AN ADDRESS

ON

MICRO-ORGANISMS AND DISEASE.

*Delivered in the Health Department of the Social Science Congress.*By CHARLES CAMERON, M.D., LL.D., M.P.,
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THERE never has been a period since the days of *Æsculapius* during which so much has been accomplished to entitle medicine to take a place among the exact sciences as within the last ten or fifteen years. Up to that period, we knew diseases only as groups of effects. Of their causes we had no certain knowledge. As the methods of research adopted became stricter and more systematic, a mass of information was accumulated, pointing generally in one direction, and enabling more accurate hypotheses to be framed; but although, for years past, what is termed the germ-theory of disease has been generally accepted among scientific men, it is only recently that the organisms themselves have been identified; and it is only within a period to be reckoned by months, rather than by years, that their habits have been so exposed to us, that it is already in our power in many cases to isolate them from the living body, and cultivate them in artificial soils—to multiply, destroy, modify, weaken, or intensify them at pleasure. If, then, as is obvious, a correct knowledge of the nature and tactics of the foes we have to contend against, in our battle with those maladies which sap the health and life of mankind, is essential to the waging of successful war against them, there never has been a time when the physician could look forward with so much certainty as now to a speedy solution of many problems hitherto deemed inscrutable; or the man of science could anticipate with so much hope the possibility of triumph, not merely over individual cases, but over whole genera of disease.

I have, therefore, thought that I could not choose a more opportune theme for the address which, as President of the Health Department of this Association, I am called upon to deliver, than the light cast by recent discoveries upon the nature of virulent and infectious maladies, the practical account to which those discoveries have already been turned, and one or two lessons which they suggest in connection with the preservation of the public health.

The first idea to be grasped is that specific diseases are like specific forms of animal or vegetable life: they can be produced only by specific pre-existing germs or seeds. There is no such thing as spontaneous generation of the entities which cause disease, any more than there is of the innumerable forms of animal and vegetable life which make their appearance wherever a material suitable for their development is exposed to the atmosphere. We know that the air is full of floating living particles, ready to spring into activity whenever they may light upon a congenial soil. We know that in such numbers do they in many cases exist, that, present but the proper soil, and the appropriate germ inevitably finds its way to it. We know, on the other hand, that, but filter the air, purify it from such germs, and, without their intervention, no form of life can arise. It has long been suspected that the same was the case with certain specific diseases, especially with what are known as zymotic diseases. It has long been considered probable that the symptoms which constitute each particular malady in that class were due to the invasion of the system by some microscopic organism, which, multiplying itself within the living body, gave rise to the phenomena and constitutional disturbance which physicians described as the disease. It has now been proved that this is so in a number of diseases where such an origin was never suspected; so much so, that it may be taken as an axiom of medical science at the present moment that it is the case in every contagious and infectious disease, as well as in a number of diseases whose communicability is so masked that, up to the present, it has been generally believed not to exist.

Now, it is a remarkable illustration of the impossibility of foreseeing to what results any scientific investigation or discovery may lead, that the great advance recently made in our knowledge as to the causation of disease is to be traced to a very large extent to certain investigations made by a French chemist, M. Pasteur, with regard to fermentation. In the first place, it was through facts elicited in the course of these investigations that Lister first entertained the theory on which his system is based. At that time—now about fifteen years ago—it was known to

the surgeon that the gravest laceration of tissue might occur under an unbroken skin without any danger of suppuration; but that, if the skin were broken and the lacerated tissues brought into contact with the air, suppurative action, attended with great constitutional disturbance, was the dangerous and, it was believed, the inevitable consequence. The same difference was recognised with regard to wounds made in surgical operations, which were known to be almost certainly followed by suppuration if they were external, while the reverse was the case when it could be so contrived that the air should not reach them. Taking Pasteur's researches regarding fermentation and the allied subject of spontaneous generation in connection with these facts, Lister asked himself whether this difference might not be due to the disturbing fermentative action of invisible organisms borne to the surface of the wound by the atmosphere. If so, if these could be destroyed suppuration would be averted, and the fracture where the bone had pierced the skin might be repaired as easily as that where the skin remained intact; the incision made in amputating a limb would give rise to as little constitutional disturbance, and would heal as readily, as the internal cut which had been so contrived by the surgeon that no air could find access to it. The experiment was made. By careful use of carbolic acid the air-borne germs were destroyed, and the results followed for which Lister had ventured to hope.

Again, it was the remarkable practical results which had attended his researches on fermentation that induced the French Minister of Agriculture, in 1865, to select M. Pasteur to investigate the causes of the silkworm disease, which at that juncture threatened to extinguish one of the most important industries of France. For M. Pasteur knew nothing about the silkworm. Indeed, he tells us that up to that period he had hardly seen the insect. But having undertaken the work, he applied himself to it for five years with all his energy. The result was, as he had shown the wine-grower how noxious fermentation might be guarded against, so now he showed the silk-producer how the silkworm could be regenerated and the disease stamped out. Previous observers had noticed, in the juices of diseased silkworms, tiny microscopic corpuscles, but of their nature, or the rôle which they played in the disease, nothing definite was known. To these M. Pasteur directed his attention. He soon ascertained that they were living organisms, which could be introduced into the insect's system through its skin, or in its food, and which, multiplying themselves in the silkworm's body, constituted the real cause of the malady. By watching their development M. Pasteur made this important discovery, that they take a considerable time to spread within the insect's tissues to such an extent as to do very much mischief. If a larva was not infected until it had completed a portion of its existence, the ravages of the disease had made comparatively little progress when it entered into the chrysalis stage. It spun an excellent cocoon, and for the purposes of the silk-spinner was as valuable as its healthy neighbour. If, however, it were reserved for the production of eggs, the corpuscle had, by the time it became a butterfly, made such progress within its body that it had penetrated even into the eggs it produced, and a greater or smaller proportion of these contained corpuscles. The silkworm which issued from an infected egg inevitably died before it could produce silk. But M. Pasteur observed that, even among the eggs produced by the most infected butterfly, a certain proportion were sound. Availing himself, then, of this fact, M. Pasteur devised a system whereby each silkworm was reared by itself under careful observation, and in conditions which would ensure the healthy insects against infection. The eggs of those that retained their health to the last—of insects which, after they had laid their eggs, the microscope showed to be free from the disease—were found to produce a perfectly healthy race. By breeding only from such stock, by avoiding conditions favourable to the production of the disease from germs which might find their way from without, M. Pasteur showed that in a short time it would be possible to regenerate the race and entirely to stamp out the disease. He showed, too, how, when circumstances did not admit of such elaborate precautions, a seed might be secured which, if not absolutely free from the disease, would still afford a very satisfactory crop. By a series of striking demonstrations, he converted the silk-grower to his views, and his services obtained the recognition, not only of his own, but of foreign Governments.

It is thirty years since Dr. Davaine discovered that, in the splenic fever of sheep and cattle—a terribly fatal disease, which continental writers identify as the plague sent upon the cattle of Egypt—a tiny microscopic organism, measuring the fraction of a thousandth part of an inch, was to be found in the blood; and subsequent researches induced him to believe that this was the true cause of that disease. As time passed, other microscopic beings were discovered in the blood and tissues in other diseases. I will not trouble you with any attempt to describe the differences which these organisms present, for subse-

quent experience has shown that the most deadly may be undistinguishable from the most harmless by any detectable physical peculiarity. Like many of the lowest forms of vegetation, they exhibit movements, when viewed under the microscope, and multiply themselves with extraordinary rapidity, in certain circumstances by budding or subdivision like the yeast plant, and in others by the production of germs or spores. In 1876, Dr. Koch, a German physician, succeeded in isolating the little rod-like organism or bacterium which gave rise to the splenic fever of which I have spoken, and in cultivating it outside the animal body. Dr. Koch's success was of immense scientific importance, for, whereas it had before been impossible satisfactorily to observe the development or peculiarities of any of these organisms, or even to prove beyond possibility of cavil that it was they, and not the organic media in which they were found, which when inoculated on other animals gave rise to the disease, it now became practicable to remove them from all possible contamination, and to prove that this or that organism was really the cause of this or that malady. Dr. Koch's discovery was rapidly followed up by that of Dr. Klein, who showed, by methods similar to those adopted by Koch, that the disease known as pig-typhoid or pig-plague was also the result of a microscopic organism which he succeeded in cultivating; and, about two years ago, M. Toussaint, a veterinary surgeon of Toulouse, to whom I shall frequently again have occasion to refer, achieved a like success with the bacterium of fowl-cholera. I may say in passing that this is a disease in no respect resembling cholera, but, from the circumstance of its having ravaged the poultry-yards of France coincidentally with an epidemic of human cholera, it acquired that unfortunate title. M. Pasteur had been engaged for some time, at the instance of the French Government, investigating the causes of the splenic fever which annually wrought such havoc among the flocks and herds of France, and Toussaint's discovery at such a juncture naturally directed his attention to a disease presenting peculiar facilities for experiments, and possessing this feature in common with the splenic fever of cattle, that it had been proved to be of similar parasitic origin. Having once brought to bear upon this fowl-cholera, then, his extraordinary scientific instincts and great experience, M. Pasteur was able, in February of last year, to announce to the French Academy of Sciences a series of discoveries, which, followed up as they have been by himself and others, have completely revolutionised our ideas of the nature of diseases, and the proper methods of dealing with them. Within little more than a year and a half—thanks to the enterprise and emulation of French investigators—a new romance world of contagion has been opened up, peopled with innumerable microscopic races, which every week shows to be more and more susceptible to human domination and control, but many of which are—till tamed by science—so fatal to mankind, that the slightest carelessness on the part of the experimenter, the accident of a scratch on the hand, might any day entail upon him a rapid and appalling death.

But to return to the bacterium of fowl-cholera. The vehicle of cultivation employed by Toussaint not proving satisfactory, M. Pasteur's first care was to find a more congenial medium, and this he soon discovered in chicken-soup. If the point of a needle be dipped in the blood of a fowl suffering from chicken-cholera, and then placed in a vessel containing pure chicken-soup, from which care has been taken to exclude all contamination by air-borne germs, and a suitable temperature be maintained, the bacterium or microbe—as M. Pasteur terms it and cognate organisms—multiplies itself exceedingly, rendering the liquid turbid by its presence. If, after this process has gone on for some days, a drop of the contents of this vessel be transferred to another portion of similar chicken-soup, it, too, speedily becomes permeated with the organism. The process may be repeated a hundred times, and the result inoculated upon fowls, or given them in their food, will produce the same fatal effects. But if, instead of carrying on these fresh cultivations at intervals of a few days, you allow the infected chicken-soup to lie over for a few weeks or months, Pasteur discovered that an extraordinary change occurs. The malignant powers of the bacterium diminish; it becomes, so to speak, tamed, or, as he terms it, "attenuated". A given quantity of infected chicken-broth, even at the hundredth rapid cultivation, inoculated upon twenty chickens, would, let us say, prove fatal to eighteen of them. If the same infusion were allowed to remain exposed to the oxygen of the air for a month, it would be so far attenuated that it would only prove fatal, say, to ten. Exposure for another month would render it still less virulent, so that it would only prove fatal to two or three; while, after exposure for six or eight months, it would not prove fatal in a single instance. But does it still retain any active power? and, if so, what relation does it manifest to the original disease? In its most attenuated form, the bacterium gives rise only to trifling local symptoms, not at first recognisable as bearing any affinity to the deadly fowl-cholera, and consist-

ing of a small local slough. But the extraordinary and valuable fact discovered by M. Pasteur is, that the tamed and attenuated organism works upon the system a change protective against subsequent attacks of fowl-cholera, exactly similar to that which had been remarked to be enjoyed by fowl that had recovered from the virulent form of the disease.

Here, then, is a result exactly analogous to that experienced in the protection exercised by vaccination with cow-pox against subsequent attacks of small-pox, only in the one case the protective virus has been elaborated in the laboratory of nature, in the other in that of art.

Time will not permit me to do more than allude to one or two of the many curious and interesting features elicited in M. Pasteur's researches as to the life-history of this parasite. One most important fact elicited is this, that, altogether contrary to what one would expect, the most virulent organism is to be found, not in the ordinary rapidly fatal cases, where the fowl dies in the course of a few days, but in a much rarer form of the disease, where the bird lingers for weeks or months. Then the microbe acquires such virulence that the fraction of a drop of blood charged with it, inoculated on a score of hens, will kill every one of them within four-and-twenty hours. And yet even this doubly poisonous species of the organism can be reduced to a harmless vaccine by artificial cultivation, and between its most and least deadly form the microscope does not enable us to detect the smallest difference.

What is the theory of the protection which this new vaccination affords? I will not enter into the details of the theories which have been advanced; suffice it to say, that the world has long been familiar with the fact that one occurrence of a certain disease—such as small-pox, measles, scarlatina, typhus, etc.—in an individual, effects a change in the constitution which, except in very rare instances, is protective against any recurrence of the same complaint. Recent discoveries prove that in certain instances a similar change is effected by diseases not identical with those against which they protect. Thus, Pasteur has found that inoculation with fowl-cholera renders at least one class of animals refractory against subsequent inoculation with splenic fever, although the organisms which give rise to the two diseases are entirely distinct. But, in the course of his researches into the mechanism of the protection thus conferred, M. Pasteur discovered a very curious and interesting fact. One of the most prominent symptoms of ordinary fowl-cholera is an irresistible drowsiness which overcomes the fowl attacked. It lies down, falls asleep, and is with difficulty awakened, only to sleep again until, finally, death overtakes it. Well, M. Pasteur, in the course of his researches, filtered some chicken-broth in which the disease-organism had been cultivated, so as to free it from all traces of it, and injected the liquid into the circulation of healthy fowls. After a short time, they exhibited the same symptoms of overpowering sleepiness, and that whether they had been rendered proof against the disease by previous inoculation or not; but, instead of dying after four or five hours, the symptoms passed off; and they were restored to perfect health. This proves that, in the course of its development, the organism of fowl-cholera, by a fermentative action, gives rise to a narcotic poison which occasions this symptom, a symptom which masks the essential phenomena of the disease, but which can be altogether separated from it, and is only indirectly incidental to it. In the typhus fever of man, a similar symptom is constantly noted, and the question naturally presents itself, is it produced in a similar way? Here is a curious fact bearing on the point. In Senegal, the natives are subject to a terrible disease known among them as *nelavan*. The disease takes eighteen months or two years to run its course. It is attended with acute pain, stiffness of the limbs, glandular abscesses, and notably with constant drowsiness, the sleep being heavy, and accompanied with terrible dreams. The patient preserves his appetite to the last, but often loses his reason, and invariably dies. A French missionary in Senegal addressed a communication on the subject to M. Déclat, a French physician, and an ardent disciple of Pasteur's, who, suspecting in the disease a parasitic origin, recommended the missionary to try a treatment having for its object the destruction of the organism—its probable cause—by the injection into the circulation of phenic acid. The experiment was made in several cases, notably in one where the patient was in so advanced a stage of the disease, that the missionary was only induced to try the treatment by reflecting that if it did no good, it could do no possible harm; and in every instance the result was success. The organism was killed, and the patient recovered.

Turning now to the *Bacillus anthracis*, the organism gives rise to splenic fever in cattle. M. Pasteur found that it too could be cultivated in chicken-broth. In its case, however, a preliminary difficulty was experienced. The class of organisms to which the bacillus belongs multiply themselves in two ways—by subdivision of their cells into other cells, which rapidly attain the dimensions of the standard cells

and, secondly, by a process analogous to flowering in the higher classes of plants, resulting in the production of spores or seeds. So tenacious of life are these spores in the case of the bacillus of splenic fever, that M. Pasteur has found them in full vitality in pits in which oxen and sheep that had died of the disease had been buried for ten years. He has proved, too, that when thus buried, swallowed by earth-worms in the soil from which these derive their nourishment, they are brought by them to the surface, and may thus give rise to fresh outbreaks of the disease. He found that this was the case in an instance where a bullock had been buried in a pit over six feet deep. His proofs were absolutely conclusive. He placed sheep on the ground, and they took the disease. He separated the bacillus-germs from the earth by washing it, and, multiplying them by cultivation, found that by inoculation they produced the disease. He found them especially in the casts brought to the surface by earth-worms, and in the contents of their digestive organs; and he found, further, that in districts where the soil was of such a nature that earth-worms were rare, the disease, when accidentally imported, was not found to spread. Here is an anecdote which curiously illustrates how scientific discoveries may come about. In 1865, Baron Seebach was Saxon Minister at Paris. Having suffered severely from splenic fever on his estate, he took great interest in the subject, and had evidently conversed with the French Minister of Agriculture respecting it. The result was that he was asked to detail his experiences in a memorandum. That memorandum the French Minister placed in M. Pasteur's hands, and it seems to have given him the clue to the manner in which the disease is spread. It has recently been published. In it the Baron narrates various circumstances which had induced him to think that his enormous losses from splenic fever were due to the propagation of the disease from the graves of dead animals. But what confirmed him in his suspicions was this: a sheep that had died of the disease had been buried in the corner of a field on which a crop of corn had subsequently been grown, and which the following year was sown with clover. The attention of the Baron had been accidentally directed to the place at the time; and one day, in passing, he remarked that the clover had grown with exceptional luxuriance over the spot. A few days later, he noticed that someone had stolen the clover which grew at that corner of the field. The next day, a woman on his property came to him weeping, to tell him that her goat had just died, and her cow was very ill. The disease was found to be splenic fever; and the woman confessed it was she who had stolen the clover, and given it to the unfortunate goat and cow.

But to return to M. Pasteur and his experiments in cultivating the bacillus of this disease. He was not the man to allow himself to be foiled by the perversity with which this organism insisted, when artificially cultivated, on running to spores. He found that, by maintaining his chicken-broth at a temperature of about 110° Fahr., he could prevent spores from being developed, and induce the organism to multiply itself by subdivision like its congener in fowl-cholera. He found that, when this was accomplished, precisely the same results followed exposure to the atmosphere as had followed in the other case, but with much greater rapidity; that the organism could be tamed; that a virus could be produced of any desired degree of attenuation; and that, when it was sufficiently attenuated, inoculated upon sheep or cattle, it gave rise only to trifling constitutional results, but at the same time wrought such a change in the system of the animal as protected it against subsequent attacks of splenic fever just as effectually as was known to be the case when an animal recovered from the natural disease.

The annual loss to France from splenic fever being close on a million sterling, the commercial value of this discovery was too great to allow it long to remain without a public test. In May last, at Melun, before a number of scientific authorities, fifty sheep were taken, twenty-five inoculated with the attenuated or tamed organism, and ear-marked, and the others left untouched. A fortnight afterwards the whole number were inoculated with splenic fever. On the twenty-five previously inoculated with the attenuated bacillus, no result followed. As to the others, within fifty hours the whole number were dead of splenic fever. A similar public test undertaken in July exhibited precisely similar consequences. Since then many thousands of animals have been inoculated with the attenuated virus, and the commercial results of the experiment will soon speak for themselves.

But M. Pasteur has discovered that not only can this bacillus be attenuated, but that by a converse process it can be restored to its original virulence and ferocity. This *Bacillus anthracis* appears to be an organism of very cosmopolitan taste, so far as mammalia are concerned; for though it is chiefly known to us as infesting cattle and sheep, it also, when accidentally inoculated on man, gives rise to that terrible disease known as malignant pustule. It lies hid in the condition of spores, in hair of horses and the wool of sheep that have died of the disease, and finding its way along with other dust to the lungs of the

people who handle them, occasions another terrible malady, known as hairworkers' or woolsorters' disease, and it particularly affects the class of rodentia. In them this bacillus appears to find a most congenial home, and in them it flourishes with a deadliness peculiarly characteristic. Now M. Pasteur discovered that, if the attenuated bacillus—the organism tamed through long cultivation in oxygen—be cultivated through a succession of young guinea-pigs, it will speedily re-acquire all its original virulence. That this is not an isolated fact in the history of such organisms is shown by the circumstance that a similar recrudescence can be effected in the case of the virus of fowl-cholera, by repeated cultivations of the attenuated organism on small birds, such as sparrows, to which it proves fatal long after it has ceased to be capable of destroying the life of fowls.

I shall only refer to one other curious discovery made in the course of M. Pasteur's investigation. I relate it because it seems to cast some light on the success which has attended the treatment of certain fevers to which mankind is subject, by cold affusions. M. Pasteur discovered that if you introduce the bacillus of splenic fever into the circulation of the fowl, under ordinary circumstances it produces no result. The temperature of the fowl's body appears to prevent its multiplication in the system. Cool down that temperature, however, by placing the fowl in water, and repeat the operation, and the disease at once manifests itself. Let the temperature rise, the organism perishes, and the fowl revives. And here I shall for the present leave M. Pasteur, and briefly recapitulate the results obtained—most of them, be it remembered, within the last few months—by other labourers in the same field.

There is another disease of cattle equally fatal in its results with splenic fever, but distinct from it, and known amongst French veterinarians as *charbon symptomatique*, or from the name of the author who first described it, *la maladie de Chabert*. Now M. Chauveau—to whose researches I have before referred—had proved that very different results followed on the introduction of certain morbid viruses into the animal system, according as they are carried right into the blood by injection into a vein, or simply introduced into the tissues outside the circulation. More recently, in investigating the strange resistance displayed by Algerian sheep to the power of splenic fever, M. Chauveau found that it could be overcome by the introduction of large amounts of the specific organism into the system. By carefully limiting the number of bacilli introduced, however, he found he could give rise to a trivial infection which increased the natural resistance of the animal to subsequent experimental inoculation with the disease. Working on the lines thus disclosed, three young veterinary surgeons of Lyons, MM. Arloing, Cornevin, and Thomas, discovered that if the micro-organism which gives rise to the *maladie de Chabert*, and which can also be artificially cultivated, be injected in carefully graduated doses into the torrent of the blood, so that the tissues shall not be contaminated, it gives rise to but very trifling constitutional disturbance, but at the same time produces a change in the system of the animal which effectually protects it against subsequent attacks of the disease. The discovery was publicly tested at Lyons in June last, and it, too, the French Government are now engaged in testing on a large commercial scale.

Let us now turn to another disease, which is probably the last in the world that you would suspect of being due to a parasitic organism—rabies, or hydrophobia. M. Pasteur has been working at it for some time past, and he has made some extraordinary discoveries. Among other things, he has found that the saliva of a boy who died of that disease contained organisms which could be cultivated artificially; and that the results inoculated on rabbits produced a disease which proved fatal with startling rapidity, but was quite distinct in its symptoms from any known form of hydrophobia. M. Pasteur considers this to be a new and distinct disease, but as yet no practical result of his investigations has been published. Meanwhile, M. Galtier, another veterinary surgeon of Lyons, who for years past has made a special study of rabies, adopting a hint from the result of the investigation of his colleagues with respect to the *maladie de Chabert*, tried the effect of introducing the virus of hydrophobia into the torrent of the blood by injecting it into the veins of a number of sheep and goats. To his delight he found that the same results followed the practice which had attended it in the *maladie de Chabert*. Animals which received the virus directly into their circulation, not only did not suffer the least inconvenience from it, but, when subsequently exposed to repeated inoculations of hydrophobic virus, it produced on them no effect; while unprotected animals, subjected to the same tests, invariably succumbed to the disease. Hydrophobia, communicated in the ordinary way, is generally a long time before it takes a hold upon the system; and M. Galtier is at present endeavouring to ascertain whether, by stepping in with his intravenous inoculation in animals which have been bitten by rabid dogs, he cannot

anticipate and neutralise the natural development of the disease, as we can the slower development of small-pox infection by the more rapid action of vaccine lymph.

Another disease, which, until within the last few years, was in this country believed to be absolutely non-contagious, is consumption; and yet it, and the whole class of tubercular diseases to which it belongs, have been proved to be eminently infectious. They have been transmitted from man to the lower animals, and from one lower animal to another. For some time back, M. Toussaint has been engaged in investigating the subject. He tells us that a large number of the cattle sent to the slaughterhouse in France suffer from the disease, and that the presence of tubercles in their lungs is not considered to render them unfit for human food; and I believe that the position of Great Britain, in both these respects, will be found precisely similar to that of France. He found that, by feeding pigs with the lungs of such animals, he produced tubercular disease in them. He found, further, that the juices of the muscles were permeated with the infection, and that they, too, were effective for the propagation of the disease. Further, within the last few weeks, M. Toussaint has announced to the French Academy of Sciences that he had succeeded in isolating and cultivating the microscopic organism which gives rise to tuberculosis; and, after a series of cultivations in animal soups, had reproduced tuberculosis with it on other animals. The important fact in connection with the organism is, that it can stand a high degree of heat without perishing, M. Toussaint having succeeded in inoculating the malady from juice expressed from the steak of a tubercular ox, cooked so as to be but slightly underdone. If this be true, it affords us a certainty of at least being able to limit the ravages of human tubercular disease, by directing our attention to what must be a most fruitful source of infection, namely, the sale of diseased meat.

Ague, again, has long been known to be associated with exposure to exhalations from marshy ground. Of late years, it has been known that a microscopic organism—also a bacillus—was to be found in the blood of persons afflicted with the disease. Within the last couple of years, Dr. Klebs, a German who has done much work in this field, and Dr. Tomassi Crudelli, an Italian *savant* associated with him in the investigation, discovered that, by treating with water the soil of a fever-haunted marsh of the Campagna, the germs of an organism which flourished in the soil could be washed out; that germs of this organism floated—though in much smaller numbers—in the air which rested on the marsh; that, by shaking it up with water, they too might be washed out; and that, by repeating the operation again and again, an appreciable number of them might be collected from the air. Water, suspending the organisms thus obtained, introduced into the circulation of a dog, produced ague more or less rapidly and more or less violent, according to the numbers in which the bacilli were present. This not only explains the nature of the danger encountered by persons exposed to emanations from marshy ground, but it shows why intermittent fevers so frequently manifest a new activity after operations involving a disturbance of the soil; and it further renders apparent why it is that quinine, which is known to kill such organisms, is so invaluable a remedy and preventive against the effects of exposure to swampy malaria.

But *cui bono?* you may ask; of what advantage is all this knowledge when, without possessing it, quinine has for years been known to be the appropriate remedy? In many forms of malarial fever the poison is too virulent, and the course of the disease too rapid, for routine medicine to be of any avail. But, guided by exact knowledge, you can go straight at the source of the mischief. With this object Dr. Déclat, to whom I have before referred, suggested the vigorous use of phenic acid, by injection into the veins and otherwise, as a means likely to prove effective against the organisms of yellow fever and kindred acute forms of malarial poisoning. The suggestion went out to Brazil, and in June last M. de Lacaille, a French physician resident in Rio, wrote home his experience of it. The first case on which he tried it was a young lady apparently on the point of death from the worst form of the disease, a fever attended with the fatal black vomit. In three days she was out of danger. "During the thirty years in which I have been employed in fighting yellow fever," writes M. de Lacaille, "this is the first patient whom I am certain of having snatched from death at such a period of the disease." In a dozen other cases the treatment was crowned with equal success; but in most of them, adds M. de Lacaille, "the cure was so rapid that, notwithstanding my long experience, I have asked myself if they could really have been yellow fever. Called in at the period of incubation, the triumph is easy."

Did time permit, I might quote other instances in which within the last few months the specific organisms which constitute the potential causes of diseases of mankind and the lower animals have been successfully isolated and cultivated in artificial media. I might tell you of the researches of M. Pasteur with regard to boils and puerperal fever. I might describe the important discoveries of M. Talamon with respect

to diphtheria—how he has succeeded in isolating and cultivating the organism which occasions it—how he has shown that it can be conveyed from mankind to various domestic animals, and from domestic animals back to man; and how these facts explain many features in the history of diphtheric contagion hitherto inexplicable, and present to preventive medicine a new indication for the limitation of this terrible disease. I will conclude by briefly referring to two only of the numerous practical points which the history of the brilliant series of discoveries I have very inadequately sketched seems to me to suggest.

In the first place, it teaches in every line the necessity, from the standpoint of public health, of regarding every person suffering from an epidemic or contagious malady as a hotbed swarming with living organisms which cause and spread the disease. So long as these are confined within the body of the individual, the public—selfishly speaking—need not trouble itself; but when the organism commences to be eliminated from the body, when its spores in millions and hundreds of millions are sent forth by the skin or the intestines, then the danger to the community begins. We have seen how tenacious of life these disease-germs are, and we know that in many cases—as, for example, in small-pox and scarlatina—the stage of the disease at which the process of elimination is most active occurs when the patient is already convalescent. According to our present system, it is nobody's business to look after him at this period, and he is sent forth into the community to scatter disease-germs by the thousand wherever he goes. We spend enormous sums of money in endeavouring to cope with disease when it has broken out. It seems to me we might spend a little much more profitably in securing the destruction of its seeds. It should be the duty of the public sanitary authorities to provide convalescent homes for patients recovering from serious infectious diseases, where they might be taken care of until all danger of the propagation of infection by them had ceased. Were this duty attended to, the recent discoveries as to the nature and causation of disease, to my mind, leave not the smallest doubt that we might be spared many epidemics, and that one disease especially—I refer to scarlatina—might be made to show a very different death-tale in our tables of mortality.

In the second place, the whole history of the chain of discoveries which have furnished the topic of this address seems to me to teach the enormous importance of the study of comparative medicine and pathology—of medicine and pathology, not in their connection with human diseases alone, but as branches of a science affecting the whole animal and vegetable world. It was, as we have seen, Pasteur's researches on the pathology of ferments which led to Lister's application of his great principle to human surgery, and to the discovery of methods which promise to stamp out some of the most fatal diseases of flocks and herds; it was to Jenner's observation of an eruption of the cow that we are indebted for the discovery of vaccination; and it is their investigations into the diseases of domestic animals that has enabled the veterinary surgeons of France, within the last few months, to make such preponderating contributions towards the solution of questions vitally affecting, not merely those animals, but mankind. The University within whose walls we are now assembled has, by the institution of a new degree, acknowledged the importance of the study of State Medicine. If she would add to the many services she has already rendered to the cause of science, I would suggest that she could adopt no step of greater practical utility than the institution of a chair of Comparative Medicine and Pathology—a chair the duty of whose incumbent it should be to investigate and expound the most recent knowledge and discoveries as to the diseased condition of every living thing, and their bearings or probable bearings upon the diseases of mankind.

However this suggestion may be received, one thing is clear: unless greater prominence is given to such studies, this country can hardly hope to hold her own against her neighbours in the cultivation of medical science. And no greater misfortune could befall the nation. For it is all very well for us here to discuss the administrative phases of public sanitation. Administration, when intelligent and active administration can be secured, is capable of much. There is much which enlightened legislation may still effect. But we must beware, while crying out for fresh enactments and extended powers, not to overlook the fact that throughout the kingdom those powers which the law already provides for the preservation of public health are but half enforced. After all, the law in such matters can only follow in the wake of science, and for its effective operation must everywhere depend on the diffusion of correct and exact ideas as to the cause of diseases and the modes of preserving health. Every year's experience, therefore, convinces me more and more that it is to the spread of scientific knowledge, rather than to Parliament, that we must look for the full development of preventive medicine; that to the physician, rather than the statesman, we must appeal "to stand between the living and the dead, and stay the plague".