On the limits of the infectiveness of tubercle. A lecture, introductory to the course on public health and hygiene at the Owens College, Manchester, May 19th, 1884 / by A. Ransome.

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A Lecture,

INTRODUCTORY TO THE COURSE ON PUBLIC HEALTH AND HYGIENE
DELIVERED AT THE OWENS COLLEGE, MANCHESTER,
MAY 13TH, 1884.

BY

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ON THE LIMITS OF THE INFECTIVENESS OF TUBERCLE.

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I HAVE been asked to choose for an introductory lecture some subject of general interest, and within the limits of my own branch of medical knowledge it ought not to be difficult to comply with the request. It would be easy, for instance, to dilate upon the importance of sanitary science, both to the individual and to the State—to describe its aims and to note its victories; but I am happy to think that all these points are now becoming too well known to be interesting. Moreover, when the chair of Hygiene was first founded in this College I delivered a lecture introductory to the course, and this lecture was published. It is never politic to preach an old sermon, especially when one would so soon be found out, and I must therefore diverge from the usual track, and must select from amongst my notes some material that may at the same time instruct the students of the class, and yet be of interest to the general practitioner.

There is one such subject that is attracting a good deal of attention at the present time, namely, the question of the infectiousness of tubercle; but, in order to mark more distinctly my line of thought, I propose to-day to treat "of the limits of the infectiveness of tubercle."

Assuredly, if the conflict of opinion on any subject tends to strike from it some sparks of human interest, we shall not be likely to miss them to-day.

At the present time the most diverse opinions are held in reference to this question. On the one hand, we have medical men holding strongly to the view that consumption is infectious, and they are supported by the belief deeply impressed upon the popular mind in Italy and other hot climates that the disease may be conveyed as readily as ordinary zymotic complaints—not only from person to person, but even by means of bedding and clothes.

On the other hand, we have the testimony of physicians to consumption hospitals entirely opposed to this view, and notwithstanding the fact that about one-half of the mortality in this country between the ages of twenty-five and thirty-five is due to consumption, there are thousands of English medical men who have never seen a case of undoubted tubercular infection.

Professor Koch's great discovery of the bacillus of tubercle has, moreover, greatly increased both the popular and medical attention to the question; and quite recently inquiries on the matter have been addressed by the Collective Investigation Committee of the British Medical Association to nearly every practitioner in the kingdom. I propose, therefore, to consider the subject in some detail, and shall endeavour so to marshal the evidence that is at our disposal as to enable us to attain to some definite idea one way or another on this moot point.

That, in a certain sense, tubercle is an infective disease cannot at the present time be doubted.

Long before the discovery of the specific bacillus it was proved by Villemin and others that tuberculous material would convey the disease to sound animals, when it was introduced into their bodies by puncture or inoculation. Animals fed with it contracted the complaint, and the inhalation of dried and pulverised sputum from consumptive patients caused the disease in dogs and other animals.

Moreover, as Cohnheim has shown, the course taken by the complaint in the animal body, as in the human subject, completely justifies the denomination of infective, which was applied to it by Professor Burdon Sanderson; and this remark holds good however the disease may have been contracted, whether arising naturally or introduced by inoculation.

Tuberculous material always follows the track of the absorbents of the part infected. Implanted in the peritoneum, it produces first tubercular peritonitis and then tuberculosis of the spleen and liver. Injected into the anterior chamber of the eye, it attacks the iris. When the disease has been produced artificially by feeding animals with tuberculous substances, it is first observed in the glands of the bowel and of the mesentery. After inhalation of dried and pulverised sputum, it appears in the lungs and bronchial glands. And lastly, when subcutaneously injected, it makes its way to the nearest lymphatic glands.

It seems indeed highly probable that acute tuberculosis in man or animals arises only when the peculiar virus obtains an entrance into the general circulation.

And we cannot ignore the significance of the facts that have been placed before us by Professor Koch. He has proved, beyond a shadow of a doubt, that both scrofula and tuberculosis are due to an organism—one of the large group of Desmo-bacteria. This organism is about the same size as many of the putrefactive bacteria, and would often be undistinguishable from them but for its peculiarity of retaining the magenta dye, after washing in nitric acid diluted with two parts of water. It has never yet been found in any other than tubercular disease, and its presence is so constant not only in tubercular organs but also in the sputum from phthisical patients, that search for it has now become in doubtful cases a necessary branch of clinical work.

By a series of cultivations on sterilized ox-blood serum, this bacillus has moreover been obtained distinct and separate from other organisms, and has been proved to possess the power of generating tubercle in animals into whose bodies it has been introduced by inoculation, ingestion, or inhalation.

But it may well be objected that although tubercle may be due to a parasitic growth, and that it may thus be infective within the body, in the sense that after inoculation it spreads infectively through the body, yet this is no answer to the questions whether or not tubercle is capable of being conveyed by ordinary methods of contact from person to person, nor as to the conditions that are necessary to its propagation. It will be needful, then, to see (1) what proofs are forthcoming that the germ is implanted from without, and under what circumstances it is so conveyed; and (2) to what extent direct contagion between individuals has been observed.

We shall find, I think, that the answers to these questions are by no means identical in their bearing, but each of them must now be carefully considered in their order.

Let us glance then, first, at the evidence so far as it relates to the transmission of tubercle through media external to the body.

It has been remarked by Cohnheim ("Die Tuberkulose vom standpunkt der Infectionslehre," p. 20) that a tuberculous or scrofulous product is mostly deposited in those parts of the body that are either most exposed to attack from without, or in which any virus coming from the outside may lodge for the longest time. Thus no internal organs are so constantly brought into relation with the atmosphere as the lungs, and accordingly no other organ is attacked by tubercle with the same frequency and the same intensity.

In many cases of this disease also all the other organs, not connected with the lungs, are free from its attack.

This fact cannot well be accounted for on any other supposition than that of a primary and immediate attack upon the respiratory tract by the virus. Next in order to the lungs and pleuræ, and to the bronchial and tracheal glands, come the glands about the pharynx, and then next after these, owing probably to the swallowing of sputa, we find the lymphatic apparatus of the wall of the intestine, the isolated and agminated follicles, most liable to be the seat of tuberculous ulceration.

The œsophagus escapes contagion because of the rapidity of the transit of the virus, and the stomach, perhaps, owing to the presence of the gastric juice.

Through the intestinal ulcers a path is opened to the bacillus into the mesenteric glands, to the liver, and to the whole of the rest of the body, thereby producing general tuberculosis.

In fact, long before the discovery of the specific bacillus it had been shown that tubercle is intimately associated with the lymphatic system.

Virchow ("Cellular Pathology," translated by Chance, p. 481) says: "There is a complete correspondence between the real constituents of (tuberculous) granule and the corpuscles of lymphatic glands."

Wedl: That "the tubercle cell . . . belongs to the nature of a lymph gland element."

Rindfleisch ("Pathological Histology" [Sydenham Society], vol. i., p. 141) declares that "Specific irritation of the endothelia of the lymphatics, the serous membranes, and the blood-vessels (Schüppel) is the essential factor in the production of the miliary nodule; and it is only because the lymphatics run by preference in the immediate neighbourhood, in the adventitia, of the blood-vessels that miliary tubercles exhibit a preference for that locality."

Aufrecht regards miliary tubercle as "a granular peri-lymphangitis."

Wagner (p. 449) speaks of the extension of tubercle . . . in the course of lymphatic vessels, or in that of blood-vessels.

Southey ("Gulstonian Lectures on Tubercle," p. 55) remarks that "scrofula and tubercle are allied genera of one large family, the lymphatic; and *Dr. Wilson Fox* (on the "Artificial Production of Tubercle," 1868, p. 25) speaks of it as "a lymphoid growth."

Villemin says: "Tubercle is characterised by small lymphatic elements, as suppurative inflammation is by globules of pus." And, again (p. 167): "In the present state of our knowledge we possess no means of distinguishing the globules of tubercle from lymphatic cells, and probably there is in the nature of things no difference."

"Tubercle arises from a single essential, *i.e.*, specific, cause."

Treves, in his work on scrofula, speaks of tubercle as infective, and affirms that "lymphatic structures of some kind are essential" to its formation.

"Giant" cells he conceives to be "merely peculiar lymph coagula."

Buhl ("Lungenentz," p. 106) says: "Tubercle extends from the internal wall of the alveoli into the textureless lymphatic vessels;" and in this he is confirmed by

Klein ("Report of the Medical Officer to the Privy Council," new series, No. iii., p. 92), who says that tubercle does not originate either by a free cell formation in the veins, or in the lymphatic vessels, but that he has followed "their development from the epithelial cells of the alveoli;" and lastly,

Ziegler ("Tuberculose und Schwindsucht," p. 1279) plainly tells us "to regard tubercle as an inflammatory product, the

result of an irritation, an infection," and he does not doubt that "schizomycetes play an important part in phthisis."

In the points of attack chosen by the organism, and in the course which it takes throughout the body, we see then clear proof (1) that the poison is derived from without, and (2) that although in rare cases it may be taken up by the intestinal tract, its usual point of entrance is by the air passages, and we might hence conclude, without further evidence, that its favourite vehicle would be found to be the atmosphere. Direct evidence on this point must, however, be brought before you, and is not difficult to find. But before doing this, let us clear the ground of other material, and let us for a few moments pass in review the several other conditions that have been found to favour the production of tubercular disease.

The fact of the production of tubercle by the agency of an organism does not entirely exonerate us from this labour. We are bound to find out whether there are any conditions that are essential to the operation of the virus, and which of these are the most potent for evil. There may be more than one factor to produce the result, and, as Dr. Addison has well said of certain epidemic diseases, "One blade of the destroying shears may be forged at home, without it the other cannot do its work."

Let us, then, try to discover which of the so-called causes of tubercle are only predisposing or favouring influences, and which are necessary to its genesis and propagation. We shall probably thus throw some further light upon the question as to its truly infective character.

1. *Heredity.*—First amongst such causes must certainly be placed hereditary tendency to the disease, but how seldom are the germs actually transmitted from parents to offspring, and how constantly is the disease acquired in after life.

Moreover, a large proportion of cases of consumption arise in families that have not been known to have lost any member from this cause within any recent period, or within the last generation. Mr. Welch, in his prize essay, "On the Nature and Varieties of Destructive Lung Disease," tells us that sixty per cent of the cases of phthisis amongst soldiers are non-hereditary; and, owing to the medical supervision of recruits, we may be tolerably sure that most of these cases arise after the commencement of their military service.

Even if we grant that statistics on this point are defective and unreliable, heredity cannot be regarded as an essential condition of tuberculosis; and we may say, on the contrary, with Louis that "very few people are born necessarily to die of consumption."

As Villemin has said ("Etudes sur la Tuberculose," p. 289), "At best the influence of heredity is an affair of the transmission of an aptitude to contract the disease," though we may hesitate to follow him when he further declares that "it has nothing to do with physical conformation, constitution, or temperament," and that "there is no such thing as a tubercular diathesis" (p. 299).

Viewed from the standpoint of present knowledge, we may say moreover that, except in the case of infants born tuberculous, it is in the highest degree improbable that the tubercle bacillus could produce spores that would *rest* so long as they must be supposed to do, on the hypothesis of the hereditary transmission of the disease.

2. *Climate* has often been accused of causing consumption, and especially the changeable humid climate of this country, but we find no support to this doctrine from the geographical distribution of the disease.

In his elaborate work on the geographical distribution of disease, Dr. Lombard, of Geneva, gives the proportion of

deaths by phthisis to total deaths in nearly every country district and town of the world, and though in some cases his authorities may be unreliable, yet on the whole a fair idea of the range of the complaint may be obtained from them. You will see from the following table that consumption is rife

PROPORTION OF DEATHS FROM CONSUMPTION TO 1,000 DEATHS AT

London	121	Rome	114
Paris	143	Milan	132
Brussels	163	Lisbon	115
Vienna	208	Athens	183
Berlin	109	New York	167
Stockholm	160	Rio de Janeiro	186
Christiania	172	Lima	171
St. Petersburg	151		

(Lombard.)

in all the chief capital cities of the world, independent of climate, and that, as Lombard says, it is just as ubiquitous as man himself.

Under this head also we must class the undoubted influence of a damp, impenetrable subsoil as being essential to the production of phthisis. Drs. Bowditch and Buchanan have each shown independently of one another that phthisis flourishes best on such a foundation as this, and that it is comparatively rare in districts with loose, porous, sandy soil. Moreover, Dr. Buchanan has shown by comparative statistics that good drainage may diminish the prevalence of the disease by as much as fifty per cent.

These results have since been confirmed by the Registrar-General of Scotland and by Dr. Haviland.

But there is no necessary connection between dampness of soil and consumption. There are in different parts of the world large tracts of country that are excessively damp, many of them wholly given over to malaria and to intermittent fevers; and yet these districts are so free from phthisis that

some continental writers (amongst whom is Wagner) have supported the theory that ague is antagonistic to consumption.

Even an elevated site gives no immunity from the disease. Places more than 2,000 feet above the level of the sea have been supposed by Hirsch ("Hist. Geogr.," Part ii., 2) to be free from consumption, and accordingly such places have been selected as health resorts for persons suffering from the disease, but Dr. Emil Müller shows that there is no special immunity from the disease in the mountain regions of Switzerland—a certain proportion of the inhabitants of these regions die of the disease—the rate depending not upon the elevation of their dwellings above the sea, but upon the nature of their occupations. Industrial indoor pursuits give a rate varying from 6·5 to 10·2 per cent, and one of the highest of these factors, 9·8, is at an elevation of 3,400 to 4,400 feet. At 4,400 to 5,000, in mixed labour, the rate from phthisis was 7·7.* Climate can, therefore, only be regarded as a predisposing cause.

3. *Mal-Nutrition.*—It is not surprising that, at one time, tubercular disease should have been ascribed to some form or another of want of proper nutrition, and especially to deficiency of fatty food. The poor ill-nourished denizens of towns have always furnished the largest proportion of victims of the malady. It was found by M. Marc d'Espine that, at Geneva, in every 1,000 deaths amongst the poor 233 were from consumption, whilst of the rich only 68 were from this disease. This theory is even yet not quite exploded. One of the latest writers on the subject, Dr. Jaccoud, gives it as his opinion that the consumptive constitution is essentially due "to insufficient nutrition, taking this word in its widest sense."

* Der verbreitung der Lungenschwindsucht in der Schwytz. 1876.

Mons. Bouchardat also, in his treatise on "Hygiene," published last year, affirms emphatically that "the continuous loss of calorific elements, in any considerable proportion, leads to pulmonary tuberculosis" (p. 665). He defends this opinion by reference to the large mortality amongst cows from tuberculosis when the supply of milk is forced, and to the appearance of tubercles in the lungs of diabetic patients when the elimination of sugar has taken place to any considerable extent for a sufficiently long period (p. 653).

He even ascribes the sixty-eight deaths amongst the well-to-do to some form of "misère physiologique." No one can doubt that want of sufficient food and mental distress are amongst the most powerful agents in preparing the ground for the successful sowing of the seeds of consumption, but even if we had not known of the existence of a specific organism, and indeed before it was known, it had been already long apparent that these causes are predisposing only and not essential.

The terrible mortality from phthisis that prevailed at one time amongst the finest soldiers of the British army occurred for the most part when they were not on active service, but in the time of peace, when they were well fed and well cared for in every material respect far better than the artizan and agricultural labourer with whom they were compared. These soldiers, selected to form the household troops, chosen for their strength and stalwart proportions, and with no signs of mal-nutrition about them, succumbed at more than twice the rate of the ordinary civil population at the same ages.

4. Similar remarks, so far as the army and navy are concerned, would apply to the next series of supposed causes of consumption—namely, *hardship*, *exposure to the*

weather, and *cold;* but these conditions might rather be characterised as being antagonistic than favourable to the onset of the disease.

The poor fishermen of Iceland and the hunters and trappers of North America, the nomad tribes of Asia and Africa, the wretched natives of Australia, all these people escape the disease almost entirely, whilst half the deaths of the well-protected, well-clothed adult inhabitants of towns are from this cause.

The Highlanders who inhabit well-built houses on the mainland of Scotland are subject to the same rate as the other inhabitants; whilst the ill-fed, ill-clothed fishermen of the Hebrides, who are of the same race, hardly ever contract the disease.

I may say that Dr. Morgan, who wrote a paper on this subject twenty-four years ago ("Brit. & For. Med. Chir. Rev.," vol. xxvi., p. 483), ascribes the escape of these people also in some measure to the antiseptic properties of the peat smoke.

A striking case under this head is quoted by Dr. H. Bennet from Professor Hind: "Consumption," he says, "is unknown amongst the natives of Labrador whilst they remain in their own country. Here they live a kind of wild life in tents made of spruce branches, imperfectly lined with skins, and more or less open on all sides to the air. They are exposed to famine and all kinds of hardship; but when they come down the great River St. Lawrence to take part in the fisheries, they occupy well-built houses, and, being well paid, they live in comparative luxury, and then many of them, in the course of a year or two, become consumptive, and thus miserably perish."

5. Certain *occupations* have also ranked amongst the causes of phthisis, especially those carried on indoors, or accompanied by dusts of various kinds, or carried on in a stooping

position; but we may at once put these aside as in no way essential causes, though they may prepare the way for the reception of the specific virus.

Dusts, indeed, act mechanically by irritating the air passages and lungs in various degrees according to their cutting nature; but as Dr. Arlidge and others have shown the disease they produce is not tuberculosis, though it may afford a suitable nidus for that disease.

Indoor occupations and stooping positions at work are too often accompanied by other conditions to be regarded as simple causes, and with regard to the stooping posture, *per se*, it is worth while noting the remarks of Rokitansky, Wagner, and others as to the rarity of tubercular consumption in hunchbacks.

6. There yet remains to be mentioned the one antecedent of consumption, without which none of the other predisposing influences that we have mentioned, however potent they may be, can do their deadly work. This cause is *foul air*, or, to limit the scope of this phrase more strictly, it is air rendered impure by respiration.

Before the discovery of the specific element of tubercle, Mr. Simon ("Supplementary Report to the Privy Council," 1874, new series, No. ii., p. 16) expressed his opinion that "the common (septic) ferment, which in its stronger actions quickly destroys life, by septicæmia, can, in slighter actions, start in the infected body chronic processes which will eventuate in general tubercular disease;" and it was then pretty generally held that any putrefying organic matter might so irritate the air passages, and especially the lymphatics of the lungs as to produce an unhealthy form of inflammation, culminating in tubercle.

At the present time, however, this simple pythogenic theory, as it might be called, is quite untenable, and Dr.

M'Cormack showed true prescience when he brought forward his doctrine that it is to "re-breathed air" that phthisis pulmonalis is to be ascribed. It behoves us, therefore, to examine the grounds for this opinion, and if you judge it to be well-founded, we shall have advanced another step towards our conclusion that tubercle is truly infective, and that it is derived from without the body, though we shall not have proved that it is communicable from person to person.

We may, then, notice (1) that with the exceptions of the direct hereditary transmission of the complaint, and of tuberculosis conveyed by food, air befouled by breathing is the constant associate of each of the conditions that have been found to be effectual in predisposing to phthisis, and it is absent where there is an immunity from the disease. The geographical distribution of phthisis is thus acccounted for, rather than by any differences of climate.

The Arabs and other tribes living in tents in the pure air of the desert, the Persians who lead for the most part an open-air life, the fishermen of Labrador and the Hebrides, the mountaineers of Switzerland and of the Andes—all these men breathe an atmosphere that, if not germ-free, is almost entirely clear from the contamination of other men's breath.

In Mexico, Dr. Coindet says that "the Indians are never phthisical."

In Algeria, whilst the free Arabs do not suffer, of the captives and prisoners many die of the disease.

In Central America, whilst it is common in the plains, it becomes more rare as people rise to the higher grounds.

Many similar instances might be given.

In cold climates again, such as Iceland, Lapland, the Faroe Islands, Finland, and Canada, although the inhabitants often live in huts, we may probably ascribe much of

the absence of consumption to the purifying influence of frost, and to the consequent dryness of the atmosphere.

The vapour of the air, when condensed by the frost, carries down with it much of the organic matter of the breath, and thus takes it out of the air of the rooms, and the outer air is also thus purified to a very considerable extent.

On the other hand, in populous towns, where the air is never free from human miasm, the disease is common in all climates and in all parts of the world.

Even in Australia, where formerly it was unknown, it now produces, we are told by Lombard, one-half the deaths of the civil population.

There is in fact an almost exact numerical ratio between the phthisis-rate, and the density of any population—or, in other words, the more closely people are congregated together, and the more concentrated the respiratory impurity of the air, so much the larger is the proportion of persons dying of consumption. In the following table, compiled by Dr. Farr, it will be seen that the mortality from chest diseases and especially from phthisis is in proportion to the density of the population of the several districts :—

MEAN MORTALITY IN THREE GROUPS OF THE THIRTY-TWO METROPOLITAN DISTRICTS, 1839.

Districts.	Square yards to one person.	Annual rate per 100,000.		
		Totals.	Respiratory organs.	Phthisis.
1 to 10	57	3,321	822	478
11 to 20	78	2,839	768	451
21 to 30	217	2,163	588	354

2. With regard to mal-nutrition. How seldom are the circumstances of persons exposed to want of food such as to

enable them to secure a sufficiency of pure air. The squalid living-places—one cannot call them "homes," in which these people live, are for the most part in the most densely-crowded parts of our cities; in the narrow alleys and close courts in the lowest and least desirable quarters thereof; in the slums, as they are technically and even legally named. As Dr. Buchanan says: "Nothing short of a tornado can effectually ventilate these courts, in still weather the atmosphere in them is unchanged and unchangeable" ("Rep. of Med. Off. to Privy Council, 1864"). And, on the other hand, as we have seen, where fresh, pure air can be obtained, even by the worst nourished and most poverty-stricken of the population, how seldom does consumption reach them.

3. The fatality of different occupations is closely connected with the respiratory impurity of the air breathed by the work-people. The miners who work in the narrow cells which they have excavated, with the air so polluted that their lamps will hardly burn; the wretched lacemakers of Nottingham and the watchmakers of Coventry, who work in ill-ventilated work-rooms; the printers, who are exposed day and night to organic vapours from their own lungs—all these persons die in excessive numbers from phthisis; whilst agricultural and other labourers, whose work takes them into the open fields, are free from the disease. Nothing can be more striking than the contrast between the phthisis rates of males and females in rural districts. The women, who for the most part are employed indoors, die at much the same rate as their sisters in towns, those of them at any rate who are not especially attracted to still more unwholesome work in factories; and a very striking instance of the results of indoor occupation amongst women is given by Laennec in his classical work on Phthisis.

He there cites the case of a religious community of women, with strict seclusion and sombre surroundings, amongst whom in ten years he had seen phthisis arise so frequently that within this period the population of the institution had been two or three times renewed, with the significant exception of those who had charge of the gardens, the kitchen, and the infirmary.

4. The history of phthisis in the British Army, at home and abroad, affords perhaps the best proofs of the overpowering influence of bad ventilation, assisted in its work by the influence also of bad drainage.

Dr. Farr, in his report to the Army Commission after the Crimean War, remarked that "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," and "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."

At the time of which Dr. Farr wrote, the rate at which soldiers died 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 overcrowding and deficient ventilation, and the absence of proper sewerage of the barracks."

The evidence from jails, workhouses, and schools is all to the same purport, and need not here be quoted. It is given by Dr. Parkes in his work on Hygiene.

We may then with much confidence support Dr. M'Cormack's theory that the chief agent in producing consumption is air that has been polluted by respiration, and if this conclusion is once reached we are again brought into relation with all the pathological observations that have just been considered, and the opinion is greatly strengthened that the bacillus is derived from human lungs, and that in some mode or other it is conveyed by the air into the lungs of other people.*

But we must carefully guard ourselves from deducing the further proposition that tuberculosis is infectious in the ordinary sense, and that it is directly conveyed like an exanthematous disease from person to person. It may well be that there is another and a necessary stage between the shedding of the germ and its fructification in the form of genuine phthisis, and thus there may be no direct transmission.

It behoves us then to consider carefully what is the evidence with respect to the actual communicability of the disease by contact or by fomites, and this we must do without bias due to the tendency of the teaching hitherto laid before us in these pages.

That contagion from a consumptive patient is a possible event is an opinion that has been held by many eminent men — Morgagni, Van Swieten, Valsalva, Morton, and Baumès amongst the ancients; Laennec, Copland, Bowditch, Dr. Wm. Budd, Dr. Gueneau de Mussy, and Dr. Hermann

* "Breath infects breath."—"Timon of Athens," Act iv. Sc. 1.

Weber in more modern times. All these observers have expressed their view that the disease is contagious; and although there are many others on the opposite side, affirmative evidence is in this case of more value than negative. Quite recently, too, a number of supposed cases of contagion have been contributed by medical men to the Collective Investigation Committee of the British Medical Association; and on the first perusal of the Collective Investigation Record it would seem to be impossible to doubt that, although the contingency may be a rare one, the possibility of such direct infection has been proved. A little consideration will show, however, that the importance of these cases is liable to be exaggerated, and that they afford but little certain proof of the contagiousness of phthisis.

Regarded simply as statistics the tables of cases laid before us by the Collective Investigation Committee cannot indeed be said to prove anything.

In the Record we are happily supplied with a means of testing the results of the inquiry in a paper by Dr. Longstaff. He has calculated the "probability of the *accidental* and fatal incidence of phthisis upon both husband and wife" during the ten years, 1871 to 1880, and he finds that without any infection being assumed, 4,358 cases of deaths of both husband and wife would have occurred in this period. On applying these figures to the data given in the Record, it appears that about 250 of these purely accidental double deaths ought to have been noted by the 1,078 medical men who have made returns.

In point of fact this number is barely reached in the tables intended to prove contagion, so that it becomes at once highly probable that many of the cases given were only accidental.

In the Record, moreover, the observations extend over a variable period—dependent upon the experience of the observer—in some cases less, in some more than a period

of ten years, and some extend even so far back as fifty years. In any comparison also it would be necessary to deduct cases occurring out of Great Britain, and it would be hardly right to include the thirty-five cases said to have only become manifest a few months after the partner's death. On the whole as a statistical record it appears at once to be both meagre and imperfect. We are, however, expressly told that the tables are not to be looked upon as ordinary statistics; they are affirmative only, and many cases have probably been omitted in which there seemed no distinct contagion to persons not hereditarily disposed to the disease.

We are not, then, to deal with the figures before us as mere statistics; each case is intended to stand upon its own merits, and although we cannot entirely put aside the theory of probabilities, we must be prepared to admit the weight of the evidence given of absence of hereditary predisposition, previous good health, and so on.

Even when admitted to this more favourable hearing, however, the records afford but little proof of direct contagion. It has been suggested that some of the instances given, and notably those of the infection of several wives by one husband, were really due to the influence, in some fashion, of the syphilitic virus, and others might perhaps be referred to some form of inoculation; but a much more serious objection to the admission of the evidence as a proof of contagion is the consideration that the occurrence of phthisis in both husband and wife may simply have been due to their exposure to similar influences, and that they are thus only proofs that these influences greatly favour the production of tubercle.

I think, however, that it must be conceded even by the strongest opponents of the contagionist theory that there are in the record a few facts to which these remarks do not apply. The following instances—Nos. 194 and 196—are

entirely free from the source of fallacy just noticed, and are well worth transcribing.

In 194 we learn that "in 1862 a servant came home to her mother (a widow, with three sons and two daughters, all grown up, father died of epithelioma) suffering from phthisis. The house, consisting of two rooms and an attic, and lying under the brow of a hill, on its northern aspect, was ill-ventilated and worse lighted. By the end of 1868 the only survivor of this family, she being still alive and healthy, was a thin delicate girl, who took little or no part in the nursing. They all died of phthisis, the mother dying last between fifty and sixty years old."

No. 196.—"A young man, of the Indian navy, came home suffering from phthisis. In a few months two of his sisters were taken with the same complaint and died. A third sister married and soon afterwards died of the same disease. The young man also died. Later on the father was similarly affected and died. After his death the widow became phthisical and died also. I should think four years covered the whole outbreak, that is, from the arrival of the son from India. The father was originally a very healthy, strong man, and all the children healthy up to about twenty or twenty-one, or even later; one sister still lives, and is now between forty and fifty."

In these cases truly something seems to have been introduced from without, into dwellings previously untainted by the disease, and although there is still a possibility of some third element having intervened, some forcing-bed outside the body, yet we cannot refuse to admit these facts as evidence in favour of contagion.

But, after all, to what do these instances amount? Even admitting for the moment that contagion had taken place in some two or three hundred cases, extending over a period varying from five to fifty years, what are these amongst the

hundreds of thousands of cases in which no sign of contagion has been observed, and how can a disease be regarded as ordinarily contagious upon so small a foundation as this? A disease, moreover, that never occurs as an epidemic, but which has all the characteristics of an endemic disorder.

The absence of contagion in hospitals for consumption, to which we have already alluded, must also be taken into account, and from a review of all the evidence we are driven to the conclusion that whilst tubercle is a truly infective disease in the sense that it may be and generally is taken into the body along with air rendered impure by breathing, yet that direct infection from person to person is, in temperate climates at least, one of the rarest events.

How, then, are these opposing facts to be reconciled?

It is natural in the first instance to ascribe proclivity or immunity to the disease mainly to the influence of individual predisposition, and to say that though the germs of the disease may be present everywhere that human beings affected by it exist, yet that it cannot take root without a suitable soil—without either hereditary tendency to it, or some other source of weakness. There can be little doubt that this influence is, truly, very great, but it is difficult on this theory to account for some of the facts that have been stated. It will not account, for instance, for the multitude of cases of non-hereditary phthisis amongst the magnificent troops assembled in the Knightsbridge Barracks, nor for the comparatively low rates amongst the civil population; and it in no way accounts for the difference which we have found between direct and indirect infection.

We must seek, then, for some other mode of accounting for the limitation of the virulence of tubercular infection. Can it be found in the natural history of the organism so far as it has been drawn for us by its discoverer? Professor Koch found (1) that the bacillus would not grow except within

certain accurately defined limits of temperature, namely, from about 86° to 107° Fah.; (2) that it required at least a week in which to develop; and (3) that the best cultivation substance was a preparation of blood serum.

The second of these conditions is the one most important to our present inquiry, for it is obvious that, if the organism is in an active state, it will develop almost anywhere in the human body, provided it can rest in any tissue without being destroyed. The possibility, therefore, of the bacillus resting in the body, for at least a week or two, is the condition of most importance.

From Dr. Watson Cheyne's observations it appears that the epithelium of the ultimate portions of the air passages is the usual point of attack, and we may therefore suppose that it is necessary for the organism to effect a lodgment somewhere in this position.

But it is hardly limited to this mode of entrance into the lungs.

Deposits of fine particles of coal dust ("anthracosis," as it is called) are common in the lungs of miners and in the inhabitants of smoky towns; and other substances, such as oxide of iron (producing "siderosis"), particles of silica ("chalicosis"), may also lodge in the pulmonary tissues.

Dr. Klein has shown in his research "On the Lymphatic System and its Relation to Tubercle" ("Rep. of Med. Off. to the Privy Council," new series, iii., p. 82) that these substances make their way into the interalveolar lymphatics by means of the prolongation of the branched cells of the alveolar septa termed pseudostomata, and he accounts thus for the observation of Sikorski, who found that Carmine entered freely from the cavities of the alveoli into the lymphatics.

It can hardly be doubted that, if these inorganic particles can thus find an entrance, the bacillus of tubercle may surely do the same. The way into the body is therefore, so to speak,

open to the organism, and once planted in such soil, if it can remain there any length of time, it will find a suitable temperature and ample supplies of the nourishment that it requires. There would thus seem to be wanting none of the conditions that we have seen to be required for its development, and for the production of true tubercular disease.

There must also be, at any rate in towns, an abundance of these germs floating in the air we breathe. Consumptives for the greater part of their illness are not confined to their rooms, or even to their houses. They go about like other people, and mix in crowded assemblies of all kinds. The dust from their dried-up sputum must then be everywhere present, and this has been shown by Professor Koch to be capable of producing the disease.

I have also myself discovered a bacillus that was undistinguishable from that of tubercle in the vapour condensed from the breath of persons in an advanced stage of the disease.

How does it happen, then, that tubercle does not arise in healthy persons more frequently than we have seen that it does? And why does not direct infection from person to person take place even more commonly than its indirect production? What are the barriers that interpose? These are questions that are well worth considering at the present time.

In a perfectly healthy body, when every portion of the lungs is in full activity, a tuberculous infection may well be a rare event, for the specific organism has to run the gauntlet of several opposing forces.

1. The virus runs the chance of being at once entangled in the mucus lining the air passages, and of being speedily ejected by the action of the ciliary waves.

In some forms of lung disease, also, accompanied by copious bronchial secretion, the probability of this event is increased, especially if the accompanying cough prevents the lodgment of mucus in any of the air tubes. As I have myself shown, the organic matter of the breath is always less when there is much secretion. The immunity from phthisis of many cases of chronic bronchitis and emphysema is, perhaps, due to this cause.

On the other hand, the influence of a lessened mobility of the chest, and the consequent partial stagnation of the air, is shown in the tendency of the upper lobes of the lungs to tubercular deposit, and we may place in the same order of predisposing causes the evil results of a stooping or constrained posture during work. Perhaps, too, the well-known tendency to tubercular infiltration of parts of the lung, consolidated by catarrhal pneumonia, may be due to the facility afforded for a prolonged lodgment of the bacillus, and the same may be said of hæmorrhagic deposits in the lungs. In this case the organism would receive both board and lodging for a term amply sufficient, in many cases, for its development.

In the case of the various pulmonary deposits another condition favourable to the disease may also come into play—for

2. It is possible that the healthy body may have the power of destroying a certain quantity of the virus by the energy of vital actions, especially by oxidation in the highly vascular organs, the lungs.

The good effects of fresh air in preventing infections of this kind, as well as of every other, is testified by a multitude of witnesses, and we can hardly doubt that if the air passages are all clear and well supplied with pure ozonized air, it will destroy any bacillus that may have penetrated into the recesses of the lungs.

When, however, a lung has in any part lost its elasticity, and ceases to expel its residual air from that part, and when moreover there is but little bronchial mucus in the air-tubes, it must be very open to attack and must combine all the conditions that we have seen to be favourable to the onset of tubercular disease. Some physicians, notably Neimeyer and Buhl, have been so struck with the fact of some local inflammation being frequently the precursor of genuine phthisis that they have asserted the almost certainty of some antecedent inflammatory condition.

These two barriers against infection, then, may account, to a large extent, for the immunity of healthy persons to the disease, but it is not so clear why they should serve to protect nurses and others in close contact with the sick and yet should permit the production of the disease in persons who simply breathe impure air. Nor will the theory of the antagonism of an abundance of fresh air to the development of the organism entirely satisfy the conditions of the problem.

It is certain that free ventilation is a great enemy not alone to this, but to many other forms of infection, and it is not necessary to assume that the organisms in these cases have been destroyed by the oxygen or ozone of the air; it would be sufficient if they were prevented from producing spores, or were "attenuated" in some other way.

Dr. Angus Smith has shown that even sewage water may be protected from the action of bacteria for as long as two or three weeks in summer weather, by exposing it to one hour's aeration—(Rivers Poll. Pro. Act, 1876; Report to Loc. Gov. Board by Dr. R. Angus Smith, F.R.S., p. 55)—and *apropos* of some of his own experiments also, Mons. Pasteur remarks: "The question we have proposed is then solved; it is the oxygen of the air which attenuates and extinguishes the

virulence. To all appearance we have here what is more than an isolated fact. We must have reached a general principle. We may suppose that an action, which is inherent in atmospheric oxygen, an agent present everywhere, has the same influence on other viruses. At any rate, it is worthy of interest that possibly a general cause of attenuation exists dependent on an agent present, which is in a manner cosmical."

The whole history of the subject of ventilation as a preventive of phthisis is favourable to the hypothesis that the bacillus of tubercle is deprived of its power in the presence of fresh air, and would probably alone suffice to account for the rarity of direct infection of the healthy by the sick in general or in special hospitals for consumption. It would also account for the diminution of the phthisis rate after the introduction of good ventilation of barracks.

But the good influence of ventilation still fails to explain the infrequency of direct contagion in the overcrowded, badly aerated dwellings of the poor, and we have not yet grappled with the allegation that tubercle is more directly infectious in hot than in cold climates, an allegation that is supported by many significant facts.

It is certain that chronic inflammations of the lungs are not more common there, and thus one source of the disease, at least, is not more frequently present.

On the other hand, we have only partially explained the comparative immunity of the inhabitants of cold and dry countries, who suffer more from these chronic affections of the chest, and who ought therefore to be more exposed to the ravages of the bacillus. We have no reason to suppose that this organism is absent from the crowded towns and close rooms, which are certainly to be found even in Canada, and seeing that cases of phthisis do sometimes occur in these places, there would seem to be no special reason why the

disease should spread less frequently here than it does in the warmer, more genial air of Italy.

To construct a working hypothesis that will include all these points, as well as Professor Koch's conditions, it will, I think, be necessary to assume the existence of some condition antecedent to infection by the bacillus, and I venture therefore to suggest that the organism in question, like some other infective microzymes, may take up an increase of virulence by its sojourn for a time in some medium external to the body, and that this medium is usually the impure aqueous vapour of the breath in some definite proportion in the air.

We have not time now fully to develop this hypothesis, but I think that further consideration will show that it meets most of the requirements af the problem. It appears to me that we have at least strong *à priori* grounds upon which to proceed. It has been shown by actual experiment, as well as by the history of many epidemics, that the virus of cholera, and that of enteric fever, grows in intensity after its emission from the body, always provided that it meets with a suitable menstruum.

Pettenkofer indeed bases his cholera theory on the necessity for some such occurrence, and it is well known that enteric fever is much less infectious in the immediate neighbourhood of its subjects than when the poison has escaped into drinking water or into the sewers.

It is interesting to note also that just as in hospitals for consumption so in fever hospitals, medical attendants and nurses have been shown to escape contagion, and it is therefore not unnatural to surmise that the causes of this immunity may be the same in both cases.

Moreover, if the bacillus of tubercle is facilitated in its operations by its sojourn for a week or more in contact with putrefying organic matter at a constantly high temperature outside the human body, an explanation is afforded not

only of its greater infectiveness in hot climates, but also of the frequent occurrence of phthisis in the cottage houses of the poor, where it can find quiet lurking places in which the temperature is favourable to the germ, and in which the vapours arising from a badly-drained soil, as well as the polluted atmosphere, will supply the natural and fitting food of the organism.

The theory may also account for not a few of the cases of apparently direct contagion, and especially for the occurrence of infected houses and infected areas.

I simply broach the theory, however, as a subject for further investigation.

My task is now ended, but I should like for a moment to advert to certain collateral consequences of the conclusions at which we have arrived. Our aim in the inquiry before everything else must be truth, but it may be allowable to point out that if the doctrines now laid down are true, and I think they are, then what an emphasis do they lay upon the sanitary teaching respecting the need of fresh air and of good drainage.

They at once place consumption and other tubercular diseases amongst the list of preventible disorders; and further, they free the poor consumptive patient from the odium of being a source of special danger to his attendants, and, to a great extent, do away with the dread that many people now entertain of his giving his disease to others.

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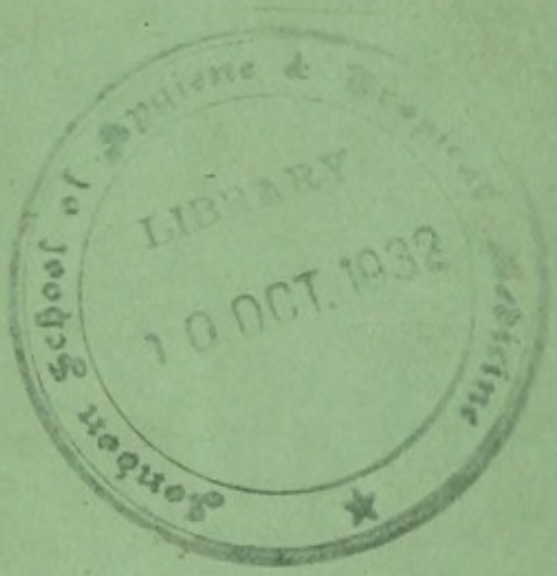
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