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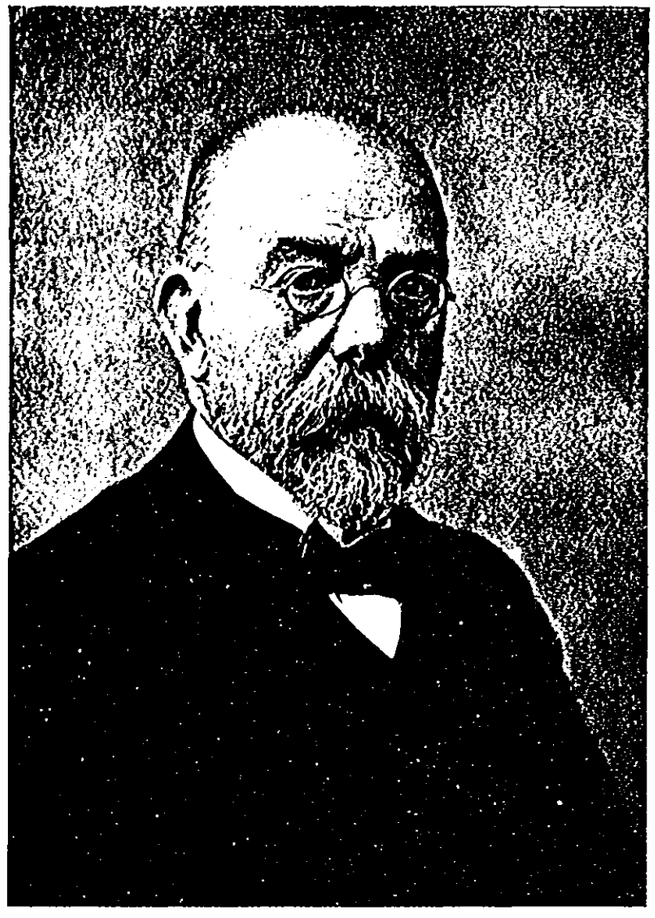
1843-1910

AFTER Pasteur and Lister, as if to set the seal upon their work by providing, as Sir Charles Martin, the Director of the Lister Institute, has so aptly said, "the tools of inquiry at each stage in the development of bacteriology," came Robert Koch. Although the list of his brilliant bacteriological achievements is a long one, his name is chiefly associated in the public mind with the discovery of the tubercle bacillus, and the identification of this germ was of vast importance to the welfare of mankind as being the starting-point for a world-wide campaign against one of the most deadly enemies of the human race. But as the founder of modern methods of bacteriology, Koch prepared the way for a new direction in the science of hygiene, and the last quarter of the nineteenth century saw the advance of sanitary science, not by slow and painful efforts as in the century's beginning, but by vast strides forward which left far behind them the accumulated knowledge of the ages. Pasteur had led the way by the discovery of the germ theory; Lister, with the insight of genius, had been quick to grasp its application for surgery, saving millions of lives by the introduction of antiseptic methods; but even so, when Koch began his medical career, the science of bacteriology was still in its infancy, and its technique quite undeveloped. Koch's arrival



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at this juncture was fortunate for the world, for, as Sir Charles Martin has said, "to devise successful means to attack a problem involves a clear insight into the nature of the problem, and fertility of resource in overcoming the technical difficulties arising in every experimental inquiry. With both these qualities Koch was richly endowed. He defined clearly the exact point at which knowledge had already arrived, and not only saw what was the next question to ask of Nature in order to advance one step farther, but devised experimental methods which ensured an answer to his question. In this last faculty Koch was pre-eminent, and the methods of the sciences are to a large extent the methods of Robert Koch."

One of the thirteen children of an official in the Prussian Forestry Department, Robert Koch was born on the 11th of December 1843, at Klausthal in Hanover. He studied medicine at Göttingen from 1862 to 1866, and held an appointment as assistant in the General Hospital at Hamburg for a short time before setting up as a general practitioner first at Langenhagen, near Hanover, and afterwards at Rackwitz. In 1872 he was appointed Medical Officer of Wollstein, a small town in Polish Prussia, and here, far removed from all laboratories and facilities for research, with little more than a good microscope to aid him, and the cares of a private practice to claim his attention, he began his studies in bacteriology. Four years had not gone by before he published the results of his first research, one which was to bring his name into prominence in the scientific world, that on the etiology of anthrax.

In 1839 the bacillus of anthrax had been seen in the blood of infected animals; but its significance had not

been grasped, and in 1863, when Pasteur's researches were becoming known, Davaine had been able to prove that this bacillus was capable of infecting animals inoculated with it, but that the germ was the true cause of anthrax was disputed. Koch, therefore, set out to prove that the anthrax bacilli were the only cause of the disease. Up till then although numerous bacilli had been identified in various diseases, it had not been proved beyond dispute that a given bacillus was the cause of a given disease, and the difficulty of isolating one bacillus from other germs in the blood had not been overcome. Koch's first contribution to the science of bacteriology lay in his success in overcoming these difficulties. He cultivated the germs of anthrax outside the animal body in broth and succeeded in developing many generations of them, isolating them from all other germs in the blood, thereby obtaining a pure culture. By inoculating mice and rabbits with this culture, he produced in them the disease of anthrax, and for the first time there was conclusive proof that a particular bacillus was the cause of a particular disease. His paper on the life-history of the *Bacillus anthracis*, containing the account of these experiments, was published in 1876, and in the same year he published a valuable paper describing the use of the microscope and his methods in staining and photographing bacteria, for he was convinced that better results would only be attained when the investigator had at his disposal better tools and methods of work.

After the anthrax research, Koch went on to the study of infective diseases caused by wounds, to which his attention had been drawn by the disasters from septic wounds in the Franco-Prussian War, and possibly

by Lister's success in the use of antiseptic surgery. Here again, his aim in investigating the infectious diseases of wounds was to isolate the particular organism that caused the septic condition. Bacteria had frequently been found in erysipelas, in pyæmia and other diseases, but as in anthrax, the proof was wanting that any particular germ caused the disease and no other. Koch's research was carried out by inoculating animals with a putrid serum or broth, which contained numerous bacilli of all descriptions. And his anticipation that from this medley of germs, which he was himself unable to separate, the animal's blood would pick out for cultivation the germ which suited it, and leave the rest, proved to be correct. After small quantities of the putrid broth containing the various germs had been injected and the animal had developed symptoms of the disease, its blood was examined microscopically, and in it there was found one, and one only, of the many germs with which it had been inoculated. The disease, too, could be given to a second animal by inoculating it with the blood of the first. The animal body was then seen to be a most effective mechanism for obtaining a pure culture. Koch proved also the now well-established fact, that some species of animals are proof against, and will not develop, certain parasites, or microbes, as was seen later when the cholera microbe was discovered, and it was found impossible to produce this disease in any animal. The paper in which these researches are described was published in 1878, under the title, *Untersuchungen über die Ætiologie der Wundenfektions-krankheiten*, and was translated into English by Sir Watson Cheyne, on Lord Lister's suggestion, for the New Sydenham Society, in 1880,

entitled *Investigations into the Etiology of Traumatic Infective Diseases.*

The publication of these important papers at once attracted the attention of the scientific world, and Koch was appointed a member of the State Public Health Department in Berlin, the Director of which had not failed to notice that the author of these works was possessed of exceptional ability. There was at that time no department of bacteriology in the Health Office, and Koch fitted up with all his apparatus the one room which was allotted to him as a laboratory, and here he was joined by his two assistants, Loeffler and Gaffky, whose distinguished work was subsequently to leave its mark in the history of medicine. These three, working together, directed their energies to the improvement of the technique for obtaining germs in pure culture outside the animal body, and Koch soon evolved his famous solid culture medium. The account of this work was published in the first volume of the reports of the State Public Health Department in 1880, and the paper was translated for the New Sydenham Society by Sir Victor Horsley. It contained a full account of the rules and methods to be followed in the study of bacteriology, and became the standard for bacteriological work in all countries. Koch laid stress upon the importance of giving photographic pictures of micro-organisms, on the absolute necessity of obtaining pure cultures of bacteria if the knowledge of these organisms was to be advanced, and gave a detailed description of the methods he employed for obtaining these cultures. His introduction of the solid culture medium, such as gelatine, was a great advance on former methods of growing cultures. He described how this had been

suggested to him by observing that a boiled potato cut in half and exposed to the air for a few hours and then placed in a damp room to avoid drying, would produce upon its cut surface small droplets or colonies each of which differed from the other. It occurred to him to spread the contents of one of these droplets upon the surface of another potato, and by placing this in a damp room, he found that the bacteria contained in the droplet grew and produced his pure culture. Speaking of this solid nutrient medium for cultures introduced by Koch, a colleague, writing in the *British Medical Journal* of 4th June 1910, says: "There can be no doubt that the introduction of this method of making cultivations on solid media constituted the greatest advance in bacteriological technique which has ever been made, and enormously advanced the science by giving to it a degree of accuracy which it had not previously possessed."

Koch next turned his attention to the research for which his name is justly famous, the identification of the tubercle bacillus. For generations consumption had been regarded as a congenital disease and hopeless because undiscoverable until its advanced stage was reached; and this was in some measure still the popular view of it, when Koch's discovery was made, although its infective nature had been recognised by Klencke as early as 1843, when he infected one animal with the disease from another, and by Villemin in 1865-68. Cohnheim had shown that it was capable of being communicated inside the body, and his pamphlet entitled *Tuberculosis as an Infectious Disease*, published in 1880, was the first attempt to popularise the idea of the infectious nature of the complaint. But, until the bacillus was isolated and its habits

known, no great advance could be made in the measures adopted to prevent its spread. For a long time Koch examined specimens of miliary tubercle under the microscope, in the hopes of finding the microbe, but without success till, by a modification in his methods of staining, the bacillus was at last found; and although difficulties were at first experienced in isolating it, they were eventually overcome when the right culture medium for its growth was found. At the International Medical Congress in London in 1881, Koch showed the tubercle bacillus to some privileged members and, on the 24th of March 1882, at the Physiological Society in Berlin, he made public his discovery. In announcing it he said: "Henceforth, in our warfare against this fearful scourge of our race, we have to reckon not with a nameless something, but with a definite inmate of the body: its conditions of existence are for the most part already known and can be further studied. Before all things, we must shut off the sources whence the infective material comes, so far as it lies in the power of man to do this." The news soon spread through the laboratories of the world and was greeted by some scientists with enthusiasm, by others, who still clung to the hereditary nature of the disease, with incredulity and adverse criticism. Koch himself set to work to study the life-history of the bacillus and to evolve the best methods of combating the disease. Then the bugbear of cholera threatened Europe from the East, and the German Government hastily appointed a Commission with Koch as President, to visit Egypt and investigate the disease, and to lay plans for the prevention of its spread. It was not, therefore, till 1884 that Koch was able to publish his paper on "The Etiology of

Tuberculosis," in the second volume of the *State Public Health Department Reports*. This essay contained a description of the whole process of infection by the bacillus, and all the scientific facts necessary for the guidance of health officers in the campaign against the disease. He showed that the bacillus is not inherited, that it invariably enters the animal body from without, that it grows under conditions of heat and moisture, but is not killed by freezing, though direct sunlight will kill it in a few minutes, and darkness and stagnant air on the contrary will favour its growth.

The repercussions of this discovery led to a campaign against the disease in every civilised state. Congresses on tuberculosis were held in the years which followed, and methods of prevention were gradually brought to a high state of perfection. Koch's disciple, Dr George Cornet, carried out a series of experiments to demonstrate the truth of all Koch had proclaimed, the results of which he published in the *Zeitschrift für Hygiene* of November 1888 and April 1889, entitled "The Distribution of Tubercle Bacilli outside the Body," and "On the Mortality among Nurses and its Causes." The popular instructions against the disease contained in these two papers were adopted by the health authorities all over the world, and when Cornet addressed the Berlin Medical Society in 1895, he was able to prove that a great reduction in the mortality from tuberculosis had followed the adoption of the precautions advocated.

In 1883 Koch's services to science were recognised by the German Government by his appointment as a Privy Councillor, and in the same year, as has been

said, he visited Egypt and India with the German Cholera Commission. When the Commission arrived in Egypt the epidemic of cholera was nearing its end, but it had not quite died out before Koch found strong evidence that the comma-shaped bacillus, so named from its resemblance to the punctuation mark, was the causative agent in the disease. To verify his conclusions, the Commission went on to India, where cholera was then endemic, and Koch satisfied himself that the comma-bacillus fulfilled the four conditions, known as Koch's postulates, those strict rules which he had himself propounded for the identification of micro-organisms. It could always be found microscopically in the bodies of animals having the disease; and in that disease and no other; it could be propagated in pure culture outside the animal body; the inoculation of the pure culture produced the same disease in a susceptible animal; and the organism could be found in that animal.

The discovery, however, was not unanimously accepted until after the Hamburg epidemic of cholera in 1894. Haffkine, a celebrated bacteriologist who did much work on this disease in India, has said that "the cholera microbe is one of those in which, owing to its organisation and mode of life, variability is particularly marked; so much so that not unfrequently, after an examination with all available tests, it is impossible to say whether the germ dealt with is, or is not, a representative of the cholera species." It was little wonder then, seeing that the world-wide researches carried on for years had all ended in unsuccessful attempts to identify this microbe, that Koch's discovery was received with some scepticism.

Before leaving Egypt, Koch had made two other discoveries of importance—that of the amœbæ of dysentery, and of the bacillus which is the cause of the widespread disease of ophthalmia among natives.

In 1885 he left the State Public Health Department and was appointed Professor of Hygiene in the Medical Faculty of the University of Berlin and Director of the new Hygienic Institute which had just been established by the University. He now returned to the study of the tubercle bacillus and endeavoured to find a remedy for the disease. In November 1890 great excitement was caused by his announcement that he had prepared from cultivations of the bacillus a remedy for tuberculosis of the lungs in its early stages, and that experiments had shown that guinea-pigs could be immunised against the tubercle bacillus by repeated doses of this culture, which was later named tuberculin. Doctors flocked to Berlin from all parts of the world to see Koch's results at first hand. He claimed for his discovery not only that it might be expected to cure phthisis in its early stages, but that it might be used as a means of diagnosing the disease. The enthusiasm that is naturally awakened by a new discovery probably led the world to exaggerate the claims that Koch had made for tuberculin. It was administered to patients in what was, in the light of later knowledge, enormous doses, and the results on the whole were disappointing and often fatal, and exposed the discoverer of tuberculin to a good deal of unmerited abuse. The remedy fell into discredit. But tuberculin has since been used extensively in some of its forms as a diagnostic both for man and for agricultural purposes, and Koch rightly claimed the importance

of his discovery. The mistake he made was in underestimating the virulence of the remedy, and in the premature publication of it.

In 1891 Koch was appointed Director of the new Royal Institute for Infectious Diseases, now commonly called the Koch Institute, and in the following eight years a large part of his time was spent in travelling in tropical climates to study tropical diseases. He was engaged on experiments with the mosquito as the means of transmission of malaria when Ross's great discovery of the part this insect plays in infecting man was proclaimed, but the work which Koch did in showing that the three types of malaria are associated with three types of parasites proved of much value in the preventive treatment of this disease. His researches in malaria took him to New Guinea to study a particularly severe type of the disease, and it was here he published a statement that quinine might be a contributing cause of black-water fever which, being misunderstood, for a time prevented the use of that drug in the German colonies in case it should prove to be the only cause of that much dreaded scourge, a conclusion which was far from Koch's meaning. He himself advocated the use of quinine for the prevention of malaria.

In 1896 he went to Cape Colony at the request of the South African Government to study the rinderpest which was threatening to destroy the cattle in South Africa, and in 1897 he returned to India to investigate the plague. The first Plague Commission, appointed at the request of the Indian Government, began its work in 1898. The germ of plague, *Bacillus pestis*, had been discovered by Kitasato and Yersin in Hong-Kong in 1894; but the means of transmission of the

disease was still obscure, and it was not till the Commission had done its work that the flea was definitely proved to be the culprit in the spread of this disease (a disease of rats) from rat to man. From Bombay Koch returned to Africa and made a study of East African fever among cattle. "It would be difficult to adjudge just how much of the knowledge gained upon these diseases to attribute to Koch," says Sir Charles Martin, speaking of Koch's studies in tropical diseases, "as the problems were also under investigation by numbers of other observers, and, moreover, he was usually accompanied by one or more distinguished workers . . . it is very clear, however, . . . that his insight into the nature of infectious diseases and his unrivalled experience were never directed to any of these inquiries without materially enhancing our knowledge of the causation and of the means by which each disease was spread."

In 1901 Koch astonished the world by announcing to the British Congress on Tuberculosis which met in London that the result of experiments had brought him to the conclusion that human tuberculosis was of a different character from the bovine variety of that disease, and that man is little if at all susceptible to the bovine bacillus. Such a statement, coming from the chief authority on the subject, caused widespread consternation, for almost every civilised Government in the world was by this time committed to large expenditure in preventing the infection by milk and meat supplies, and the publication of the news caused the Health authorities in Europe and America to institute inquiries as to whether tuberculosis of bovine animals is communicable to man or not, lest their efforts for the prevention of the disease should be

misdirected. The Second Royal Commission on Tuberculosis, appointed by the English Government, after exhaustive inquiries, reported that bacilli of the bovine form of the disease are often found in human beings, and this evidence was generally accepted as conclusive.

In his later years Koch ceased to take quite such an active part in official life in Berlin as he had done in former times, but his researches in tropical medicine were carried on, often involving long visits to unhealthy climates, right up to the end of his life. From 1903, at an age when most men are glad of some respite from the strenuous work of life, until 1906 he was engaged in studying sleeping sickness in Africa and, that he might the better study the habits of the tsetse-fly which transmits this disease, he settled down in a camp in one of the Sesse Islands. It was well said of him that "scientific work, fearless, keen, close and unremitting, was his greatest happiness, the very breath of his nostrils," until life was done. He died unexpectedly at Baden-Baden on the 27th of May 1910, after an attack of influenza which had weakened his heart, at the comparatively early age of sixty-seven.

Koch was one of the great discoverers of medicine, but he was also a practical contributor to the health and comfort of the human race. It has been said of him: "It was characteristic of Koch's attitude towards scientific problems that he was not satisfied merely to establish laboratory facts—he was always ready to go on to investigate the conditions under which they could be applied to practical hygiene, a task commonly far more difficult than the repetition of experiments in a laboratory, and often raising side-issues which

demand the highest scientific acumen for their elucidation." Born at a time when vast new fields of research were spreading new light all around, he lived to see the science to which he had so largely contributed grow from slender beginnings till it filled an all-important place in medicine, its influence reaching to the ends of the earth. "In a dozen years," says Sir Charles Martin, "the etiological factor of eleven important human diseases—tubercle, cholera, typhoid, diphtheria, erysipelas, tetanus, glanders, pneumonia, epidemic meningitis, influenza, and plague, as well as numerous animal diseases—was discovered by Koch and his pupils." Surely an amazing record for scarcely more than one decennium. Koch himself attributed his success with characteristic humility, to the luck that came his way. Speaking at a dinner given in his honour by the German Medical Society in New York in April 1908, two years before his death, he said: "I have done nothing else than what you are doing every day. I have worked as hard as I could and have fulfilled my duty and obligation. If the success really was greater than is usually the case, the reason for it is to be found in the circumstance that I came in my wanderings through the medical field upon regions where the gold was still lying by the wayside. Fortune is necessary to be able to distinguish gold from the base metals, but that is no great merit."

Koch received many honours from scientific societies during his lifetime, and the German Emperor conferred upon him the *Ordre pour le Mérite*. He was elected a foreign Fellow of the Royal Society, and an Honorary member of the British Medical Association.

He was cremated in Baden-Baden on the 30th of May 1910, and his ashes were buried by his own wish as quietly as possible, only his widow and his most intimate friend Gaffky, besides a few others being present. But if the ceremony was simple, as became a man of science, a whole nation mourned his loss, for his name was a household word in Germany, and one of which his countrymen were justly proud, while the admiration and affection he inspired in his pupils knew no bounds. And outside Germany, seeing that science has no nationality, the world at large paid fitting homage to the passing of one of its greatest sons.

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