevertheless, produce in conjunction with the large excess of carbonic acid, a profound effect upon the general vitality." As regards all the effects upon the human system of air laden with putrid emanations, it is unnecessary to refer to the large amount of evidence accumulated on the subject. For a special reason, however, we quote one passage. Sir J. Simon writes (II. 457): "The mucus membrane of the intestinal canal seems peculiarly to bear the stress of all accidental putridities which enter the blood,"—and he goes on to point out how diarrhœa is "the universal result" of the septic ferment which has once found its way into the blood. We quote the passage because we believe this diarrhœa of the intestinal canal is the exact analogue of, and so perfectly illustrates, the poisoning of the mucus membrane of the throat, which takes place in a "cold,"—the cold being caused in so similar a manner. In each case the septic ferment is breathed into the blood, is again separated from the blood in the tract that is most suitable for its elimination, causing considerable disturbance and suffering in the tract itself, but relieving the system from grave dangers by its separation from the blood.

The case of malarial air seems to offer another example of a subtle poison that, as yet, cannot be determined. Parkes writes: "The most important organic impurity in the air is malaria,"—and Aitken, quoting this, (vol. I., 420), says "no *poisonous* principle has yet been *chemically* demonstrated in the air of malarial regions. But many other acknowledged disease-poisons are in a similar predicament as to visible proofs of their substantial existence." . . . . . "But, although no one has seen malarious spores, there is evidence of some subtle invisible imponderable element—the product of the decomposition and decay of vegetable matter under certain conditions of heat and moisture";—and again: "whose presence (*i.e.*, of the malarial poison) is solely detected by its action on the human body." He adds: "The human system is the only field for the action of this specific poison"; a statement which, though it would be denied by Professors Crudeli and Klebs, suggests suspicion, in the case of these very subtle poisons, as regards the conclusions drawn from experiments made upon animals. On the subject of malaria, Watson, writing at an earlier date, says (I., 768): "The effluvia . . . . are probably gaseous . . . . But they are imperceptible to any of our senses; of their physical or chemical qualities we really know nothing"; and Dr. W. Maclean (Quain's Dict.) writes: "Chemists have not been able to demonstrate the presence of a malaria—a fever-generating agent—in the air of marshes, any more than they have been able so to do in other places where the same fevers prevail." He then goes on to describe the researches made into the bacillus malaria. On this point Dr. Cornelius Fox

writes (268): "The experimental evidence which at present exists as to the presence of a bacillus malaria (Klebs) in the air of marshes where ague abounds . . . is insufficient and unconvincing."

Into the evidence on the subject afforded by experiments upon animals we have not entered. Whatever is the evidence afforded by these experiments, we think that Drs. Haldane and Lorraine Smith will admit that the facts of daily observation and human experience, the facts of human health and disease, and the reasonings founded upon them, must be satisfactorily dealt with before the new doctrine as regards the harmlessness of organic emanations and the hurtfulness of carbonic acid can be accepted. Until this is done a fortress likely to give much serious trouble is left untaken in their rear. A considerable number of experiments on animals made some time ago [by Gavarret, Hammond, Richardson, Brown-Sequard, Du Bois-Raymond, Friedlander —as regards excess of carbonic acid (30 p. c.) with full supply of oxygen —see Carpenter, 391] to which more modern experiments have to be added, gave results opposed to the new doctrine; and it is a matter of regret to one of our number (A. H.) who has invincible prejudices on this subject, that probably a long series of experiments by many experimenters will now be performed in the effort to adjust the conflicting evidence. Professor Jacob wrote (12): "Some experiments made in Paris a few years ago seemed to shew conclusively that the principal agent was the organic impurity referred to above. Recently, however, these experiments have been repeated, both in Germany and England with negative results, and it seems probable that, as was originally held, the excess of carbonic acid must be credited with the injurious effects noted." Without entering again here upon a subject on which one of our number (A. H.) has explained his own position on p. 18 of the text, it is enough to state that results obtained from experiments upon animals by careful and competent persons have produced results apparently in flat opposition to each other; and it does not seem easy to choose the evidence of one set of experiments and reject the other.*

*NOTE.—A. H. writes: "I cannot, however, help adding that I think that this conflict of evidence should offer a strong inducement to those, who have moral objections to this special method, to make a systematic and well-thought out attempt on their own account to work by other methods of physiological research. I should like to submit to my medical friends, who favour experiments upon animals, whether this instance does not betray a weak side in their method? Grant for a moment that Drs. Haldane and Lorraine Smith are right in their view as regards carbonic acid and organic emanations—what has taken place? Certain experiments on animals were made in the past years, from which it was concluded that the organic emanations were highly poisonous. That conclusion—principally in virtue of these experiments—becomes widely accepted, and finds its place in all the text-books and in the schools of medical teaching. After a certain number of years new experiments are made and—granting for the moment that it is so—a contrary doctrine is established and accepted. Meanwhile just because the conclusion (which was once accepted) rested upon laboratory experiment, it lay outside the criticism and daily observation of many thousands of medical practitioners in all countries. It was to 99

out of 100 practitioners a mere statement of the text-books. It was to them as a dogma which they could only accept, and as regards which no call was made upon their own intelligence and observation. On the contrary had this conclusion rested on facts of health and disease, and on clinical deduction, it would have provoked continual observation and criticism on their part. Does not the question then arise, whether physiological experiment—divorced as it is from ordinary medical practice—is not more of a hindrance than a help to the ordinary medical practitioner? In other words does not the ordinary practioner lose more than he gains by thinking in terms of the laboratory—which lies apart from his experience and observation—instead of thinking in terms of his own daily practice?"

It may be well before concluding to restate the case quite shortly as against Dr. Haldane's view. (1) Dr. Haldane admits an organic excretion; (2) our sense of smell gives evidence of the strong and peculiar nature of this excretion; (3) the physiological probability is strong that any excretion continuously got rid of would be hurtful, if re-introduced into the system, from which it is regularly eliminated; (4) slight increases of carbonic acid and slight decreases of oxygen in the air, and want of personal cleanliness, do not seem sufficient to explain either the immediate or the remote effects of stuffy rooms; (5) the evidence—such as it is—seems to be on the side of the comparative harmlessness of slightly increased carbonic acid in the air, when pure, and unmixed with products of human respiration; (6) the capacity of the skin and the lungs to separate substances from the blood—a capacity which may on occasion be carried to a very high point—offers indirect evidence that both these organs normally exercise some eliminating and purifying action upon the blood; (7) the unascertained nature of such poisons as the malarial poison and the poison of sewage-air offers illustrations of the subtle nature of certain virulent poisons, and the great difficulty in tracing them except by their effects.

Books referred to (with abbreviation used in text) which are not included in former list. The abbreviated form is placed in brackets.

Beale, "The Liver" [L.]; "Urinary Diseases" [U.D.]; Fothergill, "Practitioners Handbook of Treatment" [H.]; "Diseases of Sedentary Life" [S.L.]; Cornelius Fox, "Sanitary Examinations of Water, &c."; Mortimer Granville, "Gout"; Professor Jacob, "Ventilation and Warming"; J. Parry Laws, "Reports on sewer air investigations" (L.C.C.); Louis Parkes, "Hygiene and Public Health"; Sir John Simon, "Public Health Reports."

ADDITION TO GLOSSARY OF TERMS.

Ammonia is a colourless pungent gas resulting from a combination of nitrogen and hydrogen. In the analysis of water the ammonia, which is found, is spoken of (1) as free, and (2) as albumenoid,—the two together making the total ammonia found. Free ammonia is produced on boiling the water with an

alkali* ; and albumenoid ammonia is given off at another stage as the albumen (an organic compound, the presence of which shows pollution of the water) is broken down and decomposed under the action of oxygen. The *free* ammonia does not necessarily shew organ impurity of water, resulting from organic matter. It indicates the presence of salts of ammonia (whatever their origin) not combined with organic matter. These salts may result from previous pollution.

* An alkali neutralises an acid, forming, when combined with it, the neutral substances, called salts.

Eczema: A skin disease. "An eruption of small vesicles [vesicles—small elevations of the outer skin, containing lymph (lymph is an element of the blood, transparent)] usually crowded together."

Infusoria: Minute organisms, most of which can only be seen microscopically. "Most possess a mouth." Most possess cilia or hairs, on the movement of which their own movement depends. "There may be more infusorians in a cup of stagnant water than there are people on the globe." They are not to be confounded with bacteria.

Proteid: Composed of protein. Protein is a compound containing carbon, oxygen, hydrogen, and nitrogen. "Nearly identical with white of egg."

Psoriasis: A skin disease "consisting of patches of rough amorphous (shapeless) scales."

APPENDIX C.

A Fresh Air Society.

As already suggested, we think that those who hate stuffiness and love fresh and pure air might usefully combine in some simple form of association. Such an association (exacting a shilling a year from its members for postage stamps) might meet once a year—in some place with a large airy room and suitable garden accommodation—so as to allow the members to know each other, and to report and consider the best ways of inducing a greater love of fresh air amongst the public ;

The work of the association might be carried on in a more individualistic manner than generally prevails at present in associations ;

The committee would act principally as a central body to receive and impart information ;

A, B, C, D, &c., might then be named as individuals, who would act on their own account and on their own responsibility, receiving subscriptions from all those interested in their special class of work. They would undertake work of the following kinds,—the instances given below being only given as examples :

(1) To communicate with persons responsible for churches, concert-rooms, theatres, public halls, hotels, &c., as regards the means of ventilation provided, and the purifying of the building by the free admission of air during the time that it was not in use ;

(2) Special arrangements with hotel keepers (*a*) for the use of a second coffee room, where a window could be continually open ; (*b*) for taking meals under a sheltered verandah ; (*c*) for carefully exposing the bedding of special bed-rooms to the air, and for regular cleansing from time to time of the bedding in use ;

(3) To induce some of those who are in the habit of entertaining to give dinners, dances, parties, house-concerts, in rooms permitting the free and abundant admission of air, with such adaptations of dress as are found convenient, and with simple efficient arrangements to prevent any person from being hurtfully affected by cold air blowing upon them* ;

Any member of the committee, or of the society, might underwrite the names of persons willing to undertake this kind of work, as expressing their belief in their suitability ; and those persons who contributed towards A or B or C's work would meet together and arrange between themselves and with A, B, or C, as regards the work ;

In all cases A, B, or C, would act on his own responsibility, and not on the responsibility of the Society or of his special group of subscribers, unless it were so specially arranged.

We are afraid that we both of us are too much occupied personally to undertake any part in the direction, but we would receive names of all persons who are generally favourable to the idea of creating a shilling-society for these objects, and the names also of those who would undertake work for the society, and if the names of intending members were sufficient we would call the members together.

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* A good deal of thought and contrivance is necessary on behalf of those chilly people, who, notwithstanding their chilliness, delight in fresh air, and have learnt that their risks of taking cold are much increased in the long run by "shutting up." For all such people it is necessary that they should bring with them a sufficiency of wraps, just as if they intended to take a drive in the open air. Overcoats, caps, and bonnets, may be just as necessary in a fresh-air dining room, or at a fresh-air concert, as in a carriage or in the street. For dancing—both for men and women—the true dress would be the loose easy flannel dress that suits lawn tennis or cricket. The present ballroom dress of men and women is a triumphant success in unreason and unsuitability, on which the most perverse skill in devising the wrong thing could hardly improve.

APPENDIX D.

We feel that we ought not to bring this little tract to a conclusion before insisting once more upon the truth that, important as is the breathing of pure air, it is but one of the factors in preserving a high state of efficient health. The value of pure air consists in its effect in keeping the blood-stream pure; and the purity of the blood-stream depends upon other conditions besides the breathing of pure air. The water which is drunk must be pure, as with impure water there is a constant accumulation of impurities in the blood and in the tissues, which means future trouble of some kind, either infectious or non-infectious. In the same way cleanliness of the person and care as regards dress and bedding are necessary. Where cleanliness in these respects is not observed, the skin does not play its part efficiently in helping to keep the blood pure. Clothes and bedding should be exposed to pure air much more frequently than is usually done. It is a good rule never to wear the same underclothing on two following days, but to let the clothes worn on one day be exposed for some hours to pure air on the next day. Such an arrangement means trouble, since clothes so exposed often require warming at a fire before use. In the same way, all bedding should go out into the sun at certain intervals,—a process easy enough in the country, but requiring special arrangement in towns. If such an arrangement is found impossible, it should be exposed for as many hours as possible to the sun in a room, where the windows are large, and where a large body of air can be made to flow through the room. Again sufficient exercise is necessary, since the movement of the muscles both drives the products of "waste" out of the tissues into the blood-stream, where if the conditions are healthy, they can be got rid of, and also supplies the tissues with the oxygen required for the breaking up of waste into the products that are to be got rid of. In the same way constipation—whenever it exists—must be overcome, not by use of drugs, which are an evil in themselves, and are only serviceable on emergencies, but by those alterations in diet and in habits of life, which each person, after careful reading upon the subject, must slowly discover for themselves by experiment. Constipation is just as certain a means of fouling the blood-stream as either drinking impure water or breathing impure air,—noxious substances being re-absorbed into the blood-stream and slowly poisoning the whole system. So also excess of every kind must be avoided. Excess of eating and drinking means a defiled

blood-stream, because the overworked liver or kidney is no longer able to fulfil its function of purifying the stream, and impurities accumulate whilst the purifying organ itself becomes less and less efficient. Other excesses lower nerve power; and the loss of nerve power results in the accumulation of poisons in the system, since all the eliminating and purifying organs do their work less effectually.

A few last words should be said on the subject of infection. Whatever immunity may exist in special races of animals or men as regards certain diseases, or in special individuals, we hold that, speaking broadly, immunity from infectious disease depends upon the purity of the blood-stream. We have said in an earlier passage that the growth of the germ is in reality an agricultural operation within the individual, and, in this instance, as in all other agricultural operations, the soil must be in a fit state for the growth of the crop introduced. This favourable condition exists whenever the blood or tissues are unduly charged with impurities, whenever the eliminating organs are not working effectually, whenever improper substances, as those contained in impure air or impure water, are being accumulated from any source. The evidence on this point, that infection depends upon the impure state of the blood, seems to us very strong. Without giving in this tract all the heads into which this evidence may be divided, we may call attention to some of them*. (1) The great results attained by simple sanitary improvements, as regards the draining, or cleansing of districts, the replacing of impure water by pure water, the ventilation of buildings, the removal of filth, &c., all of which improvements simply mean that the blood-stream of the individuals ceased to be continuously and necessarily defiled; (2) the greater intensity of disease and its more dangerous forms where the conditions are insanitary, and the individuals are continuously prepared for disease; (3) the dying out of terrible diseases over large tracts as the condition of the people has improved; (4) the evidence that infectious disease often requires a previous unhealthy state in the person attacked,—thus, for example, Dr. Thorne Thorne has pointed out that diphtheria seems to require an unhealthy condition of the part attacked; thus the stomach in a healthy condition resists the cholera bacillus (see page 26); thus some fevers in the East are specially dangerous during times of lowered health; and thus the nurses who attended patients escaped typhus when the wards were well ventilated; (4) the almost certain emergence of infectious disease amongst plants, animals, and men, when the favourable conditions have existed for a certain time, and when at last, by some accident, the stray germ is introduced; (5) the far greater immunity from disease in wild plants and wild animals, as compared with domesticated animals and cultivated plants, owing to the high rates of health after in the wild plants and animals.

We have collected a certain amount of evidence on these and similar points, which we hope later to publish, and we believe that the

*Merely a few examples are given here under some of the heads.

evidence that might be collected is almost unlimited. The present continental tendency to discover anti-toxines for almost every infectious disease seems to us a step wholly in the wrong direction. Immunity from infectious disease is to be secured by a more careful study of the conditions of health, and by greater intelligence and prudence exercised by the individual. Everything in the long run turns upon the intelligence and prudence of the individual. If he will not assist nature to do her work easily and without unnecessary difficulties and exertion in his own person, no protection and no remedies can save him. Indeed the (temporary) banishment of infectious diseases, either by the use of preventive remedies, or by the blocking out of the infectious germs by elaborate contrivances—were it even possible—would be a misfortune and evil for the human race, not an advantage. For this reason. Every infectious disease is a measure of wrong living. By its spread and by its intensity it exactly expresses the amount of our departure from the conditions of health—the amount of the defilement of the blood stream, and of preparation for the growth of the germ. Could we, therefore, for a time suspend the danger of infectious diseases, we should only sink to lower levels of health, and still further encourage ourselves in improper habits of life. The consequence of this false protection and encouragement in unintelligent and unhealthy habits of life would be that, when disease at last came to us, it would come with the destructive violence with which, for example, measles came to the inhabitants of Fiji. But in real truth disease is not to be evaded. The new forms which it is always tending to assume, both among men and animals, assure us that if we block the enemy out at one gate, he will enter at another. New forms of infections constantly disclose themselves; diseases which were comparatively unimportant become active and intense; whilst non-infectious diseases, in the absence of infectious disease, would become far more serious in their character. There is but one true defence, and that is the wise and healthy conduct of life by the individual. The thanks of all intelligent persons are due to Dr. Thorne Thorne, for the war he has so ably waged against the barbaric stupidity of quarantine; and the moral of this war holds good in many directions. No locks and bolts will keep out disease. No preventive measures are of the slightest permanent utility which leave the standard of health unaltered, or which leave the individual free to persevere in unhealthy habits. All disease—whether infectious or not—marks the exact amount of our own aberration, or the aberration of our parents, from the true ways of health; and immunity from disease depends, not upon laboratory dodges, but upon our discovering and conscientiously following, the true practice of health in all matters of everyday household life. Nature insists upon a continual raising of the type, and disease is one of her most efficient instruments towards that end. Of course, things being as they are, all reasonable precautions should be taken to avoid infectious germs; but the safety so obtained is only a precarious and temporary safety.

APPENDIX E.

As regards the protection afforded by the white cells (alluded to on page 26) which have been stated to incorporate into themselves and devour noxious germs, it is now maintained by other observers that these cells exercise their protection by secreting a substance which is unfavorable to the invading germs, and not by actually devouring the germs.

ERRATUM.

On p. 18 (Note), instead of "assigning a bacterial origin to cancer," read "assigning a microbe origin," &c.

On p. 59, instead of "Appendixa," read "Appendix A."

On p. 88, last line, for "produced" read "liberated."

THE FREE LIFE:

ORGAN OF VOLUNTARY TAXATION AND OF THE VOLUNTARY STATE.

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"*The widest possible liberty, only limited by the equal liberty of all*":—
HERBERT SPENCER.

"*Over his own body and mind the individual is sovereign*":—J. S. MILL.

THE FREE LIFE believes that no real progress of any kind can be made until we frankly recognise the great body of truths which are expressed in the word SELF-OWNERSHIP.

We must recognise that every individual is the true owner of his own faculties, bodily and mental, and of all property acquired (without force or fraud in his dealings with others) by means of his faculties,—individual ownership of property being the necessary complement of individual ownership of faculties, and resting on the same moral basis;

That the only rightful use of force in the world is to protect this self-ownership against force; * in other words to guarantee the person and property of all against violence and certain forms of fraud; in other words again, to restrain the murderer, the thief, the swindler, and so to preserve everywhere an open and free field for the employment by each of his faculties in such manner and for such purposes as he chooses;

That the one limit to the employment of faculties is the force-and-fraud-limit, since force and fraud, employed by A and B, are the negation of self-ownership as regards C and D;

That the consent of each individual as regards the use of his faculties, or the employment of his property, is the foundation on which all morality depends,—apart from which foundation morality is resolved into the shifting will of a casual majority;

* There must be included certain coarse forms of fraud, which are the equivalent of force, since some forms of fraud set aside the consent of the individual concerned in the same manner as force itself sets it aside. The force to be restrained is not the force of the more skilful, or the more industrious, or the more wealthy, it is not the force of circumstances, which favour some individuals more than others, but simply and exclusively the force, of either the bludgeon or the law, which sets aside the consent of another as regards his own actions or his own property.

That this consent of the individual as regards himself, his actions, and his property, is the most sacred thing in the world, and can never be set aside on the plea of any alleged public safety, or any alleged public interest; that force can never be rightly employed to advance the opinions or the interests of any section, however important such opinions and such interests may be; that it never can be rightfully employed as the instrument of any section to better their condition in life;

That force cannot be rightly employed to fight any moral evils, to make men sober, to regulate sexual relations, to compel children to be educated, to regulate the conditions of labour, to prevent any men working on such terms as they themselves choose, or to compel one section to accept and to serve the opinions and interests of another section;

That all compulsory takings of property, under the name of taxes, from the individual, all compulsory services placed upon the indivldual, all barriers and restraints to trade, all legal gates placed in front of professions and occupations, all creation of vested interests, or privileges, or monopolies, by means of law, all tariffs and custom duties, all forcible interferences with the faculties, habits, and lives of individuals, are wrongful acts on the part of the State, without any moral foundation, and with no title of right for their enforcement, except that the State is in mere brute strength stronger than the individual;

That free trade, free acquisition of property in the open market, free contract, free life, are supreme and inviolable moral rights of the individual, which cannot be taken from him by any body of persons, whether calling themselves by the name of the State, or by any other name;

That whatever rights the State possesses of using force are simply rights first possessed by the individual, and then delegated by the individual to the State; and, therefore, State-rights of using force can never exceed those rights of using force possessed by the individual as an individual;

That it is absurd to suppose that individuals, as individuals, possess any rights of using force except the one right to resist force, if necessary, by force, since in such case, instead of all men being self-owners, some would be owners of others, and possessed of a moral right to do as they chose with the lives and the property of these others;

That if the individual may not use force, except to repel force, then clearly the State cannot do so; that as the State is the creation and instrument of the individual, and consists simply of a collection of individuals, its rights must always be in subordination to the rights of the individual; that it is a hopeless confusion of thought to suppose that the rights of the State can ever transcend or exceed the rights of the individuals by whom it is created, and for whom it exists;

That the rule of the majority is only an artificial arrangement, suitable in one set of circumstances, and not in another; that it can only deal with such things as fall rightfully under its dominion,—for example, with such things as are voluntarily submitted to it by those who make up both the majority and the minority; that it is a mere superstition to suppose that a majority, as such, possesses any rights over the faculties or property of a minority, unless the minority, individual by individual, consents to place their faculties and property at the disposal of the majority;

That numbers can not give rights or take away rights ; that if the whole world be placed on one side, and a single individual on the other, there is no moral power on the part of the whole world, minus one, to take from this one any part of his self-ownership ;

That where differences of opinion exist between majorities and minorities, each should take their own way, without any use of compulsion and without any compulsory use of the resources of each other ;

That this or that scheme of state-socialism may grow for the moment, until men learn to see the uselessness of all reforms founded on force, but it cannot endure ; that just because every state-socialistic scheme is founded on the denial of human rights, and on the usurpation of authority by some over others, it must sooner or later be broken to pieces on the unalterable rock of individual rights.

The Voluntary State is the expression of these supreme individual rights. The Voluntary State will rest on a voluntary basis, in the sense that it will compel no one to join it, or to subscribe to it, or to do service for it. It will depend entirely on voluntary payments and voluntary services. It will be the depository of compulsion or force for the purpose, as already shewn, of restraining the use of force or fraud in the dealings of men with each other, of keeping the field open for the employment of the faculties of all within that one limit. It will use force, not for the fanciful purposes of this or that section of politicians, but simply and solely to restrain the use of force. As a voluntary institution it may have a great career of usefulness. For many years, until voluntary effort finds a stronger development and assumes the many different competing forms which await it in the future, the Voluntary State may continue to be a powerful popular agent in matters of education, sanitation, inspection of factories, workshops, buildings, and other matters affecting the welfare of the people. But it will simply play the part of friend and adviser ; it will use no compulsion, it will usurp no authority, it will act with the concurrence of those concerned. It will be a conciliating and remedial agent, not an oppressor and a begetter of strife. The mad attempt to drive and regulate and persecute by means of rival political factions and clumsy uncontrolled public departments being abandoned, we shall become far more really interested than we have ever yet been in the welfare of each other, and far more disposed to co-operate together ; while the moral forces of discussion, sympathy, and example, will acquire much more influence, as our hatred of coercion increases. We shall not gladden and exalt the politician by spending our time quarrelling and struggling for power ; we shall not be rushing from one form of property-holding into another, living in perpetual confusion and uncertainty as to what each day may bring forth ; we shall not have any reason for hating and fearing the domination of some rival section over ourselves ; we shall not see from year to year enormous burdens silently growing, whilst in exchange services of very doubtful value are conferred upon us, about which we are allowed no individual choice ; but we shall all be living face to face with the reality of things, knowing exactly how best to employ our faculties for our own advantage or for the help of others, and knowing the exact conditions under which our labour is to be applied. The free market, free enterprise, free acquisition of property, free contract, free conditions of life and labour,—these are things which we can all understand, and reckon with accordingly ; but no man knows or can reckon with

what the socialistic state, or semi-socialistic, or demi-semi-socialistic state may have to offer him. It is all hidden in the region of uncertainty and arbitrariness; it defies calculation and precision; it depends upon the blind struggles of parties with their varying success; it is independent of growth and evolution. A rush of vague expectations may create state socialism to-day; a rush of disappointments may sweep it out of existence to-morrow. From the point of view of material prosperity, what the human race requires is stability and certainty as regards the general conditions under which it is to apply its labour, and as regards the ownership of the produce resulting from its labour,—not abrupt changes, affecting labour and property, made by those who have got hold for a moment of an all powerful central machine, and are ambitious of remodelling the world according to very crude and hastily formed ideas. Only by respecting rights, only by refusing the temptation to create fancy social states by force, can there be peaceful growth and development, and peaceful growth and development are the only road to better things. The Socialist may go on grinding out artificial states of society till the end of time by means of his central machine, but his only service to society will be to demonstrate the uselessness of his force-systems. He cannot alter the laws of our existence. Men, deprived of their own judgment and volition by an external authority, are worthless for all great purposes. No civilization of a high order can be built up from compelled units, but only from free units. There is no system possible for human beings, touched with the real instinct of progress, but Voluntaryism,—freedom to pursue every path, except the one path of aggression by force or fraud on others; freedom limited only by freedom; force employed for no purpose whatever except to rule out force and fraud, as inadmissible elements in the open field of men's dealings with each other.