

LECTURE TO THE WORKING CLASSES,

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THE PREVENTION OF TUBERCULAR DISEASE.

I BEGIN what I have to say this evening by showing you a lantern slide, and I must ask you to note it well, for it is a portrait of the arch-enemy of mankind; I mean, of course, in a material and not in a spiritual sense. These simple inoffensive looking little rods and threads, which, when alive, have not even the humble faculty of motion of their own, are the tubercle bacillus, as it is called—a microscopic fungus which is the one true cause of consumption of the lungs and of the bowels, of water on the brain, of scrofulous glands, bones and joints, of lupus of the skin, of all those tubercular diseases in man and animals, about the prevention of which I am to speak to you.

I daresay you are all aware that of late years microscopic fungi of this kind, or microbes, infinitely minute particles—so minute that, as Professor Crookshank has told us, 400,000,000 of them could stand upon a penny postage stamp—have been proved to play a stupendous part in mundane and human affairs. Our improved microscopes have enabled us to watch them; ingeniously devised systems of experiment have enabled us to interrogate them, and thus we have satisfied ourselves that the study of bacteria and their products is of the utmost importance to the welfare of our species.

Do not suppose, however, because I have introduced microbes to you in connection with the tubercle bacillus that all microbes are like it, of a malign and pernicious nature, engaged in the production of disease. On the contrary, microbes, like human beings, are good and bad, and to those of the former character we owe not merely many of the comforts and luxuries of life, but perhaps our very existence itself. Like the busy and benevolent fairies of the tales of our childhood, these good microbes, although invisible, are incessantly and diligently at work, and do us many a signal service. They brew our beer for us, and ferment our wine, for where would these be without the yeast fungi? they bake our bread for us by converting starch into sugar, and that into alcohol, and carbonic acid; they

grow our corn for us by carrying on the process of nitrification in the soil; and they act as scavengers for us by the chemical changes they induce in decomposing organic matter.

But besides the good microbes we have the bad ones, and of these one great class—the pathogenic, or disease-causing—has been proved to be responsible for many of the worst ills that flesh is heir to.

These disease-causing microbes or bacteria (for they are all included under that name) are varied in form. When they are round or spherical, they are called cocci; when they are rod-shaped or cylindrical, they are called bacilli: and when they are twisted or screw-shaped, they are called spirilla. They vary also in their life history, and they vary very widely in their effects on animals and human beings. Amongst them we have the drum-stick bacillus that is responsible for tetanus or lock-jaw; Pfeiffer's bacillus, the short rodlets of which are believed to be the bearers of that influenza by which we have been recently so grievously visited; the clubbed bacillus of Klebs and Löffler, which sets up that diphtheria, the increase of which amongst us is giving rise to anxiety; the well-marked bacillus of anthrax, that decimates our flocks and herds as splenic fever, and communicates wool sorters' disease to human beings; the flagellate bacillus of typhoid fever; the capsuled micrococcus of pneumonia; and the comma bacillus of Asiatic cholera, that is for ever ravaging the East, and now and again makes desperate raids upon Europe.

And really, when we consider these disease-causing, these reprobate bacilli, and think of their dire effects, of the pain and weakness, the anguish and sorrow and death that it is their mission to spread over the world, we are tempted to liken them, small though they be, to those fell potentates of diverse essences who, according to Milton, assembled in council in Pandemonium: Beelzebub, Belial, Moloch, Mammon, Rimmon, Chemos, and the rest of them, and who since then

“Wandering o'er the earth
Through God's high-sufferance for the trial of man,”

have been ceaselessly contriving against his happiness in open onslaught or in hidden ambush. And, as in the Stygian conclave of Milton's “Paradise Lost” there was one, uplifted high, “by merit raised to that bad eminence,” Satan—the subtlest and mightiest of the infernal powers—so in the Synod of Bacteria there is a bacillus that stands forth paramount; the most cruel, inveterate, and relentless of all, and that is the tubercle bacillus, which I have already ventured to designate the arch-enemy of mankind.

And that the tubercle bacillus really deserves that appellation will be abundantly apparent when I tell you that the diseases to which it gives rise are the most terrible, deep-rooted and fatal of the scourges that afflict our present stage of civilization. In 1892, the last year for which returns are available, tuberculosis in its several forms caused 63,606 deaths in England and Wales, and in the year 1893, that is to say last year, it caused 1,731 deaths in this your City of Liverpool. Year by year tuberculosis is responsible for as great a sacrifice of life in your midst as occurred in the British Army on the field of Waterloo, while in England and Wales it kills annually nearly three times as many human beings as perished in the whole British Army in the Crimean War, killed in action or dying of wounds or disease. Could we but obtain an accurate record of the ravages of this ruthless destroyer—which is not like cholera, a thing of comparatively modern origin, for it has existed in all ages; which is not like leprosy, limited to certain areas, for it is spread all over the world—we should have an appalling revelation of human mortality. But the figures of such a death-roll, frightful though they might be, would but feebly convey to us the burden of misery and loss that tuberculosis has laid on our race, unless we reflected on the nature of tubercular disease and remembered that it involves in almost every case, not short, sharp pangs, but long drawn out suffering and distress. Water on the brain affecting children is soon over, but the other forms of tuberculosis are tardy in their course, and consumption, the commonest of all, has an average duration of from two to three years, lit up no doubt here and there by phosphorescent gleams of fallacious hopefulness, but dark, dreary and pain-fraught for the most part, and casting long, sad shadows around. If we remember further that tuberculosis carries off not the aged and worn-out but the young and the promising, that it selects often the brightest and fairest in the family circle, and that it takes a special delight in quenching the fire of genius and robs us of men like Spinoza, Keats, John Sterling, Kirk White, Hood, David Grey, John Richard Green, and Clifford, and of women like Charlotte and Emily Brontë and Rachel, when only half their work was done, we shall faintly realise the calamity that tuberculosis entails on our species, and that entitles it to be described as the arch-enemy of mankind.

Now this arch-enemy of mankind has only been properly identified of late years. Of course tubercular diseases have been long recognised and distinguished, but it was not until 1882 when Koch of Berlin undertook the most memorable research in modern pathology that their dependence on the

tubercle bacillus was proved. Before Koch's time, the particular tissue degeneration that is always associated with tubercular disease, the tubercle itself, was well known, and it was also well known that it contained some kind of *specific* poison, for it had been shown that if minute portions of it are taken from men or animals affected by tubercular disease and inoculated into healthy animals, these become affected by tubercle, at first at the seat of the inoculation and then by gradual circles of extension throughout their systems generally. But the tubercle tissue, thus inoculated, is a highly complex structure, and it was Koch who demonstrated that its one essential constituent that carries the disease is the tubercle bacillus, that he first brought into view. By ingenious modifications in the use of staining agents in preparing the tissues for the microscope, he succeeded in showing that it invariably contains one micro-organism with special character of its own, different from all others, which he named the tubercle bacillus.

When prepared and stained by Koch's method, tubercle bacilli are seen as delicate rods or little clippings of thread, thin and rounded at the ends, straight or more commonly curved, lying singly or in pairs or rows, varying in size but generally 1·3 micromillimetres or microns in length, that is to say so small that it would take two or three of them, end to end, to stretch across a red corpuscle of the blood, of which there are 5,000,000 in a cubic millimetre of blood or a drop the size of a pin head. As represented on the screen, the tubercle bacilli look far from insignificant, but they are here magnified 60,000 times, and I may perhaps best convey to you what that means if I tell you that a pin an inch long magnified to the same extent would be one mile long, and that I myself, if magnified to the same degree, would, in a recumbent position, extend across the country from Liverpool to Derby, a distance of about 70 miles, and no doubt attract the attention of the inhabitants of Mars as a new and magnificent terrestrial ship-canal.

The constant association of these minute bacilli with tubercular disease was demonstrated by Koch. He showed that they are invariably present in the lungs of persons dying of consumption, and are to be found in the expectoration of such persons during life. He traced them in the ulcers of the intestines in children dying of consumption of the bowels, along the blood-vessels of the brain in those dying of water on the brain, in the marrow of the bones of those affected by scrofulous joint disease, in the skin of those suffering from lupus, and in the tubercular nodules, discovered in the bovine species, in the monkey, sheep, rat, mouse, guinea-pig, fowl, or other animal subject to tubercular disease. And more than that, he

established that these bacilli are always most abundant when the tubercular disease is most active and where it is spreading into the surrounding tissue, and that they are never to be seen where tubercular disease does not exist.

But notwithstanding all these demonstrations, Koch was still far from having convinced his profession that the bacillus is the true cause of tubercular disease. The bacilli are, as I have said, most numerous around the edge of a tubercular nodule or mass, where it is growing and extending; they dwindle and become indistinct and infrequent as we approach the centre or original starting point where degeneration is most advanced, and where only the *débris* of broken down tissue remains, and in the centre, very often, no vestige of them is to be discovered. Now it was pointed out that if particles be taken from this centre of the degeneration, where there are no bacilli, and inoculated in an animal, copious crops of tubercles, all containing bacilli, are produced. The opponents of the bacillary theory, therefore, argued that the poison of tubercle is not necessarily associated with the bacillus, which is really a result of its operation or an accidental concomitant. But their argument was answered, when it was shown that the tubercle bacillus produces spores or seeds, specks much more minute than itself and of great vital resistance which may, like the seeds of plants, remain latent, as it were, in degenerated tissue long after the bacilli themselves have disappeared, to sprout into active life and multiplication whenever the surrounding conditions as regards nutriment, moisture, and temperature become favourable. These spores or seeds, although indistinguishable when isolated, may often be seen to the number of two to six enclosed in the bacillary rods, and they it is that communicate the disease when tubercular tissue without visible bacilli is inoculated, and that play a very important part, as we shall see, in the propagation of tubercular disease amongst human beings.

But still, even after the demonstration of the spores of the tubercle bacilli, Koch's proof was incomplete. In all direct inoculations of tubercular tissue from man to animals, or from one animal to another, many elements besides the tubercle bacillus or its spores are transplanted, and it is, of course, possible that one of these, and not the accompanying bacillus or its spores, has infective properties and may be chemically or organically the source of the transmitted disease. It was only by isolating the tubercle bacillus from all its surroundings, inoculating it and it alone into an animal with the result of setting up tubercular disease that an absolute conclusion could be arrived at. And this Koch has done. He discovered that the bacillus is not exclusively parasitical, but can live outside

the living body which is its usual home, and he found that the solidified serum of blood, when kept at a proper temperature, is a nutrient medium on which it can thrive and multiply; and then by a series of most delicate manipulations he succeeded in obtaining pure unadulterated cultures of the bacillus. Under strict antiseptic precautions he dipped the point of a needle into a tubercular nodule in a newly-killed animal; he drew that point across the surface of some solidified serum in a test tube; he kept the test tube in an incubator at blood heat, and in a proper degree of moisture, but protected against any possible contamination by germs from the air, and he had the satisfaction of observing, in from ten to fifteen days, some small grey specks or tiny scales along the track of the needle point which expanded and coalesced, and which when microscopically examined proved to be pure colonies of the tubercle bacillus. From the cultivations thus made invisible specks on the point of a needle were transferred to other tubes containing solidified blood serum, in which colonies of tubercle bacilli again sprang up, and so on through many tubes and many generations of bacilli. And, last step of all, Koch took the pure cultures of tubercle bacillus thus obtained and inoculated them under the skin or into the blood or serous cavities of healthy animals, in which invariably in due course tubercular disease marked by tubercles, containing crowds of bacilli, was developed. He thus crowned the edifice of his great discovery, and put it beyond cavil for ever, that this little organism is the one true cause of tubercular disease—that arch-enemy of mankind seeking whom it may devour, the origin of the breathlessness, the cough, the hectic fever, the wasting, of all the dread symptoms that we associate with consumption, that feeder of our graveyards, the harbinger of the grief and desolation of many homes. Where this bacillus is present there we have tubercular disease; where it is absent tubercular disease is not, and hence it has now become a matter of routine practice to examine the expectoration in every case in which there is reason to suspect consumption. Our diagnosis is thus enormously aided. We are often able to banish unnecessary anxieties and fears; we are often able to detect the disease at its beginning when it is most amenable to treatment, and we are often able to estimate, by the number of bacilli in the expectoration from day to day, the rate at which the lung structure is breaking down. The doctor who, now-a-days, in any doubtful case, omitted an examination of the sputum or expectoration would be guilty of a grave dereliction of duty.

The tubercle bacilli being the true cause of tuberculosis—and that truth is now universally accepted by the medical

profession—it is obvious that we must aim at the destruction of that bacillus, at a diminution of its virulence, at its exclusion from the body, or at its rapid elimination, should it have gained an entrance, in all measures for the prevention of tubercular disease. Koch thought to take a short cut to the abolition of tubercle. He had noticed that the tubercle bacillus is readily killed outside the body by various agents called germicides, such as corrosive sublimate, cyanide of gold, carbolic acid, ethereal oils; but, unfortunately, most of these germicides are poisonous to, or exert an injurious effect on the tissues, and so could not be employed for the destruction of the bacilli in the body, even had the tubercle been in positions accessible to their application in sufficient strength to prove fatal. But he knew that in certain cases, for instance, in small-pox, the action of disease-producing bacilli upon the body is modified by the use of vaccines—attenuated or mild cultures of the same bacillus—which accustom the body to the action of the poison of the bacillus and enable the tissues to resist it when presented in its more virulent form, or confer what is called immunity. He knew that the tubercle bacillus cultivated outside the body varies greatly in virulence, according to the nature of the food on which it is fed—the addition of a little glycerine to its diet weakens it considerably—and he hoped that he might attain an attenuated virus of tubercle, which would protect against tubercle just as the attenuated virus of small-pox—the small-pox bacillus after being fed on the tissues and juices of the cow—protects against small-pox when employed in vaccination. In this hope he was disappointed, but in his pursuit of it he hit upon some results of a very remarkable character and believed he had discovered an agent that, like Pasteur's inoculation against hydrophobia, would stop tubercular disease, even after it had obtained a foothold in the system.

The action of the tubercle bacillus on the living being is due not to its mechanical intrusion on the tissues, but to a poison it secretes, which enfeebles and kills the living cells of which the tissues are made up; and this poison Koch succeeded in separating from pure cultures of the bacillus as a glycerine extract, which he named *tuberculin*. In a diluted condition this tuberculin injected into the body was seen to have no perceptible effect on healthy animals, but to have striking effects on animals already affected by tubercular disease. In the latter it sets up general fever and local reaction around any existing tubercular deposits. It stimulates the cells in and around these deposits, induces dilatation of the blood-vessels and increased flow of blood to them, and leads, it is alleged, either to the softening, sloughing and removal of the tuberculous masses or to the formation of a

barrier of sound tissue around them, preventing the migration of the bacilli into neighbouring parts, cutting off their supplies of nourishment and compassing their death.

I am not going to perplex you with the theories as to the mode of action of Koch's tuberculin, but there can be no question that it had powerful and even startling effects on the animals on which it was first employed, and on the human beings to whom it was subsequently administered. In lupus in the latter, the tuberculous parts were actually seen dying, as it were, sloughing away and leaving a clean healthy surface, and it was too hastily proclaimed that tuberculin was a cure for tubercle, and that an effectual remedy had been discovered for the most disastrous of human maladies. Thousands of consumptive patients flocked to Berlin to be inoculated, and at first the reports were favourable, but after a time it appeared that the recoveries under tuberculin were not permanent, that its effects were uncertain, and that in some cases, instead of curing the disease it led to its increased activity, and early death.

Tuberculin has certainly not fulfilled the expectations that were formed of it, and, as a therapeutic agent, it has fallen into disuse, but we need not on that account despair of still finding some other substance that will do what tuberculin has failed to do. There are reasonable grounds for anticipating that unless folly and fanaticism and ignorance are allowed to prevail all over Europe and put a stop to experiments on living animals, we shall yet discover some agent that will infallibly control tubercular disease, that will follow up the tubercle bacillus like a sleuth-hound through the tissues and exterminate it, wherever it may be. It seems all but certain that in the antitoxin of Tizzoni and Cattani we have secured a substance that prevents the fatal development of tetanus or lock-jaw, or cures it. It seems highly probable that in the antitoxin of Behring, Roux, and Kitasato, we have had put in our hands a weapon which will enable us to reduce enormously the mortality from diphtheria. I had described to me lately two desperate cases of tetanus, in which the action of antitoxin was almost miraculous, saving the patients even at the eleventh hour, and indeed the medical journals just now teem with such cases and with cases in which the injection of a few drops of serum has compelled that bacterial thug, diphtheria, to slacken its strangling grip. It is not, therefore, extravagant to hope that an equally potent antidote to tubercle will one of these days be revealed to us.

Potent antidotes to tubercle are, indeed, being suggested from time to time. Within the last month Dr. Seymour Taylor has made a preliminary announcement that he has

secured most satisfactory results in the treatment of consumption with aniline, which destroys low organisms, and with which the tissues may be safely saturated to such a degree that they are dyed red like a cotton or woollen fabric; while Dr. Viquerat, of Geneva, has published abroad his discovery that that long-suffering, much derided, but always dignified animal, the ass, affords in the serum of its blood a sure remedy for tuberculosis.

Great prominence having been given to Dr. Viquerat's alleged discovery by a paragraph in *The Times*, which reported that twenty-five out of twenty-seven patients suffering from consumption in the second and third degree, who had been given up by their physicians as lost, were cured by it, I thought it worth while to make some inquiries regarding it, and enlisted the services of my friend Dr. Arthur Gamgee, of Lausanne, eminent alike as a physiologist and practical physician, than whom there is no one more competent to investigate such a matter.

Dr. Gamgee visited Dr. Viquerat's laboratory at Moudon on the 19th instant, and spent several hours in listening to his explanations and in examining his apparatus and records, and while acknowledging his courtesy and candour, he has no hesitation in arriving at the conclusion that his statements as to the curative effects of the serum of the blood of the ass in consumption are as yet unsupported by trustworthy scientific evidence.

This is not, I believe, the first cure for consumption that Dr. Viquerat has introduced to the notice of his profession and the public, but there is, as Dr. Gamgee points out, nothing inherently improbable in his statements. On the contrary, the splendid results, just referred to, which have followed the use of the antitoxin of Tizzoni and Cattani in tetanus, and the promising observations that have been made by Behring, Kitasato, and Roux on a similarly prepared agent in diphtheria, predispose us to believe that the blood serum of an animal rendered immune to tubercle might modify or arrest the progress of tubercular disease in human beings. But, unfortunately, Dr. Viquerat does not seem to have advanced much beyond the stage of "no inherent improbability" in his preconceived notion. He is not able to adduce proofs of his allegations that will satisfy anyone who is not dominated by a preconceived notion, and there is certainly a large measure of inherent and asciticulous improbability in some of the observations he quotes in corroboration of his views.

Dr. Gamgee found in Dr. Viquerat's laboratory an entire absence of that nicety and precision that are essential for accurate results in bacteriological research, and he noticed in some of his processes a crudity which is suggestive not merely

of error but of danger. The blood of the ass, for example, from which the serum is prepared is obtained by bleeding with an ordinary veterinary surgeon's fleam, and it is received in a large vessel which is placed over ice for 24 hours, when the serum is separated and has added to it 0.5 to 0.75 per cent. of carbolic acid, after which it is ready for use. As Dr. Gamgee remarks, this process affords not the slightest guarantee that the serum remains sterile, and there must certainly be great risk in using it on the human subject.

Dr. Gamgee gathered that until quite recently Dr. Viquerat used for his injections the blood serum of the ass pure and simple from animals which had undergone no previous preparation. At present, however, he uses the serum from an ass that, not less than six weeks or more than three months previously, has been subjected to an intra-venous injection of a bouillon culture of the tubercle bacillus and to a subcutaneous injection of the same. He asserts that as a result of these injections the donkey becomes temporarily tubercular, and that if examined between the fifteenth and thirtieth days the lungs are found full of miliary tubercles. This tuberculation of the donkey, according to Dr. Viquerat, which clears up in from the thirtieth to the fortieth day, is free from danger and unaccompanied by fever, and is marked only by an enormous increase of appetite. But for all these observations of Dr. Viquerat there is no independent testimony, nor is he able himself to supply any exact data, or anything beyond meagre assertions and general statements. Dr. Gamgee could obtain no information as to the number of animals experimented on, and of course a very large number of experiments would be required to establish some of Dr. Viquerat's conclusions, but he discovered that during the last three months Dr. Viquerat has only had one ass to furnish him with all the serum used in his therapeutical work.

The results of Dr. Viquerat's treatment of tubercular affections are set forth in a short report by a medical man who only attaches his initials to it, but who is, it may be inferred from the infallibility of his style, a very young man. The report contains a list of twenty-five cases, but an examination of the list reveals that there is no guarantee whatever for the correctness of diagnosis in these cases. Taking the only cases that are beyond the reach of gross error—cases in the third stage of phthisis, and with cavities, we find that there were seven such cases treated. Of these one was cured! Of the remaining six one died, two admittedly had not improved and were obviously worse; while the other three are still under treatment and are said to be somewhat better. It is to be remembered that

Dr. Viquerat's experiments were begun in February last, and that his treatment of consumption has been going on for only a few months. That treatment, even on his own showing, is not satisfactory.

It is announced that an institute is about to be founded at Geneva for the treatment of tuberculosis by Dr. Viquerat's method. It is to be feared that credulous and despairing consumptive patients, trusting to exaggerated accounts of its success, will flock there only to incur disappointment, and it seems important, therefore, that the true nature of that treatment should be made known, and that it should be subjected to impartial criticism.

But even while buoyed up by the hope of finding a trustworthy antidote to tubercle we are not in the meantime justified in sitting with our hands crossed waiting for the discovery of a specific against it. We have as yet no cure, but we have even now means at our disposal which, under existing circumstances, will enable us, if properly employed, greatly to circumscribe the ravages of tubercular disease, and it is towards these presently available means of prevention that I now wish to draw your attention.

In their widest sense these means embrace the whole of hygiene, for whatever makes men, women, and children, healthy at the same time fortifies them against the attacks of their tubercular enemy. All sanitary improvements, therefore, tend to reduce the mortality from tubercle, and it can be shown that there has been a diminution in the number of deaths caused by certain forms of tubercular disease owing to ameliorations in the dwellings and habits of life of our people.

Sir George Buchanan has given us grounds for believing that a damp wet soil is very conducive to the prevalence of consumption in the population living on it, and has indeed shown that in certain counties in England there is a relation between the distribution of consumption and the geological formation; the consumptive death-rate being high where the ground is moist and of a character to hold water, and low where it is dry and of a character to let water run readily away. Well, there can be no doubt that drainage, both in agricultural districts and towns, has been carried out most extensively in this country during the last forty years, and there can be no doubt that during the same period there has been a steady fall in the mortality from consumption. In 1852 consumption caused 50,594 deaths, or at the rate of 2,851 deaths per million of the population living, whereas in 1892 it caused only 43,323 deaths, or at the rate of 1,468 per million living; and the noteworthy fact is this, that the diminished fatality from

consumption has in the towns almost invariably followed the adoption of a system of main sewers and of house drainage with drying of the soil. The best drained towns on the driest soils are those that are freest from consumption, the worst drained on the wettest soils are those on which it still keeps the tightest hold; and the moral is that dampness in any town or dwelling is an invitation to the tubercle bacillus to come in, while dryness is a notice to it to pass on elsewhere.

The more rational feeding of infants in recent years has, no doubt, reduced the mortality from consumption of the bowels; and I might, indeed, go on enumerating to you all the modern sanitary advances on which we pride ourselves, and indicating how they have all influenced, more or less, the prevalence of tubercular disease amongst us, having done so by their beneficial effects on general health; for I want to emphasize the truth, already referred to, that perfectly healthy people are never successfully attacked by the tubercle bacillus.

But perhaps that statement may seem to some of you inconsistent with the other statement just made, that the tubercle bacillus is really a virus or poison acting upon the system. A sufficient dose of strychnia, you may say, will kill a man whether he be healthy or unhealthy. Why should not a sufficient dose of tubercle bacillus do the same? And the answer to that interrogation is that the tubercle bacillus is never received in a sufficient but always in an infinitesimal dose, and that, not being an inert substance, but a living organism, it manufactures its poison, and in ever-increasing quantity, after it has got possession of its victims. And there is a further answer to that interrogation, which is to this effect: that the tubercle bacillus never succeeds in invading the system without a struggle, and that the forces that oppose its invasion are much stronger in healthy than in unhealthy individuals. Extraordinary though it may sound, it is veritably correct that there are in the animal economy what we may call military as well as industrial cells, a standing army, or at any rate a volunteer corps, charged with the defence of the organism. The military cells—white corpuscles of the blood and connective tissue cells—are of two kinds, large and small, infantry and cavalry, and they instantly muster in force whenever any infective bacilli attempt to effect a landing in the tissues, and then a battle royal ensues. The small cells, the infantry, advance first and throw out a secretion which acts injuriously on the invading bacilli and cripples them, and then they come to close quarters with these enfeebled bacilli and eat them up and digest them; and after that the large cells, the cavalry, appear on the scene and eat up what remains of the bacilli and, I

regret to add, very often eat up their own infantry into the bargain. Of course the victory is not always with the animal cells. The invading bacilli or fungi throw out their poison, which may stupify or kill the cells; they defeat, or overpower, or slip past them, and entrench themselves in some favourable spot from which they make sudden sorties, or where they may long lie inactive, waiting to renew hostilities at any moment of constitutional embarrassment or weakness. The outcome of the contest depends on the infective force of the bacilli on the one hand and on the vitality of the cells on the other, and the vitality of the cells depends on the state of health of the body to which they belong, and hence it is that healthy people can resist infective bacilli when weakly people succumb to them.

This is no fancy picture I have drawn, but a literal description of what takes place when tubercle bacilli effect a lodgment in the throat or lungs or on any mucous membrane, or when they are inoculated into a wound; and how vast the forces engaged in the campaign in the case of a tubercular invasion are, may be inferred from the computation that a phthisical patient will often expectorate twenty million bacilli in twenty-four hours. I venture to affirm that there is not one of us in this room who has not at some time or other been attacked by tubercle bacilli, for they are always about; but, happily, we are in good health at the time, our defensive tissue cells were vigorous and vigilant, and so we defied the intruder; we resisted the arch-enemy of mankind and he fled from us. Had we been worn out or debilitated there might have been another tale to tell. And it is not only at the first onslaught of the tubercle bacillus, but at every step in its advance—should it have gained a foothold in the body—that this struggle between it and the tissue cells is carried on; inch by inch its progress is disputed, and one of the grand principles in the treatment of consumption is to restore, if possible, to general health, and so strengthen the hands of the defending cells. Whatever improves the nutrition of the tissues retards the disease, and if the tissues can be brought back to a certain standard of health, it is checked and routed altogether. Whatever lowers the strength and interferes with nutrition promotes the conquering career of the bacillus.

You will now understand why a state of robust health is the best protection against tubercle, and how all sanitary precautions may be regarded as measures for its prevention.

About such general preventive measures, however, I do not propose to say more, but will occupy what time you will still spare me in pointing out some special protective measures, and

these I shall consider in connection with the chief channels by which the tubercle bacillus invades the system, that is to say in connection with (1) hereditary transmission, (2) inhalation with air, (3) ingestion with food, and (4) direct inoculation.

As to the first of these, hereditary transmission, it is perhaps scarcely justifiable to speak of it as a channel of invasion of tubercle, for while believing that a tubercular mother may in rare instances communicate tubercular disease to her unborn offspring, we are not entitled to assert that tubercle bacilli or their spores are ever directly handed down from the parent of either sex to the infant in such a manner as to remain latent in its tissues at birth, to become active, as scrofulous glands in childhood, or as consumption in youth. Several eminent authorities think that this is so, but it is possible to find an explanation of the hereditary character of tubercle in another way. That hereditary character is indisputable and is within the knowledge of each of you. You all know consumptive families in which there have been several instances of the disease in the same generation or in successive generations, and, allowing for the chances of simultaneous infection in persons living under precisely the same circumstances, there is still an ample margin of proof that the members of certain families, even when widely scattered, are specially liable to this disease, and that it clings to certain lines of descent as tenaciously as do peculiarities of the features of the face, or of the physical configuration. We have, indeed, come to recognise certain external appearances as indicating a phthisical or consumptive habit.

But the consumptive habit and special liability to consumption may depend on the hereditary transmission, not of the bacillus, but of a constitution of body favourable to its reception and growth. We know as regards the seeds of vegetables that they will only germinate and grow in the soils to which they are specially adapted, and the same is, in all likelihood, true of seeds of bacilli. Especially is this likely to be true of the seeds of the tubercle bacillus, which is a very fastidious member of its tribe. In artificial cultures, outside the body, there are only a few media in which it will thrive, and in using it for inoculation it has been found that there are certain species of animals that altogether resist its action, and that even in the same species there are individuals much more refractory to its action than others. It can be readily understood, therefore, that human beings who vary so much in temperament, that is to say in tissue states, vary also in their susceptibility to tubercle, and that there are certain types of them which afford in their tissues a soil particularly congenial to the bacillus. In

them it takes root and spreads luxuriantly. The existence of tubercle in any individual affords a presumption that he or she is of that type: the existence of it in two or three members of one family affords proof that that family is hereditarily predisposed to tubercular disease.

And the lesson to be drawn from all this in prevention is that no human being actually affected by tubercular disease ought to marry on any pretext whatever, and that every man and woman should reflect well before marrying into a family in which a strongly declared tubercular tendency exists. In the first case the penalties are certain; in the second they are highly probable; and these penalties are of such a nature that a responsible human being may well pause before incurring them himself or inflicting them on others. I trust at no distant day public opinion will pronounce it not merely imprudent but flagitious for anyone on whom the plague of tubercle has fallen to marry or be given in marriage, and will condemn still more unsparingly the healthy partner in such a transaction, who, without the excuse of powers weakened by a morbid taint, sells not himself but his progeny to the arch-enemy of mankind. I trust also that at no distant date pure blood will be esteemed more highly than blue blood, and that the existence of tubercle in any family will be regarded as a bar-sinister on its escutcheon. Thus may moral forces operate for the prevention of tubercular disease.

The second channel of transmission of tubercle which I have mentioned is by inhalation, and is perhaps the most important of any, for I include under it direct infection from person to person, and the inspiration of tubercle bacilli or their spores floating in the air, alone or attached to motes in the sunbeam, and in connection with this channel there are valuable preventive measures to suggest.

Direct infection has been called in question, and the strongest argument against it has been founded on the statistics of Dr. Theodore Williams, which show that the nurses and medical staff of the Consumptive Hospital at Brompton, who are of course constantly in contact with tuberculous patients, are not more frequently affected by tubercular disease than members of the general community not so exposed; but this is probably to be accounted for by the state of high health in which these nurses and medical officers are maintained. Carefully selected in the first instance, at least as regards the nurses, for no one with tubercular tendencies would be engaged as a nurse, they are well housed and fed, and abundantly provided with fresh air and exercise, and are kept in that sound condition in which their tissues are well able to repel bacillary attacks. And on

the other hand, the evidence in favour of the propagation of tubercle by direct infection is already sufficient to be convincing, and is always increasing in volume. This view has been long held in Italy and Spain, and is gradually obtaining acceptance amongst ourselves. The often observed contemporaneous or rapidly successive explosions of tubercular disease in a number of members of the same household, related or not, and amongst the inmates of public institutions, suggest infection, which is again made probable by the numerous recorded cases in which consumption has been contracted by a husband from a wife, or *vice versa*, particularly when they have been living together in a confined space, as for example, in the cabin of a ship on a voyage to or from India. The contagiousness of tubercle is, I think, demonstrated by cases like the following:—

Mrs. R., aged 48, a dressmaker living in a rather lonely cottage at C., in Bedfordshire, had three apprentices, young girls of from 17 to 19 years of age, not related, and from three adjoining villages, who took it in turn to remain in the house and sleep with her, each one for a week at a time. During their apprenticeship Mrs. R. was taken with consumption from which she died. In less than two years afterwards all three apprentices died of consumption, although in the family history of not one of them did any trace of it occur.

The presence of tubercle bacilli and their spores in the air breathed by consumptive patients, floating independently or buoyed up by particles of dust, is now indisputable. Dr. Williams hung up glass slides smeared with glycerine in the ventilating shafts of the Brompton Hospital, and shortly found tubercle bacilli adhering to the glycerine; and Dr. Cornet, by elaborate experiments, conducted in the rooms of private consumptive patients and in hospitals, has shown that tubercle bacilli are expired by consumptive patients, in small numbers, and that they and their spores, which remember are very indestructible, and will retain their vitality even when dried, are given off in clouds from the handkerchiefs and bed-linen of consumptive patients, and from the floors or walls of the rooms they inhabit, if they are not scrupulously cleanly in their ways, from any place or thing, in short, with which their expectoration has come in contact. Cornet has further shown that tubercle bacilli may be caught in open spaces and in the air of streets and squares where tubercular persons are present, and in all these cases he has shown that the dust collected when inoculated into animals, sets up tubercular disease. Klein has shown that guinea-pigs become tubercular when finely divided tubercular matter is diffused by a spray producer in the air of

their hutches, and he has succeeded in communicating tubercle to these animals by keeping them for a time in cages in the ventilation extraction shaft at the Brompton Hospital, through which the foul air from the wards passes. And quite recently M. Straus has communicated to the Académie de Médecine in Paris a very instructive observation. By means of little plugs of cotton-wool, the dust and mucus from the nasal orifices of twenty-nine healthy nurses and medical students, serving in the wards of hospitals containing consumptive patients, were collected, and solutions prepared from these were injected into twenty-nine guinea-pigs, of which nine manifested tubercular disease within a month. There can no longer be any doubt that the air of apartments occupied by consumptive patients is loaded with virulent dust, that the germs of tubercle exist in the atmosphere of all populous districts, and that the inhalation of the dried virus floating in the air is one of the commonest ways of the propagation of the disease.

Now seeing that we are thus surrounded by a cloud of witnesses of a very undesirable kind, who will swear away our lives if they can, seeing that the principle of death lurks in the very vital air we breathe, what must we do to be saved? What preventive measures does our new knowledge propose to us? Clearly, first of all, we must henceforth regard consumption as a contagious disease like small-pox, not of course as rapidly and conspicuously contagious, but slowly and insidiously so, and we must in some measure secure isolation for those suffering from it. It is not proposed to make our consumptives like lepers, a class apart, but assuredly special public hospitals, supplied with every possible appliance for their comfort and treatment, should be provided for them—hospitals in which they should not mix with patients suffering from other diseases, and in which the walls and floors of wards and rooms should be tiled or cemented throughout, so that they may be periodically subjected to thorough washing and cleansing; and assuredly in private homes consumptives should invariably occupy separate rooms. It is culpable to allow them to sleep in the same rooms with healthy people, and especially with children, and their presence in places of public assembly or entertainment is decidedly hazardous. Within the last three months the authorities at Toronto have set an example worthy of imitation, by upholding the Medical Officer of Health in prohibiting the attendance at a public school of a child affected by consumptive disease. In Florence it has long been the practice that, when anyone dies of consumption in a house, the bed is entirely destroyed, and all the clothes of the deceased, while the room is fumigated and shut up for a time. But we should not

postpone our precautions till death has taken place, but concentrate our attention upon the receptacles of that expectoration which is known to be the chief vehicle of infection. Pocket-handkerchiefs and bed and body linen used by consumptives must be carefully sterilised by hot air or steam, and powerful germicidal agents, and expectoration should be invariably received in spittoons containing a strong disinfectant. But our enlarged acquaintance with the possibilities of inhalation of the tubercle bacillus not only suggests isolation of the sick and disinfection of their surroundings, but increases the obligation which has all along rested on us to insure good ventilation of our houses and public buildings. Where air stagnates the tubercle bacilli accumulate, and are reinforced; where it is in brisk movement they are scattered abroad and disarmed. Consumption is most common in cities and in their most densely populated parts, and is rarest in purely rural districts. In London the deaths from consumption were, during the ten years 1881 to 1890, at the rate of 2.08 per thousand living, and in Lancashire they were at the rate of 1.95, whereas in the purely rural counties of Somersetshire and Dorsetshire the rates were only 1.35 and 1.39 respectively. The history of public institutions of many kinds brings home to us the connection between defective ventilation and high phthisis mortality. Previous to the report of the Royal Commission on the sanitary condition of the army in 1858 our barracks were overcrowded and destitute of fresh air, and the mortality from consumption amongst our troops was terrific. In the ten years 1837 to 1846 it reached 11.9 per thousand of strength. But after the report of that Commission, the allowance of air-space per man was considerably increased and ventilation was attended to, and the mortality from consumption immediately and rapidly declined; it fell in 1888 to 1.2 per thousand of strength. And similar experiences might be quoted from the histories of prisons, schools, asylums, religious houses, in all of which the mortality from consumption in the past has been excessive, sometimes appalling. In Austrian prisons consumption was at one time responsible for 61 per cent. of the whole mortality, while it was only causing 14 per cent. of the mortality outside the prison. In many such establishments the tubercular death-rate is still far too high, but in most of them it has fallen and is falling. In such establishments of course many factors, such as meagre and monotonous diet, insufficient exercise and depressing emotions, have contributed, with the want of fresh air, to swell the mortality from tubercle by lowering the general health and so allowing an opportunity to the ever-present bacillus to steal a march on the constitution; but it is demon-

strable that the impurity of the atmosphere in the living apartments, and especially in the sleeping rooms, has been mainly to blame for their evil reputation as hot-beds of consumption.

Then ventilation is not less necessary for the prevention of tubercular diseases in mines, factories and workshops, than it is in public institutions. The loading of their atmosphere with particular kinds of dust, appertaining to the trades carried on in them, is a prolific cause of tubercle in the lungs, and we have come to speak of miners' and knife grinders' and potters' consumption. The dust in such cases penetrates the lungs, and by its hardness and angularity wounds the mucous membrane, setting up irritation and catarrh, and creating that raw surface on which the tubercle bacillus loves to fasten and batten.

The ventilation of mines, factories and workshops is a matter for factory inspectors who ought to, and no doubt do, give it their most zealous attention, and we may hope that their exertions will ultimately, to a great extent, banish dust from these places, or enable it to be dealt with in such a way as to make it innocuous, but the ventilation of the home is the business of the individual man as well as of public authorities, and these must co-operate if it is to be satisfactory.

In humble homes there is still, it is to be feared, too little appreciation of fresh air, too much apprehension of an open window; and when driving through a dingy, stifling working-class quarter of a big town the other day, and seeing the walls placarded with bills "Register! Register! Register!" it occurred to me that a much more valuable exhortation would have been "Ventilate! Ventilate! Ventilate!" But it must be admitted that even with a desire to ventilate properly, it is in many workman's homes impracticable to do so. To open the windows is to admit foul odours, and the construction of the house absolutely prevents any through current of air. Nothing can interfere more with free ventilation than that abominable system of economical construction, still tolerated in many towns, and known as back-to-back houses. Dr. Tatham, the Superintendent of Statistics to the Registrar-General's Department, showed that in certain courts and streets in Salford, consisting of back-to-back houses, tubercular disease was much more common than in other parts of the same town; that this disease reappeared in the same houses in these courts and streets again and again, and that the proportion of deaths from tubercular disease in the different districts of Salford increased in proportion to the number of back-to-back houses they contained. Dr. Herbert Jones has confirmed Dr. Tatham's conclusions, and has shown that in Saltaire and Ripley, in Yorkshire, the deaths from consumption are at the rate of

2·3 per annum to each 1000 living in houses with through ventilation, and at the rate of 3·4 in back-to-back houses. And Dr. Hope, your own able Medical Officer of Health in this city, has revealed that in certain streets of insanitary houses in Liverpool, happily about to be demolished if they have not already been so, the death-rate has mounted to 61, 67, and even 71 per 1000, that is to say more than three times the average rate for England. And in the production of these enormous death-rates tubercular diseases have played a prominent part. After reading Dr. Hope's description of the houses in which these death-rates prevailed, the wonder is not that so many persons died in them, but that anybody remained alive. He describes 578 houses, each consisting of three rooms, one over another and without any intermediate landing, so that the same atmosphere pervaded the entire house. They were back-to-back and side-to-side, with no separate sanitary accommodation; they had bulging walls, dilapidated window sills, crumbling mortar, rotten wood-work, and walls and ceilings grimy and saturated with foul-smelling exhalations.

Is it not high time that such pest-ridden habitations should be swept away? Is it not high time that the working classes should insist on local and municipal authorities using all the powers they possess in dealing with crowded and insanitary areas, and if these powers are not sufficient, demanding more? The prevention of tubercular and of many other diseases, the health and happiness of the rising generation, the industrial supremacy and the morality of the nation are at stake in this question. The Artizans' Dwelling Act of 1890, which enables the ground to be cleared in towns and a better class of dwellings to be provided for our toiling masses, is, it seems to me, one of the most sensible Acts passed by Parliament in our generation, and I trust that a pregnant suggestion thrown out by Mr. Chamberlain, that great and enlightened statesman, that the principle of the Irish Land Act should be applied in English cities, and the working classes be enabled, by the assistance of the credit of the State, to become the owners of their own dwellings, will not be lost sight of. "Own" is a sweet sauce to eat sour cherries with; it would, I believe, prove a potent anti-septic for the conversion of dirty, insanitary hovels into clean and wholesome human abodes. The expense to the ratepayers of such operations would, no doubt, be great, but a rich return would be obtained if the money were judiciously spent, and even the most affluent citizens living in the best parts of the town would benefit indirectly in the betterment of the health of their families. You cannot touch pitch without being defiled, and you can scarcely live amongst disease without being tainted.

The town that is healthiest and most contented is the safest to live in, and we are all interested in the prevention of tubercular disease.

The problem of the housing of the working classes in towns is no doubt difficult of solution; and is day by day becoming more complex, owing to the rapid growth of towns and the tendency of population to gather in them. The cry is still, they come. From ploughed fields and pastoral valleys, from ruddy hamlets set in bosky green, and brine-stained villages on many a breezy shore, a constant stream of men, women and children, driven by hunger, or drawn by the flare of the gas-lamp, flows into our narrow streets and noisome slums. To set against this centripetal stream we have a comparatively small centrifugal one of well-to-do people, who carry on their business in towns and make their homes in the country; and it may be Utopian, but I hope to see a very large increase of this centrifugal stream, and the provision of suburban homes for the working classes—with facilities for transit to and from them—homes in which they may enjoy fresh air and relaxation. A little cottage in the country with a curtilage around it is worth far more in all sanitary respects than a three-storey house with a brass door-knocker in a street. Garden allotments are very good things in their way, but it is a drawback to have to trudge to and from them, and it is not as refreshing as it might be to delve a patch in a row of patches—a sort of treadmill horticulture; while it is certain that every man of Teutonic origin has an ineradicable partiality for a hedge of his own. A cottage with a little garden around it is what a working man should aim at as the best sort of sanitary dwelling. “Now and then,” says Ruskin, “a wearied king or a tormented slave found out where the true kingdoms of the world were, and possessed himself in a furrow or two of garden ground of a truly infinite dominion.” And so many a time and oft henceforth I trust wearied workmen and their school-worried children will find in a few furrows around the cottage home new interests all the year round, yielding mental rest and infusing a little poetry into dull and prosaic lives, and also that exercise in the open air which is incontestably preventive of tubercular disease. It has been shown that in proportion as the male and female populations are severally attracted to indoor branches of industry, in such proportion, other things being equal, their respective death-rates by lung diseases are increased. An outdoor life wards off consumption and sometimes cures it, and the dangers of inhalation of tubercle are diminished where there is active movement under the blue sky. And in this connection the mode of life of our school children demands some attention in these days. It

will not be disputed that children of school age in our elementary schools, who are kept at work for five or six hours a day, are much more inactive than they would be if they were not at school, and are breathing more confined air than they would do if left to themselves. They are standing still, or seated, or bending over desks. And their respiration is therefore shallow, not deep and lung-expanding as it would be if they were unrestrainedly indulging in the restless movements and gambols that are characteristic of their period of life. And wherever the respiration is shallow, what we call metabolism, or the building up, breaking down, and renewal of the tissues of the body is interfered with; and wherever metabolism is interfered with the desire for food or appetite fails, and thus it is that schooling, which is now universal, is accompanied by conditions favourable to tubercular development and must be safeguarded by physical education, if it is not to induce wide-spread degeneration. All the wisdom of the Egyptians, and of the sixth standard to boot, will avail little to the boy or girl whom tubercle has once marked for its own. Pray believe, then, in the case of your children, that the merry-go-round is not mere juvenile dissipation, that a day in the country is a bracing tonic, and that dancing is a not less useful branch of education than vulgar fractions.

Monkeys in confinement die of tuberculosis in large numbers, and it would seem therefore that the monkey-house in the Zoological Gardens, with its heated atmosphere, is scarcely a safe place of amusement for delicate children.

I have been speaking of air-borne tubercular disease—of its invasion of the organism by inhalation. Let me now briefly advert to its propagation by ingestion, or introduction into the system by food and drink, and to the preventive measures which suggest themselves in that connection.

It is possible that the tubercle bacillus may be swallowed in water. It has been lately stated by Fernandez that it was found in the water of a ditch, and that a child contracted tuberculosis through drinking it; but we know no facts which warrant us in believing that this channel of invasion—a favourite one of the typhoid and cholera bacilli—is frequently adopted by the tubercle bacillus. Bad water deteriorates health and thus encourages tuberculosis, and its purification by filtration or other means is preventive of tuberculosis by its influence on general health; but there are no special measures to be recommended in the treatment of water aimed at the tubercle bacillus.

Very different, however, is the case with milk which is probably one of the most frequent vehicles of tubercular infection

in young children, and one-third of all young children dying in our hospitals are killed by tubercular disease. Long ago it was remarked that in advanced cases of consumption there is often ulceration of the bowels of a tubercular nature. This was not seen in the early course of the malady, but towards its close, and it was therefore inferred that it was due to the swallowing of some of the expectoration from the lungs, which, passing through a stomach of enfeebled power undigested, set up a secondary tubercular crop in the intestines. But in infants tubercular ulceration of the bowels often occurs without any previous tubercular disease of the lungs, and in them it seemed probable that the tubercular virus was somehow introduced directly into the alimentary canal. This view has been substantiated by many experiments and observations, and it has been made clear that milk is the most frequent source of tubercular infection in young children, and that in this case the bacillus is not, as in typhoid fever, added to the milk in water, but is in the milk as it comes from the cow, for cows are very liable to tubercular disease, which in them very often affects the udder. Where cows are tubercular the bacillus has been found in large quantities in the milk ducts and also in the milk after it has been drawn, and with the bacilli obtained from cows' milk successful inoculation has been carried out in animals. Taking the milk from tuberculous cows, Gerlach and Chauveau have fed numbers of young pigs and other animals on it, and have shown that in a large proportion of them there supervened tubercular ulceration in the alimentary canal. That the same thing occurs in children Dr. Sims Woodhead has made evident. He has statistically established that abdominal tuberculosis, tubercular disease of the intestine or mesenteric glands, is rare in infants under one year old, and that in the second year of life it is exceedingly common: and he has connected these results with the facts that during the first year the child is generally suckled by its mother and that it is towards the end of the first year that cows' milk enters into its dietary. Tubercular disease is, as I have said, very common in cows, especially in cows stall-fed and kept in towns, and it is likely, therefore, that few town children who get milk escape a dose of the bacillus now and then. That it is not more widely productive of disease than it is may be attributed to the facts that a certain concentration of tubercle bacilli is necessary in order that disease may be set up (they can only effect a landing when they attack in force), and that when a child is healthy and is freely secreting gastric juice in its stomach, and has its mucous membranes in a sound state, the intruding bacilli are baffled or destroyed. It is only when tissue weakness is present, due to debility, constitutional or in-

duced by rickets or attacks of acute specific diseases such as measles or whooping-cough, or by insanitary surroundings, or where irritation or abrasion of the surface of the alimentary canal, due to unsuitable food or other cause exists, that milk-borne tubercle bacilli are able to create disease. These contributory conditions, however, are often present in children in these days, and there can be little question that it is to the advantage taken of the facilities they offer by the tubercle bacilli contained in cows' milk, that we must trace many of the cases of miliary tubercle we encounter in the children of parents with no tubercular tendencies. Dr. Walter Carr has shown cause for believing that the primary focus of tubercular disease even in young children, is in the thoracic glands in a far larger proportion of cases than we have hitherto supposed, but even his statistics still leave a heavy responsibility on cows' milk and point to the intestinal canal as a frequent portal of entrance of the tubercle bacilli during the first five years of life and to the mesenteric glands as their first rallying point.

What must we do then to prevent the dissemination of tubercular disease by milk? Absolutely forbid the suckling of her child by a tuberculous mother, make it penal for dealers to sell the milk of cows affected by tubercle, and insure the efficient inspection of dairy farms. Already steps in this direction have been taken in several places. Tuberculosis in cattle is as rife in America as it is in Europe, and its prevalence in New York has induced the Legislature there to appoint three Inspectors whose duty it is to examine the herds in each county, and order the slaughter of all affected animals. 20,000 cattle were examined in 1893, and 686 were found infected and killed. Similar precautions have been taken by one of the great milk supply associations in Denmark, who have all their cattle subjected to veterinary inspection once a fortnight; such frequent examination being necessary, as tubercular disease in cattle is often very rapidly developed. An ordinary physical examination generally leads to the detection of the disease, but it is possible that it may be overlooked when it is of recent origin or deep-seated, and it is satisfactory, therefore, that we have now in our possession a sure, simple, and scientific test in Koch's tuberculin, which I have before mentioned to you, and which if untrustworthy in treatment is invaluable in diagnosis. When tuberculin is injected into an animal it immediately raises the temperature if tubercle be present, but has no effect on body heat if the animal be healthy; and advantage has been taken of this action of tuberculin to determine the presence or absence of tubercle in cattle. At the Central Experimental Farm at Ottawa, in Canada, some most instructive experiments have

been carried out during the last two years. Fifty-four animals in all have been tested. Of these twenty-six gave the characteristic rise in temperature, 3 to 5 degrees, and in every one of them, when slaughtered, tuberculosis was discovered, while in the other twenty-eight there was no reaction, and they, when slaughtered, were found sound and healthy. It thus appears that we have now a sure and ready method of diagnosing tuberculosis in cattle, and it is believed that the general use of this means of detection, followed by prompt isolation, disinfection, and disposal of affected animals, will greatly diminish the prevalence of this dangerous malady.

But there is still another and almost infallible precaution against the propagation of tubercle by milk, a precaution that is within the reach of each of us, and that is the boiling of the milk. I confess it is to me astonishing that the acknowledged dangers that lurk in milk—dangers not only of a tubercular nature but of various kinds—have as yet received so little practical recognition in this country, for the precaution of boiling all milk given to infants or children, so as to destroy any bacilli or spores it may contain, is still the exception and not the rule in English households. Perhaps the day will come when it will be considered as reprehensible to partake of raw milk as it would be now to devour raw meat, and I am sure I shall not have appeared in vain on this platform this evening if I can persuade some of you who are heads of households, to lay it down as an inexorable rule henceforth that all milk used by your families shall be boiled for five minutes. You will perhaps tell me that the boiling of milk imparts to it a disagreeable flavour which makes it distasteful to children, but the answer to that objection is that it is only freshly boiled milk that has that flavour, and that milk set aside for a few hours after boiling, in a cool, airy place, almost entirely loses it.

I daresay some of you recollect the story of the two sinners who had to do penance by walking to a certain shrine with parched peas in their shoes. One of them went merrily ahead, accomplished his journey, and on his way back met his companion creeping along footsore and in pain and tribulation. Interrogated by that companion as to his wonderful celerity and ease in the performance of his task, he explained it by stating that before starting he had taken the liberty to boil his peas. Now, I would say to you, that if in the pilgrimage of life you would spin happily along, free from the suffering and tribulation that sickness in the household never fails to bring, you must not neglect to boil your milk, for boiling softens the hard heart of a cruel bacillus as effectually as it does that of a parched pea.

And with reference to this great domestic function of the boiling of milk, I would impress on you that it ought always to be carried out with the utmost strictness. If it be left to the cook, or the little handmaid, or the little sister, it is certain that it will be imperfectly done now and then, and it seems to me desirable that the mother should always prepare the milk with her own hands, and herself see to the dainty cleanliness of the utensils used.

The flesh as well as the milk of animals suffering from tuberculosis may communicate the disease to human beings. That the consumption of parts of a carcase actually tubercular and imperfectly cooked may convey it is undoubted, but there are differences of opinion as to whether the flesh or muscular substance can carry it when the disease is confined to certain viscera, such as the lungs or spleen. The juice of the muscle—raw, of course—of a cow suffering from tubercular disease of the pleura, has induced tubercle when injected into rabbits, and of twenty-two guinea pigs and rabbits fed on meat from the carcasses of tubercular cattle—the meat being free from visible tubercle, and prepared with as much precaution as a butcher would use in the course of his trade—eighteen contracted tubercular disease. Notwithstanding the protection afforded by thorough roasting or boiling, I should prefer for my own part, pending the Report of the Royal Commission that is inquiring into the subject, not to touch the flesh of any animal affected by tubercle, even to the smallest extent, for visible nodules do not determine the distribution of the bacillus or its spores, and the blood and lymph streams carry these far and wide.

The comparative freedom of the Jewish race at all ages from tubercular disease—a remarkable and established fact—is in all probability, like their superior longevity and special exemption from, and liability to, certain other diseases, to be attributed mainly to their racial characteristics; but it must also, it seems reasonable, be traced in some degree to the rules as to their dietary laid down by that first great bacteriologist, Moses, and to the still stricter ordinances of the Talmud, as to the inspection of animals used as food. Among the maladies indicated in the Jewish code, as rendering an animal unclean and unfit for consumption, tuberculosis is clearly one; while the methods of examination prescribed, including insufflation of the lungs, are specially directed towards the detection of that malady. The Jewish restrictions are no doubt unduly severe, for in London they involve the rejection, on the average, of 40 per cent. of bullocks, 29 per cent. of calves, and 23 per cent. of sheep, whereas not more than 20 per cent. of adult cattle, and

1 per cent. of calves in Great Britain are tuberculous, and only a small percentage of rejections is due to other diseases; but they have certainly effectually excluded one source of danger from the food of the Jewish people, and it is to be hoped that the Report of the Royal Commission, already referred to, will recommend some further protection than now exists of Gentile food. The abolition of private slaughter houses in towns, the stringent supervision of public ones, and of meat markets, with skilled inspection, such as is provided in Berlin, of all doubtful carcasses, are inevitable, and beyond these we may expect, from the protracted deliberations of the Commission, guidance at many difficult points, and a scheme for the ultimate stamping out of tuberculosis in cattle, with just compensation to owners.

It seems particularly important for us to ascertain to which breeds of cattle tuberculosis specially attaches itself; a little difference often means much in bacteriology. The brown Hanoverian rat sets anthrax at defiance, even when inoculated with the bacillus in large doses, but the white rat is very susceptible to it; and it is probable that different breeds of cattle differ greatly in their susceptibility to tuberculosis.

The danger of the communication of tubercle by animal food was, I notice, at the last annual meeting of The Sanitary Institute made the ground for an ingenious plea in favour of vegetarianism. It was argued that the prevalence of tuberculosis in man is due to the large degree in which flesh enters into his diet, and this argument was all very well, until it was pointed out that the animals from the flesh of which the tubercle is said to be derived are pure vegetarians, and that the carnivora that are not vegetarians are comparatively free from tubercular disease.

The fourth channel of invasion of tubercle which I have mentioned, namely by direct inoculation, may be briefly disposed of, for while tubercular disease can thus be experimentally communicated with the utmost certainty, it is only thus naturally conveyed, when lupus or tubercle of the skin follows the introduction of the bacilli into a scratch or cut, unless we include under it those cases in which the bacilli are directly planted in some crevice in the mucous membranes of the first lock of the alimentary canal, the buccal cavity or mouth, or in its lower outlet, the throat. In tubercular swellings of the glands of the neck, the bacilli gain ingress through the door opened for them by a decayed tooth, or by the unhealthy and congested state of the lining membrane of the mouth and throat, and especially of the tonsils, in the crypts and follicles of which, when enlarged, bacilli have been found ensconced, ready to bore their way to deeper structures. Bathing of the

skin and cleansing of the mouth, regularly performed, and timely dentistry whenever needed, may therefore be regarded as preventive measures against tubercular disease. Decayed teeth must not be tolerated, swollen tonsils must not be left blocking up the throat, and even what are called "common colds" in children must not be neglected. Terribly, vexatiously exacting may seem the prophylaxis of tubercular disease, but the measures included in it are beneficial in warding off many other disease-enemies besides the tubercular one; and a faithful observance of them will really free life from some of its most oppressive burdens, and make its yoke easy and light.

There is just one other agent that may be employed for the prevention of tubercular disease that I wish to name to you. It is not connected either with inhalation or ingestion, or inoculation, but it is becoming of great significance, and it is *light*.

There has long existed, alike in East and West, a belief, not always, however, practically acted on—that light is salubrious and inimical to the spread of disease. But until quite recently this hygienic influence of light has been ascribed to the heating and drying effects of the sun's rays, and it is only to-day, as it were, that we have come to recognise the fact that light operates directly on the causes of disease, and that bacteria, not less than human beings, are liable to sunstroke. A few years ago Dr. Downes discovered that bacteria planted in meat broth, which multiply at an enormous rate when kept in the dark, at once cease to do so if exposed to intense sunshine, and since then, step by step, it has been established that the killing of bacteria by sunshine is due, not to any rise of temperature that accompanies it, not to the generation of any poison by decomposition of the nutrient fluid around, but to an immediate lethal effect of the sun's rays upon bacteria and their spores. Of most pathogenic bacteria it may now be said with strict accuracy that they "love darkness because their deeds are evil," and that they cannot abide the light.

The brilliant experiments of Professor Marshall Ward have demonstrated that the spores of certain bacilli, which may even be boiled for a few minutes without losing their germinating power, are killed outright by a bath of sunshine, and that bacilli which are not killed are greatly retarded in their growth under the same circumstances, and these experiments have demonstrated further that it is not all but only some of the rays in solar light—namely, the blue, and the blue-violet rays, that are concerned in the slaughter of the bacilli and their spores. The ultra-red rays, the red rays, the orange rays, the green rays, are harmless, but the blue and the blue-violet rays are injurious or fatal in their effects.

Taking a shallow glass dish, Professor Marshall Ward poured into it an ingeniously prepared jelly, which in a few minutes stiffened into a film containing about 5,000,000 invisible spores evenly distributed through it. The bottom of the dish was next covered by a zinc stencil plate, out of which a letter of the alphabet, say T, had been cut, and every other part of the dish being wrapped over with tin-foil and black paper so that no light could reach the film except what passed through the T-shaped opening in the stencil plate, it was exposed to the sun's rays for two or three hours. After this the wrappings and stencil plate were removed, and the dish was placed in an incubator where a temperature suitable to the germination of spores was maintained for from twenty-four to forty-eight hours. And then it was examined, and always with this result, that the spores imbedded in the parts of the gelatine sheltered from the light by the coverings were found to have germinated and sprouted into numerous colonies, making the gelatine opaque, whereas the spores in the T-shaped area exposed to the light had not germinated, because they were dead. The letter T was printed in the gelatine because the spores included in it had been killed by the light, and so had not produced colonies interfering with the clearness and transparency of the gelatine.

By further admirable experiments Professor Marshall Ward showed that it takes a bacillus in blue light the same time to grow 50 units of length that it takes one in red light to grow 1,200 units. He demonstrated that light acts as a retarding influence on the growth of the vegetative bacilli as well as injuriously on the germinating spores, and that in both cases it is the blue-violet rays which are effective. If these rays are sufficiently intense, or act for a sufficient length of time, they kill the organism without fail.

Now these experiments explain to us why it is so important that we should live in the light, and that our houses and streets should be inundated with sunshine; and they indicate that there is perhaps some truth in the popular notions that epidemics due to parasitic fungi most prevail in dull, heavy, cloudy weather, when the sun's light is to some extent cut off from the earth; and that there is special danger in night air. And these experiments bring home to us the value of light as an auxiliary in our conflict with this terrible tubercle bacillus, for Koch has taught us that it is destroyed by direct sunshine in a period varying from a few minutes to some hours, according to the thickness of the material in which it is suspended; and Drs. Ransome and Delepine, following in his footsteps, have proved that dried consumptive expectoration exposed to air and light

entirely loses its virulence or power for evil in from two to seven days. Cultures were destroyed even by diffused daylight when kept in it from five to seven days, and it is clear, therefore, that sunlight beneficially purifies the air of the spores of the tubercle bacillus, with which in our great centres of population it is so often sprinkled, and that it ought to be admitted as freely as possible into our consumption hospitals and sick rooms. I am not without hope that sunlight may yet be used as a curative agent in tubercular disease. No doubt in the commonest forms of that disease, in consumption of the chest or bowels, in water on the brain, or in glandular affections, the tubercle bacillus is working in dark cavities where light never comes and cannot be conducted, but there is one form that attacks the skin that is very obstinate, produces shocking disfigurement and misery, and necessitates painful operations—I mean lupus—upon which sunlight may be brought to bear. I am not going to discuss the question whether the bacillus of lupus is identical with that of consumption—different opinions are held on that point; but at any rate lupus is a form of tuberculosis, and the bacilli of the two are so similar that we may assume that they are amenable to the same influences, and that light will be as pernicious to the one as it is to the other. And indeed I think we are not without evidence even now of the controlling effect of light on the lupus bacillus. Lupus is always an unsightly blemish, and so is invariably hidden from view, and most of the medicaments employed in its treatment, lotions and ointments and dressings, involve its being covered up and kept in the dark; but still as a consequence of its position on the surface of the body, and especially of its favourite sites being the face and hands, it gets more light than any other form of tubercle, and it is therefore interesting to note that as compared with tubercular disease elsewhere it is slow in its advance, and contains very few bacilli in the diseased structure that characterises it. I am informed on excellent authority that lupus is scarcely known, except as an imported disease in the High Alps, and we must bear in mind that intensity of the sunlight is one of the climatic conditions of those Alpine regions, which have become such favourite health resorts in cases of tubercle of the lungs. All the information we possess seems to encourage the hope that benefit and perhaps recovery may be secured in lupus—that wolf at the door that is gnawing the beauty and brightness out of so many young lives—by its systematic exposure, with and without operation, to sunlight or to blue and blue-violet rays.

But whether or not lupus may be thus successfully treated, there can be no doubt that in our warfare with tubercle

generally, "light, kindly light," will help to lead us on to victory; and I would exhort the working men of Liverpool to demand for themselves and their children bright light not less than fresh air and pure water, and wholesome milk and meat. I am not going to suggest that we should all live in glass houses, but I am sure we should have big windows. I am sure that factories, workshops, and schoolrooms should be flooded with light. I am sure that working men should choose for themselves, when practicable, well-lighted dwellings, and that they should, through their municipal representatives, require that due regard be had to the free admission of light in all building operations in towns. It is deplorable to see how in some large towns, London amongst them, mansions and blocks of artisans' dwellings are being piled up to an enormous height, with no proportionate widening of the street, which is indeed converted, in some instances, into a sort of damp cellar—a street with no sunny side, sunk in perpetual and all-pervading gloom. Jedediah Morse, an old American geographer, described the town of Albany as "a city of one thousand houses and ten thousand inhabitants, all standing with their gable-ends to the street." The attitude attributed to the inhabitants seems unreasonable, but that of the houses is worthy of commendation; for a house with its gable-end to the street in the style of old Albany must have been begirt by light, and although in these days we can scarcely hope for such an arrangement, or even for houses up to the true sanitary standard, not exceeding two storeys in height, we may still insist on the maintenance of ample channels for light between our blocks of houses, and on the curtailment, as far as possible, of that great canopy of smoke that is densest over our busy hives of industry, but the fringes of which now hang over almost the whole of England—intercepting and enfeebling the solar rays that ought to cheer and invigorate us, and cleanse earth, air and water, of the perilous stuff that weighs upon the public health.

And there is one other point in connection with the usefulness of light in the prevention of tubercle to which I would allude, and it is this, that all articles of wearing apparel and bedding should after washing be dried in bright light. Water is not fatal, nay, it is not very injurious, to the tubercle bacillus, which has been known to retain its vitality when immersed in it for as long as 115 days, and therefore washing alone (unless boiling water has been used), unaided by exposure to light, can scarcely be trusted to disinfect the linen which has been used by tuberculous persons. It should be well soaked in boiling water, well scrubbed, well bleached in the open air, and so indeed should all clothing and bedding if they are to be thoroughly

fresh and wholesome. The limitations of our climate and of our modern habits of life, however, to a great extent render such a procedure impracticable, and as a matter of fact a large proportion of the drying of clothes and linen in this country is carried on in darkness in steam-presses and closets, or in semi-darkness in back kitchens, cellars and lofts. This is largely the case in hospitals and institutions in which dark drying presses are in almost universal use, and it is to be remembered that in them tubercular disease is common. I would suggest that these drying presses should be no longer dark but roofed with white or blue and violet glass, or illuminated by the arc light, which is almost as efficacious as sunlight in the destruction of germs.

And now, ladies and gentlemen, I have finished what I have to say this evening about the prevention of tubercular disease. I know I have exhausted your patience, and I fear I have had to deal with a subject not very attractive or æsthetical. An eminent scientific friend of mine says that whenever he attends a lecture on bacilli he has a creeping sensation all over him and feels like a horrid old Stilton cheese, and if I have produced effects of that kind on any of you I can only apologetically remind you that The Sanitary Institute is obliged to deal with unsavoury topics, and that bacilli are not more objectionable than drains, which might, perhaps, have occupied your attention had I not been here. And on behalf of bacilli I would also remind you of the prediction of Lord Salisbury, that they and their kindred organisms, upon which the lives of millions of human beings depend, will for a generation to come figure more largely in the field of science than any other subject. Legions of bacilli brood over, infest, and grievously afflict this over-crowded City of Liverpool. I trust the working men of Liverpool will be "up and at 'em," and do their best to drive them into that outer darkness prepared for the arch-enemy of mankind and his angels.
