[On foul air and lung disease : a lecture] / by Arthur Ransome.

ON FOUL AIR AND LUNG DISEASE.

A LECTURE

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I AM here to-night to deliver the introductory lecture of a course on health, that will be given this winter in the various parts of Manchester and Salford; and I have selected as my subject "Foul Air and Lung Disease;" for, indeed, few will dispute the importance of this topic.

The Table I. (see Appendix), that has been kindly prepared for me by Mr. Scott, shows that three quarters of a million of people died, during ten years, of diseases of the lungs, not consumption, and half a million of this last disease alone.

In Manchester and Salford, the deaths from diseases of the respiratory organs averaged over 2,000 in a year, and those from consumption more than 1,200

That a large proportion of those deaths are preventable, is shown by Table II. (see Appendix), which Mr. Baxendell has drawn up from those of the Registrar-General, and which he kindly permits me to use.

From this table it appears that during the five years 1869-73, the average death-rate from diseases of the respiratory organs was 2·27 in Westmorland (one of the healthiest counties in England), and 2·51 in North Wales. For the whole of England and Wales it was 3·54; for Salford, 5·12; and for the registration district of Manchester, 6·10. Taking, however, the township of Manchester alone it appears that in 1874, the last for which returns have been

published by the Registrar-General, the death-rate from these diseases amounted to 7·7, or three times the average of healthy districts, and more than double the general average for town and country districts—healthy and unhealthy. If, therefore, the rate could be reduced to the average for all England there would be an annual saving in the township of more than 700 lives.

Many of the deaths here recorded, as due to diseases of the respiratory organs, are doubtless those of young infants and old people, killed during the winter months by the effects of cold, and it is remarkable how closely the wave of sickness from this cause follows the fall of temperature.

Many of the deaths are, however, simply due to the cause indicated by the title of this paper, namely, to the various forms of "foul air."

Let us, then, proceed to the study of the connection that exists between them, and first let us consider what is included under the term "foul air."

It was well said by Dr. Lyon Playfair in his address on "Health" at the Social Science Congress at Glasgow in 1874, that "a great part of sanitary science can be comprised in one word, *cleanliness*;" that the substance of all our sanitary science accumulated by ages may be summed up in the pregnant advice of the prophet, "Wash and be clean;" and doubtless if we exclude from the province of the lawgiver all matters of domestic and personal hygiene, this one word, in its many bearings, would include nearly all that concerns public authorities, and much that we have to do with in private life.

But if ever cleanliness is essential to health, it must certainly be needed in the air we breathe. Dr. Angus Smith, in his work on "Air and Rain," reminds us that we take into our bodies by means of our lungs the enormous quantity of from 1,000 to 2,000 gallons of air daily—a very minute proportion of impurity, or of change in this air may therefore be of vast importance to us in the course of a day or of a week.

In what, then, does the foulness of bad air consist, and how may it be cleansed away?

The late Lord Palmerston once pithily defined "dirt" as "matter in the wrong place," and much of the impurity existing in foul air is certainly foreign to it, and comes from without. But it is important that we should know that air may also become unwholesome simply by alterations in the proportions of some of its ordinary ingredients.

Air is usually said to be composed of four leading constituents. It is a mixture of three gases—oxygen, nitrogen, and carbonic acid, and of the vapour of water.

In what is called pure air, the gaseous materials are found in the proportions found in the diagram, namely = 79 parts by volume of nitrogen to 21 parts of oxygen, and 4 parts in 10,000 of carbonic acid. The nitrogen of this mixture seems to play the humble but still important part of dilution. Somewhat in the same way that water is used to diminish the potency of ardent spirits.

Dr. Smith has shown that you can generally only find differences in the second decimal place in the proportional quantity of oxygen, but he is inclined to regard even these so-called minute differences as having an important influence upon health. It is, however, chiefly in relation to the quantity of the third gas I have named that these variations are important. If the oxygen diminishes and gives place to carbonic acid, then it is that we usually find evidence of closeness or foulness in the air we breathe. Carbonic acid gas is, in fact, the same deadly vapour that is given off when charcoal is burnt in a close room. It is the choke-damp of the miner, and is the gas that collects in old pits and wells, and that pours out into the Grotto del Cane, near Naples. Any human being or animal entering into these reservoirs of the gas is as surely suffocated as if he were immersed in water. It is in truth a poisonous compound, and only very small proportions of it in the air can be breathed without injury to health.

We need not not now consider the proportions in which the aqueous vapour exists in the air, although it also has a definite influence upon health, and specific effects are produced either by too dry or too humid a climate.

But there are yet many other things that are naturally present in the air, and that can only be called impurities when their amount extends beyond a certain very small proportion.

Robert Boyle, one of England's greatest philosophers, termed the atmosphere, "The most heterogeneous body in nature." It is the grand reservoir into which are poured all the vapours, all the gases that arise from the face of the earth, from city, town, or country. There is scarcely any emanation from the globe that is not ultimately carried into this "catholic receptacle."*

There is a constant interchange going on between the earth and its invisible envelope.

*Ut terra tota ex aëre cadentia recipit omnia, ita rursum aër de terra universa accipit.—BOERHAAVE.

The result of all this is that the air is necessarily charged with many adventitious substances; and yet owing to the vastness of its extent, and its power of diffusing gases and vapours throughout its area, and also owing, as we shall presently see, to its power of altering the nature of what is poured into it, it really has a most wonderful uniformity of composition. Many of the substances that pass into it are to be found only in very minute quantities even in the immediate neighbourhood of their source; and, on the other hand, the air collected in mid-ocean or over the unsullied snows of Mont Blanc can be shown, by the delicate processes of modern chemistry, to contain traces of these substances.

The air is, in fact, in great measure self-purifying. In the great laboratory of the sky, chemical and electrical operations are constantly going on on the grandest scale; the heated air rises, cooler currents rush in to supply its place; breezes, winds, and storms arise and act as agents that move on any gases and vapours or any product of putrefaction, and mix them up in the vast depths of the aerial sea, and there they are not only diluted, but converted into harmless substances. We know but little of "the balancings of the clouds," but we may be sure that within their recesses all organic matter and impurity is burnt up as certainly as if it had passed through a furnace; the oxygen of the air, intensified in its power by electricity, fastens upon it and changes it into the ultimate products of combustion—carbonic acid, aqueous vapour, ammonia, or nitric acid. Even without wind, any excess of gas is immediately removed by means of what was called by our great townsman, Dr. Dalton, "the diffusion of gases." Simply stated, this means that any gas can pass into the interstices between the particles of another gas, and thus mix itself up with it as readily as if it were passing into empty space.

Then, again, when the condensed vapour of which the clouds are composed is precipitated in the form of rain, it washes down some of these altered products, and prevents any excess from remaining there.

It has been calculated that 90,000 cubic miles of rain fall upon the face of the globe in the course of a year, and that it washes down in this time no less than $1\frac{1}{2}$ millions of tons of ammonia. When we remember the great value of this substance to the farmer, and how that it is the chief part of his richest manures, we see at once both what a tremendous system of scavenging is being carried on, and what an invaluable assistance the product is to the growth of food for mankind.

How, then, does it come to pass that there is such a thing as foul air at all? To account for this it will be necessary to look a little more closely into the sources from which impurity may arise; they may be grouped for the most part under three chief heads:—

1. Trades and manufactures.
2. Putrefaction.
3. Respiration.

With regard to the first of these groups, we have surely sufficient evidence in this smoky city of the extent to which they may pollute the air. And, without going into the controversy as to the direct effects of smoke upon the health, I may point to the indirect evils that it produces—the dirt that it fosters in our houses, the impossibility of opening our windows without letting in fine particles of soot, the consequent migration of all those who can afford to live out of town, and the sad abandonment of those who are obliged to remain, the loss of much that would benefit both poor and rich, if they could live side by side as they used to do, the failure of common effort to ameliorate the condition of the poor, and the decadence of the public spirit amongst our citizens. These are heavy prices to pay even for the material prosperity that has come to us; and they are the more to be deplored since it has been proved that smoke is no necessary concomitant of that prosperity.

If the outer air is thus polluted, the workshops and factories in which so many gain their daily bread, are likely to be still more heavily charged with impurities. At one time undoubtedly this was the case, as it has been shown by Dr. Greenhow, in his report to the Privy Council, and more recently by Dr. B. W. Richardson, in his lectures before the Society of Arts, that very grievous evils result from the breathing of air laden with fine particles of dust of various kinds.

Dr. Greenhow, in his inquiry into the causes of lung disease, mentions amongst those who suffer most from this cause the grinders of Sheffield and Birmingham, the brass-workers of these towns and Wolverhampton, the tinmen and enamellers of hard-ware and button-makers of Birmingham, and the card-room and cotton and weaving operatives of Nottingham and other places.

Fine particles in the air, especially if they are sharp and irritating, do mischief in several ways. When dust is breathed by a healthy person, there is always an effort made by nature to prevent it from settling in the lungs. First, when it touches the opening

of the windpipe, it causes an irritation there, and a message is at once sent, by the telegraphic apparatus of the nerves, that an intruder is trying to make his way in, the head office signals the breathing muscles to act, and immediately they contract spasmodically, and an uncontrolable cough is the result. If this fails at once to get rid of the offending particle, at the same time that the cough is ordered, certain little glands that are placed around the entrance entrance to the air-passages are made to pour out a quantity of mucus or phlegm, that envelopes the little speck of dust, and prevents it any more from touching the tender membrane upon which it at first fell. Just as a particle of coal or dust getting into the eye causes the tears to pour forth and wash it away, so an irritant at the opening of the windpipe brings a flood of glairy fluid which both covers up the particle and carries it into a position from which a further act of coughing will expel it.

If the dust should have been carried a little deeper into the air-tubes, a still further provision is made to convey it away before it has done harm, and this is accomplished by a very beautiful arrangement. Throughout the whole of the air-passages the lining skin—the mucous membrane, as it is called—is provided with myriads of most minute and delicate little hairs, called "cilia," less than a thousandth of an inch in length; these hairs are continually in movement, waving "like a field of corn bending before the wind," and then rising into the erect position, and as they always tend into one direction, namely, towards the mouth, they gradually carry any secretion, and whatever it may hold within its grasp, steadily and surely out of the lungs, and into the safer track leading to the stomach. If the particle is larger or more irritating than usual, directly it gets to the top of the windpipe another cough is ordered, and the morsel is expelled forcibly along with expectoration, and is ejected by hawking and spitting. This is the exquisitely beautiful mechanism that naturally guards the delicate lungs from harm.

In this town many of us have, doubtless, had opportunities of noticing the fact that after breathing in smoky air for a time, especially during the presence of a fog, the phlegm that is brought up sometimes the next morning is of a dark, almost black colour. This is owing to the presence of fine particles of soot or coal-dust, which, if suffered to remain, might have caused inflammation or other damage to the lungs.

For this arrangement does not always work. It is a law of nature, a law of both the moral and the material world, that when

a warning is frequently repeated and disregarded, the sensibilities get deadened, and the safeguards so mercifully provided are no longer to be relied upon. To a certain extent this is well, for it permits men to adapt themselves to circumstances in which otherwise they would be unable to live at all; but, in the case now before us, the results are often very disastrous.

For consider what takes place when, after many efforts of coughing and spitting, the nerves and muscles we have seen working so benevolently at length lose their power, or become no longer disposed to exercise it. The irritating particle lodges for a time upon the delicate membrane, and causes it to inflame in the same way that a speck of some foreign body in the eye causes it to become inflamed and shot with blood. If it is not removed, the membrane swells, becomes reddened and heated, and presently it pours out more and more of its secretion; but now it is no longer healthy mucus, but an altered thickish fluid, that has to be brought up by many acts of coughing. If the irritation is still kept up by inhalation of fresh particles of dust, the condition remains a constant one, and the workman becomes subject to what is called chronic bronchitis, a slow, lingering form of inflammation of the lining skin of the air-tubes; the cough often overstrains the minute little air-cells, and they lose their elasticity and cannot empty themselves. The patient begins to pant and wheeze at his work, and gets what is called potters' or grinders' asthma.

But in other cases the evil does not stop at the lining membrane of the lungs, the inflammatory agency penetrates more deeply, the blood-vessels are altered in their size and in their power of passing on the blood, the hard-worked tissues of the lungs are imperfectly nourished, dense tough material takes the place of the soft spongy texture found in health, and then a condition hardly to be distinguished from consumption is planted upon the lungs. And it runs a very similar course to that most trying malady, gradually ruining the structure of the breathing apparatus, and leading to a painful lingering death. These are only too true pictures of what is now taking place in many thousands of cases throughout the manufacturing districts of England.

Many useful lives are shortened through this cause. A fork-grinder once said to Dr. J. G. Hall, of Sheffield, "I shall be thirty-six next month, and you know that is getting an old man at our trade." Another, a young man of about twenty-six years, said "he reckoned in about two more years at his trade he might begin to think of dropping off the perch," adding, "you know a knife-

grinder is an old cock at thirty," and at that time, in the year 1865, many of them died miserably before the age of thirty.

Happily, in the last few years, means have been applied to diminish the evils arising from this kind of work. It is to the honour of British manufactures that they have always been ready to adopt means of saving life. At the late exhibition of life-saving apparatus at Brussels, Englishmen took the largest number of prizes, and a few years ago, when Mons. Freycinet was commissioned by the French Government to inquire into the best means of diminishing the evils of unwholesome trades, it was in England that he found the greatest advance in this direction had been made.

I wish I could say that the workpeople are equally willing to avail themselves of these appliances. One of the best of them is the fan that blows away the dust from the mouth of the workman, and carries it out of the room; but Dr. Hall says that in Sheffield in 1865, he found "hull after hull (as the workshops are called) in which scissor, razor, and fork-grinders were working without fans" —the men would not use them. One scissor-grinder, who had found the advantage of the fan, and always used one, once offered to five others, who worked in the same "hull" with him, to put up a fan at his own cost, and to take the price of it from each by instalments of one shilling a week, but they one and all refused his kind offer.

Dr. Hall was often told by dry grinders that "the trade was full enough as it was, and if the men lived much longer it would be so full there would be no getting a living in it."

The fine cotton-flue found in the air of some of the Manchester mills probably contributes somewhat to the large mortality from lung disease in this district, but this dust is not so irritating and directly noxious as some of the other dusts that have been mentioned; moreover the cotton factories are for the most part fairly well ventilated. It is perhaps owing to these facts that the factory operatives are not especially liable to lung disease. In the year 1866, Mr. Royston and I made a special inquiry into the causes of death recorded in the district of Ancoats, and grouped the deaths from lung disease between the ages of twenty and sixty, under the three heads of factory workers, other labourers, and small shopkeepers and masters; we found that the average rate for five years (1860 to 1865) was for the factory workers 61 per cent., other labourers 60, and the small shopkeepers and other masters 55 per cent., and we came to the conclusion "that although these

affections may be partly due to mechanical irritation from cotton-flue and other substances arising from the work, they are still more frequently produced by the subtle diffusion of smoke in the atmosphere, and the general vitiation of the air by noxious vapours and gases."

We shall see presently that there are other still more important influences at work amongst us.

We pass now to the second sourse of foulness of the air, *putrefaction.*

It would be foreign to our purpose now to go into the intimate nature of the processes known as putrefaction or putrid fermentation. It may suffice to state that the result of them is to discharge into the air various gases and vapours, which hold in suspension a substance never naturally present in air, namely, "organic matter."

This material is indeed so foreign to air, that if it is well mixed up with it, the air generally destroys it, burns it up, and turns it into inorganic gases, and it does this with especial rapidity when the air contains that intensely active form of oxygen known by the name of ozone.

But it is not always easy to mix it up with the air. It is a very complex thing, made up of particles from all kinds of decomposing matter, sometimes even containing minute living organisms, the seeds of disease. And it unfortunately differs from vapours and gases, in the one very important point of not being able like them to diffuse itself through the air. It is not sufficient, as in the case of gas, to make a hole for it to get out of. It has to be swept away by the winds before the air can do its beneficial work upon it.

In one of Dr. Farr's letters to the Registrar-General, published in one of his Reports, he well describes this substance:—

"Every population," he says, "throws off insensibly an atmosphere of organic matter, excessively rare in country and town, but less rare in dense than in open districts, and this atmosphere hangs over cities like a light cloud, slowly spreading, driven about, falling, dispersed by the winds, washed down by showers. It is not *vitalis halitus* (Pliny) except by origin, but matter which has lived, and is dead."

"The exhalations from sewers, churchyards, vaults, &c., commingle in this atmosphere, and . . . accumulate, and the density of the poison is sufficient to impress its destructive action on the living, to receive and impart the processes of zymotic principles, to

connect as by a subtle, sickly, deadly medium, the people agglomerated in narrow streets and courts, down which no wind blows, and upon which the sun seldom shines." He adds, "It is to this cause that the high mortality of towns is due."

It is not easy directly to connect this product of putrefaction with lung disease, since the mortality from all causes is increased by it. Fevers and nervous disorders and infant mortality also increase in proportion to the density of the population.

There can, however, be little doubt that the weakness of constitution in which consumption often originates, is fostered by breathing an atmosphere charged with emanations such as we have described. Many years ago, Dr. Noble, now the President of this Association, spoke of a "tainted atmosphere" as "one among the many causes that depress vitality, that lower the tone alike of the muscular, nervous, and assimilitave energies, productive more specifically of scrofulous than of febrile maladies."

More recently Mr. Simon, lately the medical officer to the Privy Council, remarks, in regard to filth diseases, that the common co-called "septic" ferment, the product of putrefaction, which in its stronger action quickly destroys life by blood-poisoning, can in slighter actions start in the body slowly-advancing processes, which will end in general "tubercular" or consumptive disease.

Until within the last few years there existed in Manchester an enormous area composed of open middens and ashpits, the "Lancashire system," as it was termed in dishonour. From this wide area the reeking products of putrefaction were being continually exhaled close to the doors and windows of the poorer population. Great must have been the evil produced by it, and it is probable that, owing to the hereditary character of tubercular disease, we are still feeling its effects in the evident deterioration of the now rising generation.

But, to the honour of the Corporation of Manchester be it said, this source of danger is now rapidly being done away with. A new and comparatively innocuous mode of dealing with refuse has been adopted.

I am informed that over 20,000 (about one-half) of these old abominations have already been done away with, and that the remainder are in process of reconstruction at the rate of 200 every week.

We come now to the third, and perhaps the most important of the sources of the pollution of air, namely, *respiration*. It is at once the most inevitable of evils, and perhaps the most easily

remedied. No man can help spoiling the air he breathes, but owing to the bounteous provisions of nature, there are few who cannot get fresh supplies of tolerably good air to take its place.

But let us see what changes air undergoes by being breathed.

In every 100 parts of the air that we take into our lungs, there are, as we have seen, twenty-one parts of oxygen, but when it returns from the chest it contains only thirteen parts, the other eight parts have been removed from the air by the little blood corpuscles floating in the current of the blood rushing through the lungs.

But expired air is not only deficient in oxygen, it contains a much larger quantity of the choke-damp, or poisonous carbonic acid than it did on entering; instead of only three or four parts in 10,000, it now holds nearly 500 parts in 10,000.

The oxygen previously inspired has met with a quantity of fuel in the tissues of the body and in the blood, has burnt it up, and has produced this large quantity of charcoal vapour.

One pair of lungs pours out into the air in this way, in twenty-four hours, about as much carbonic acid gas as would be formed by burning eight ounces of pure charcoal, and at every breath a full-grown man thus alters rather more than a gallon every minute by his respiration, but he really spoils nearly one hundred times the quantity he breathes, for air that contains six parts of CO_2 in in the 10,000 has been found to be unfit for further breathing. And there is yet a third way in which breathing changes air. It becomes loaded with a larger quantity of watery vapour, and this vapour contains a certain amount of putrefying animal matter. If the vapour of the breath be condensed into a liquid, as may easily be done by exposing it to a cold temperature, it may be examined by chemical processes, or by the microscope. This I have frequently done, and have estimated the quantity and kind of organic matter given off, both in health and in disease. It would be sufficient, however, to prove to anyone the nature of this product of respiration, to keep it for a day or two in a warm place, and it soon gives off a putrid smell.

It will also at once change the colour of a solution of permanganate of potash, the basis of Condy's fluid. The disagreeable odour of close air, which has been charged with impurities from the breath, is due to the accumulation of this exhalation. It is also the chief cause of the noxious nature of respired air, and will kill without any other ingredient being present. An American physician, Dr. Hammond, once kept a mouse under a bell-glass,

took care that it was supplied with plenty of oxygen, and removed the carbonic acid and watery vapour; but allowed the organic matter to remain; the mouse died in 45 minutes.

How rapidly fatal air containing all the products of respiration is, was terribly proved by the cases of the Black-hole at Calcutta, the prison in which 300 Austrian prisoners were put after the battle of Austerlitz (260 dying from it very rapidly) and by the case of the steamer *Londonderry*.

But air vitiated by respiration produces much greater havoc than this every day, in nearly all our large towns.

It is beginning to be acknowledged that it is the great cause of that fearful disease, the true tubercular consumption, from which so many thousands die every year.

It will be worth our while to examine the evidence upon which this conclusion rests.

Some of you will, no doubt, have heard this disease, "phthisis," or "a wasting," as it is called, ascribed to several other causes—to an hereditary taint handed down from parent to offspring, to our changeable English climate, to the elevation of the site of dwellings above the level of the sea, to a damp impervious soil, to imperfect nourishment, especially the absence of a sufficient store of fat in the organism. Doubtless these are all important factors in the process that ends in consumption; but except hereditary predisposition they will seldom any of them act alone, unassisted by the influence of organic impurities—impurities either retained in the system by imperfect work of excretion, or introduced from without, mostly in the form of air rendered foul by breathing.

1. The first group of facts that strikes us with regard to the distribution of consumption, is the one already noted when speaking of the influence of putrefaction, namely, the rapid increase of prevalence of this disease with increased density of the population. In proportion as larger and larger numbers of persons are attracted to a certain limited area of ground, in that proportion, *cæteris paribus*, does the mortality from consumption increase.

It is true that we have along with this condition a combination of most, if not all, of the other circumstances unfavourable to health—poverty, insufficient food, low site and often damp ill-constructed dwellings; and we might with equal right select any one of these things as the true cause of the disease, but for the strong fact that all these things exist, in still greater intensity, in some country districts of England, or in the poorer villages of

Scotland, along with a very low rate of mortality from consumption.

2. There is another way in which you may observe the influence of occupations in this regard. If you look at the map of the distribution of consumption in England prepared by Mr. Alfred Haviland, you will at once be struck by the deepening of colour that shows intensity of the disease in the great industrial centres of the country. We have already seen the evil effects of the dusty particles thrown off in the course of trades and manufactures, but this is by no means the only influence that is at work. It is not only dust that is found in the air breathed in the workshop, but also the products of the respiration of the workpeople themselves. And Dr. Greenhow, in his statistical inquiry into the special causes of consumption, found that it prevailed not only in consequence of dusty work, but in proportion as the people were attracted to indoor occupations, and to the degree of closeness and bad ventilation of the places in which they worked.

3. The influence, both of occupation and foul air, may be seen in the contrast between the male and female rates of mortality from consumption in different districts. In some parts of England the men are the chief workers at indoor employments—as in Sheffield and Birmingham; there you find the male rate the highest; in others, as at Nottingham, Huddersfield, and Macclesfield, the women are most employed, and consequently they die most numerously of consumption; and in places like Liverpool and Manchester, and Stockport, where there is little difference in the employment of men and women, there is also little difference in the rates of mortality from consumption; both are high.

But the most striking testimony is from the relative death-rate in the two sexes of country places, such as Market Drayton, Bakewell, Nuneaton, Camelford, and Pickering. Here, where the men are constantly out of doors, their consumption rate is uniformly low, while the women, who keep the house, die at a constantly higher rate of this disease.

4. We may take an entirely different mode of proof, and show that where there is plenty of fresh air there is little consumption, even though all the other surroundings are, in a sanitary point of view, almost as bad as they can be.

It has been found, for instance, that the inhabitants of Iceland and the Western Hebrides enjoy a singular immunity from tubercular disease. Dr. Morgan has made a special study of the "Non-prevalence of Phthisis in Hebrides and along the North-western

Coast of Scotland," (*British and Foreign Medico-Chirurgical Review*, 1860, vol. xxvi., p. 483) and he could not ascribe it to any peculiarity in climate, diet, race or employment. It is extremely prevalent in other parts of Scotland, and the mode of living is, in many respects, "unsanitary" to a degree; but, on the other hand, the dwellings in which the people live permit, nay, necessitate, the constant indraught of pure fresh air, and the not less incessant expulsion of the foul products of respiration.

The crofter's hut, Dr. Morgan says, "is built entirely of rough unhewn stones, no mortar of any kind being used;" the walls are thus more or less pervious to the air, and the doors are rarely closed. In the centre of the living place, on a kind of raised hearth, a peat fire is kept constantly burning, and the smoke finds a vent through an aperture in the roof of about 18 inches diameter. "There is thus, if not an altogether perfect, at least a very efficient system of ventilation, and from the fire being in the middle of the apartment the different currents of air seem to meet and neutralise each other, so as to prevent excessive draught."

Dr. Morgan ascribes some influence, also, to the antiseptic properties of the peat smoke, which he finds to have very different effects upon the chest than ordinary coal smoke. In any case the result is an extraordinary freedom from the worst form of lung disease.

5. But probably the best evidence that is forthcoming to determine the question of the causation of consumption is to be found in the records of the mortality from this disease in the British army and navy; and a similar history could be told of most of the European forces.

These men are for the most part picked lives; healthy and sound when enlisted; they have very different duties, and a varied diet; they are well clothed and are carefully looked after by well-educated official medical attendants, and yet at one time their rate of dying from consumption was uniformly high in the most varied stations and in the most beautiful climates of the world. In Gibraltar, Malta, Ionia, Jamaica, Trinidad, Bermuda—but one condition was common to all these different places, namely, the faulty ventilation of barracks or of ships, and the consequently vitiated atmosphere which the men had to breathe.

The Sanitary Commissioners for the army reported in the year 1858 that the Royal Foot Guards died at the rate of 20·4 per 1,000 whilst a similar number of civilians showed less than 12 deaths per annum, and the number of deaths from lung disease in the former was 12·5 to 5·8 of the latter.

They pointed out that in civil life, insufficient clothing, insufficient and unwholesome food, sedentary and unwholesome occupations, and the vitiated atmosphere of unhealthy dwellings, all contribute to the propagation of this class of diseases. But in the army it cannot be alleged that the clothing, the food, or the nature of the occupation in itself, are of a character which would justify the imputation that they are among the predisposing causes of the excessive mortality of the soldier by pulmonary disease. (Report of Commissioners on the Sanitary State of Army, 1858.)

What was the cause? The Commissioners did not hesitate to reply. Though certain other causes might be in operation, "the ravages committed in the ranks of the army, by pulmonary disease, are to be traced in a great degree to the vitiated atmosphere generated by over crowding and deficient ventilation, and the absence of proper sewerage of barracks."

In the navy, the deaths from consumption at one time averaged 2·6 per 1,000 of strength, and the invaliding nearly 4 per 1,000; but the extent of the disease varied with different ships, and seemed to be worst in those that had the smallest amount of space, and that were stationed in the warmer climates.

The evidence derived from jails, workhouses, and schools, is all to the same purport.

Thus, two Austrian prisons, in which the diet and mode of life were, it is believed, essentially the same, offer the following contrast:—

In the prison of Leopoldstadt, at Vienna, which was very badly ventilated, there died in the years 1834-1847, 378 prisoners out of 4,280, or 86 per 1,000; and of these no less than 220 or 51.4 per 1,000 died from *consumption*. On the other hand, in the well-ventilated House of Correction of the same city, there were in five years, (1850-1854) 3,037 prisoners, of whom 43 died, or 14 per 1,000, and of these 24, or only about 8 per 1,000 died of consumption. The comparative length of sentences is not given; but, as Dr. Parkes says, no correction on this ground, if needed, could account for this discrepancy.

Carmichael tells us that, at one time, in the Asylum of the House of Industry, in Dublin, scrofula prevailed in so great a degree that it was generally believed that the disease was contagious. This it was not, however; but the wards were so crowded with children that the air became impure to a degree. In one ward of moderate height, 60 feet long by 18 broad, were 38 beds, most of which contained three children, the entire number amount-

ing to upwards of 100. The matron of this asylum remarked that "there was no enduring the air of this apartment when the doors were first thrown open in the morning," and that "it was in vain to raise any of the windows, as those children who happened to be inconvenienced by the cold closed them as soon as they had an opportunity." As the air they breathed in the daytime was but little better, there is no occasion for wonder at the general spread of the disease amongst them.

6. The opinions of isolated medical men on this subject might possibly be open to cavil, on the ground that sometimes even men of science may take up extreme views on any matter. But when the witnesses to be called are amongst the foremost members of the profession, and when they are the pillars of the department of medicine to which they belong—that namely of public health—their evidence is surely entitled to great weight, and may be quoted to you with confidence.

Thus Dr. Farr said long ago, "The prevalence of phthisis in the armies of Europe is probably due in part to the inhalation of expectorated tubercular matter, dried, broken up into dust, and floating in the air of close barracks." ("Dictionary of Hygiene."

Dr. William Marcet pushes this view so far as to regard consumption as a form of poisoning by decomposing matter much in the same way as a dissection wound will poison.

Mr. Welch of the Army Medical School, Netley, also endorses Dr. Farr's view in his prize essay "On the Nature and Varieties of Destructive Lung Disease, as seen amongst soldiers, and the hygienic conditions under which they occur."

He shows that consumption is the great chronic devastator of our army in spite of all the selecting influence of recruiting regulations, and in spite of every variety of climate. It gradually increases with length of service, and is in his opinion due in the first place to "vitiated barrack atmosphere," "constant irritation of foul-air inspiration."

"The chief deleterious agent in the generation of consumption being the organic matter, which taken into the air passages, there lodges and chronically irritates."

Dr. Parkes says, "The great prevalence of phthisis in most of the European armies can scarcely be accounted for in any other way than by supposing the vitiated air of the barrack-room to be chiefly at fault."

Dr. Guy, in his inquiries into the causes of excessive mortality amongst working people, instituted comparisons between men

occupying wider and narrower spaces, or working on different floors more or less freely communicating with one another. "All the comparisons led to the same result, the establishment of the same vital truth, that consumption and colds were uniformly most rife wherever the cubic space was the smallest, or the air most close, hot, and foul."

Professor Alison ("Outlines of Pathology and Practice of Medicine," p. 194) points out that "deficiency of fresh air and exercise are among the most powerful and most important, because often the most remediable, of the causes from which the scrofulous diathesis arise."

Sir James Clark, who wrote one of the best monographs on consumption in our language, regarded "the respiration of a deteriorated atmosphere as one of the most powerful causes" of this disease.

The researches of Dr. Austin Flint, one of the most recent American writers on the subject, corroborates strongly the same view, and show that occupation is an agency in causing consumption, mainly "in so far as it is sedentary and involves confinement within doors." ("On Phthisis," p. 55.)

I might multiply these quotations, but I will call only one more witness in the person of Baudelocque, a great French physician; speaking of air changed by respiration, he remarks, "This is the true cause, the sole cause, perhaps, of the disease of scrofula."

Human beings are not singular in being thus affected by impure air. Many animals have been found to suffer from the same disease when kept in close confinement. It is very prevalent amongst the cows which supply milk to the inhabitants of some large towns, where they are immured during part of every year in close dairies. This was at one time remarkably the case with the cows belonging to the milkmen of Paris which were annually carried off by consumption in considerable numbers. ("Annales d'Hygiène," vol. xi. p. 447.)

A confirmation also of the influence of this cause is afforded by the usual exemption of the horse from consumption, since they have regular exercise and exposure to fresh air. "Where a number of horses, however, are collected together in ill-ventilated stables they may become consumptive." Mr. Chadwick states that a discovery of this kind was at one time made as to the effect of defective ventilation on the cavalry horses in some of the government barracks in England; and "a saving of several thousand pounds per annum was effected by an easy improvement of the ventilation

of the barracks near the metropolis." ("Health of Towns Commission,' first report, vol. i. p. 138.)

Monkeys also, when in confinement, are peculiarly subject to consumption, and a remarkable instance of the direct influence of foul air as a cause of the disease in these animals was given by Dr. Neil Arnott in evidence before the first Health of Towns Commission. (First report, vol. i., p. 52.)

It is hardly necessary to point the moral of all these tales of suffering and of death. Put into short compass it is "Beware of breathing foul air."

Whenever a number of persons are crowded together in a badly ventilated apartment, bear in mind the penalty that may be exacted for breaking one of nature's laws.

Whatever may be the cause that has attracted these people together, whether it is a cheerful company sitting around a table, with bright lights and pleasant talk, or the poor ill-furnished chamber into which poverty has driven some miserable beings to protect themselves from the elements,—in any assemblage of human beings, when the air begins to appear close to anyone coming from the outside, remember that its poisonous properties are also beginning to appear ; and when vapour is condensing on the walls or on the windows, be sure that it contains already decaying animal matter derived from the skin or from the lungs, and that the air you are breathing is fully charged with the same vapour and its noxious ingredients.

It is possible that all may not be equally affected by it ; that some persons, especially those who are already advanced in years, may even partially escape its influence, unless its potency is very great ; their vital processes may be very sluggishly performed, and they may need smaller quantities of oxygen to carry on their feeble lives ; they may not so readily take into their system the organic poison of which we have been speaking, or they may naturally have such strength of constitution that they may not feel for many years the harm of inhaling this uncleanly atmosphere ; but the young ones who are growing up around them, the children with their quick and lively actions, and consequent need of rapid combustion of refuse matter, the youths and young adults—these will all feel it, and it will show its influence either in the form of scrofulous glands and sores, or perhaps in the guise of consumption.

But the crowded or close bedroom is still more dangerous in this regard.

During the day the air of an apartment is often unintentionally changed by the opening and wafting action of a door. There is also at this season usually a fire that demands and contrives somehow to obtain a plentiful supply of air; but in the night most people are wrapt in—

Downy sleep, death's counterfeit,

and show its influence in stillness and quietude; there is only the slow involuntary action of breathing to cause any movement of the air. At this time when, as I have often seen, even in the houses of the rich, the windows are closely shut from a morbid dread of night air, and the doors are closed and made to fit tightly, and the chimney is stopped up either with a wisp of hay or a registered grate to prevent down draught, the danger is very great that portions of the air in such a chamber have been many times rebreathed.

There are very few bedrooms that will stand the test of leaving them for the outdoor atmosphere, and then on returning discovering no closeness or foulness of air. And yet this, especially for the young, is the limit of safety from disease, and especially from lung disease and scrofula.

Dr. Parkes and Dr. de Chaumont have shown that when this point of foulness is reached, to the perception, that is, of people of fair average nose-power, the air already contains about 6 parts per 10,000 of carbonic acid, and some organic matter, and all sanitarians are now agreed that this is the highest point of impurity that should be permitted.

But how can this degree of purity be preserved, and what amount of fresh air is needed for the purpose?

These are important questions, and I fear it will startle most of you when I tell you what is needed in the way of ventilation in order to make sure that the air in a chamber shall be breathable with safety. The quantity of fresh air at first needed depends of course upon the size of the room and the number of persons it contains; but, after a certain length of time, its atmosphere becomes contaminated, and then we need to supply to every person in the room fresh air to the extent of from 2,000 to 3,000 cubic feet per hour, or about 10,000 gallons of air per head per hour. That is equivalent to saying that if a man is sitting working in a room 10 feet square by $7\frac{1}{2}$ feet high, the size of many cottage rooms, the whole air of the chamber should be completely changed three or four times every hour.

Fortunately in most English houses, and especially in the cottage dwellings of the poor, there are a good many cracks and crevices left, through which the air can insinuate itself, sometimes even too perceptibly in the form of a draught.

The fire in the living room draws a considerable amount, and even the brick walls, covered with plaster and paper, allow a large amount of air to pass through them. If it were not so I am pretty certain that half Manchester would die of suffocation in the course of a winter's night. But Professor von Pettenkofer has shown ('The Relations of the Air,' p. 64), that even with doors and windows and all crevices thoroughly pasted up, there was a change in a room of 2,650 cubic feet capacity, of upwards of 1,000 cubic feet per hour, simply owing to a difference of temperature of 34° Fahr. between the inside and outside of the room; with 9½° of difference of temperature, the spontaneous ventilation through, the wall was about 43 gallons of air for every square yard of surface.

Mud walls in this respect are better than brick and brick walls are better than limestone or sandstone. So that the better material of which mansions are built are by no means of the unmixed benefit that we might suppose. Warmth in the living room also keeps the walls dry and porous, as well as draws in more air; hence, as Pettenkofer says, "Those who try to alleviate the poor man's winter by gifts of fuel, not only procure for him the benefit of a warm room, but also of a better and purer air in the room. You may consider this as a scientific parable, showing that in each benevolent action there lies a further blessing, even if we had not intended it."—P. 56.

But you will notice that there is a large deficiency of air still left to be provided for. If, judging by the test of closeness, this is not given by the crevices about a room, it must be provided by artificial means. In bedrooms this will be found essential. If we choose we might occupy ourselves for a good many hours in studying the various schemes that have been started for providing good ventilation, that is for admitting sufficient fresh air without its often unpleasant companion, "a draught."

But I shall not so trespass upon your time. There are doubtless many excellent and simple plans that could be adopted. Mr. Tobin's tubes opening straight upwards about four or five feet from the floor; grates that warm fresh air from the outside and pour it into the room; calorigen or other stoves that do the same thing—all these are good in their way, but it might be difficult to get

landlords to permit of their general adoption in working men's homes. I will, therefore, simply speak of open doors or open windows, and especially of the latter. Open doors admit to a sleeping-room the already used air of the house, and there are very few rooms without a fire in which the window should not be open both night and day.

Many people are contented with opening a room window for a few minutes before nightfall, and again for a short time in the morning, forgetting that in the course of an hour all the air, even of a moderately large room, would be used by a single person.*

But what about night air, and what of draughts?

Well, with regard to the former, I will only say that the night air in towns is often the purest. In some country places, as in the Fens, there might be malaria, and ague might be the result of exposure to it; but in most towns, believe me, there is no danger in breathing night air from without; the real danger is from night air within doors.

Then as to draughts, they must be avoided, and it is wonderful how easily they may be prevented.

Pettenkofer has shown that if air at ordinary temperatures does not move at a greater rapidity than 1½ feet per second, its movement is not felt. What is needed, therefore, is some kind of screen that will not prevent the entrance of air, but that will break its force, divide its currents, and make it flow unfelt into the room.

Perhaps the simplest plan of effecting this is the following: Open your window at the top to whatever degree is necessary to prevent closeness in the room, but if there is a draught open it wider still; place a little loosely-packed cotton-wool between the upper and lower sash, and in the open space above the upper sash place a strip of perforated zinc, with its lower edge turned upwards, so as to direct the draught towards the ceiling. If there is still too much draught,† open it still wider, but fasten in front of the perforated zinc a screen of gauze containing loosely-packed cotton-wool.

There remains to point out that the air used for ventilation must be as pure as possible. So far as impurity comes from within the house this must be the affair of the householder, and

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* 20 feet by 15, and 10 feet high.

† It is noteworthy that there must be a sufficient current to carry the air upwards along the slanting piece of zinc, and towards the ceiling, otherwise, as Mr. Corbett has pointed out, the cold air will trickle over the edge and cool the feet of the inmates of the room.

especially of the house-mother. The former must see that there is no dampness about the house or its cellars, and that the drains are in good order; the latter must obtain cleanliness in all things, in house offices, clothing, and person. As Pettenkofer says, (op. cit. p. 53), "it is a waste of ventilation if it is directed against avoidable pollutions of the air, besides its being generally not of much use for this purpose . . . The proper domain of ventilation begins where cleanliness has done its best."

In the matter of clothing, I should like to advert for a moment to one article of clothing that is often a source of impurity, and that many people are fond of carrying about with them at this time of the year. I mean the chest protector, or bosom friend, or whatever else it may be called. To my knowledge, this morsel of clothing is often worn week after week without change, until it becomes sodden with perspiration, and reeking with decomposing matter, and it gives off its noxious emanations just under the mouth and nose.

It is far more likely to produce consumption than to prevent it. Besides its foulness its protection is too partial, and a good warm flannel vest would preserve the chest from the effects of changes of temperature far better.

Purity of out-door air can only be attained, I fear, by legislation and good local government. It involves both freedom from the noxious results of trades, and efficient scavenging, and finally, free access of air to dwellings, so as to sweep away unavoidable nuisances.

We have spoken of the evils produced by smoke and other vapours, and we have glanced at the several methods by which in nature the air is purified—absorption by plants, diffusion of gases, winds, storms, and rain. But these means, as we have seen, are not equal to any burden that may be laid upon them. The destruction of plant-life, and the injury to human beings that occur where the air is loaded with these substances, show that something more is needed than Nature unaided is able to perform.

She cannot stifle the stokers of furnace fires when they carelessly allow volumes of dense black smoke to escape, either from factory chimneys, or from equally great offenders, the flues of our great warehouses. She cannot turn the stream of evil vapours and gases back into the works from which they pour. Legislation and vigilant inspection can alone interfere with this; and it is for you and for the people of Manchester so to influence the governing bodies that they shall protect you from the pollution of vital air.

It is not a question now of interfering with the prosperity of trade and commerce, though where human life and health are concerned I think some interference would be justified.

It has been amply proved in this case that this is no question of driving away the ox, in order that the crib may be clean. The refuse matter now so noxious has been shown to possess such value when stored that it has proved a source of revenue, and we may without scruple urge manufacturers to adopt the necessary processes for keeping them out of the air.

There is yet another thing that the artisans of this town cannot do for themselves, and for which our association has more than once asked for aid from without. I mean the securing free access of air to the houses, and free passage of fresh air through them. Two sessions ago, an act was passed entitled the Artisans Dwelling Act, popularly it was called the Rookeries Bill, and was intended to enable local authorities to open up many of the worst quarters of our towns, and get better dwellings built upon these sites. In some towns (notably in Edinburgh, Glasgow, and Liverpool) efforts had already been made to do this before the passing of the Act, and since its passing many places have availed themselves of its powers, but Manchester has done nothing hitherto in this way.

And yet the need for something being done is very great; the description of another place by Dr. Buchanan would very well stand for many parts of Manchester. "In small closed courts, surrounded by high buildings, and approached by narrow, and perhaps winding gangways, houses of the meanest sort stand, acre after acre of them, with but privies and dustbins to look upon. And sure such can only be counted fit for human habitation *while the standard of that humanity is low.*"

"Nothing short of a tornado can effectually ventilate these courts; in still weather the atmosphere in them is unchanged and unchangeable."

I have here a drawing of a group of some of these "back slums" of Manchester. It is a block of cottage dwellings in Ancoats, and is only a specimen of several that have been visited by members of the committee. You may notice, first, the way in which the houses are arranged in dense masses so as to surround several small courts. These are each entered by narrow entries, burrowed, so to speak, through a block of buildings. The little air that is thus admitted is rendered as stagnant as possible in one or two of the courts by walls built across them, and is fouled by the presence of offices.

But the most striking feature of the picture is one that is very common in this town, namely, the character of the houses. Many of them are without opening at the back, built on what is called the "back to back" principle. Any air that contrives to find its way in at door and window (and I fear the latter are not often opened) has to turn itself round inside, so to speak, and must come out again the way it entered. No through current is possible, and when you remember the impossibility of getting rid of the organic impurities of air without such a current, it is not surprising that the interiors of these dwellings, especially of the bedrooms, are close and foul to a degree, and that they contain an atmosphere not to be breathed without danger. They are caves and not houses, and they open into narrow spaces wherein the air is already polluted with noxious vapours, smoke, and filth. The death-rate in the district is about 35 per 1,000 or twice as great as that in healthy parts of England, and three times as great as that of some of the suburbs in which well-to-do people live. It is in truth utterly unfit for human habitation.

I have only spoken here of the material atmosphere breathed by the inhabitants, but we cannot wonder if the moral atmosphere in such places is equally impure. Remember that each of these houses should be a "home," a place to which husband, wife, and children could repair after their work for rest and refreshment and pleasant talk. It is a mockery even to mention the word in relation to such places as these. But I will ask those who are responsible for their existence to ponder well these words of Charles Dickens, with which I will conclude. "If those who rule the destinies of nations would but remember this—if they would but think how hard it is for the very poor to have engendered in their hearts that love of home from which all domestic virtues spring, when they live in dense and squalid masses where social decency is lost, or rather never found—if they would but turn aside from the wide thoroughfares and great houses, and strive to improve the wretched dwellings in byways, where only poverty may walk—many low roofs would point more truly to the sky than the loftiest steeple that now rears proudly up from the midst of guilt and crime and horrible disease, to mock them by its contrast."

APPENDIX.

TABLE I.

Deaths from Diseases of the Respiratory Organs and Phthisis in England in the ten years 1865-74.

Year.	Diseases of the Respiratory Organs.	Phthisis.
1865	69,952	53,734
1866	77,249	55,714
1867	72,183	55,042
1868	63,103	51,423
1869	80,397	52,270
1870	82,186	54,231
1871	81,825	53,376
1872	73,393	52,589
1873	85,626	51,355
1874	90,612	49,379
Total	776,526	529,113

Annual average number of deaths from all causes, 497,974.
Mean population 1861-71 = 21,389,245.

Deaths from Diseases of the Respiratory Organs and Phthisis in Manchester and Salford in the ten Years 1865-74.

Year.	Diseases of the Respiratory Organs.	Phthisis.
1865	2,122	1,275
1866	2,366	1,257
1867	2,252	1,255
1868	1,783	1,110
1869	2,197	1,229
1870	2,108	1,270
1871	2,442	1,314
1872	1,966	1,318
1873	2,395	1,176
1874	2,560	1,139
Total	22,191	12,343

Annual average number of deaths from all causes, 11,881.
Mean population 1861-71 = 365,074.

TABLE II.

Mortality from Diseases of the Respiratory Organs, Average for five Years, 1869-73.

Westmorland	2·27
North Wales	2·51
All England and Wales . . .	3·54
Salford	5·12
Manchester Registration District .	6·10
„ Township (1874) .	7·7