In the absence of mortality statistics derived from death certificates a review of 50 years' progress would of necessity have consisted of one great question mark. Given the full co-operation of the medical profession in the difficult and

somewhat thankless task of writing down causes of death "to the best of my knowledge and belief," a review of progress 50 years hence will tell the story in much more illuminating fashion than has been possible to-day.

MEDICAL PROGRESS FROM 1850 TO 1900

BY

CHARLES SINGER, M.D., D.Litt., D.Sc., F.R.C.P.

Professor Emeritus in the University of London

The preceding articles survey the progress of medicine from 1900 to 1950. So that the reader may see this in perspective Professor Singer here traces the development of medical ideas in the fifty years before 1900.

History does not really accommodate itself to those exact dates and places that we learned at school. The Norman Conquest did not begin and was not ended at Hastings on October 14, 1066. The struggle extended over a far wider area, started generations before, and was not completed till long after—if it ever was completed. And so with the history of medicine. It is a deceptive anecdotal simplification to write it as though it consisted of a series of great discoveries each made by a particular investigator in a named year. Knowledge seldom advances by such precise and measured steps. Were I to follow that method here, this little essay would be a mere list of names and dates, and misleading ones at that.

It must be remembered, too, that discoverers no more work by themselves than do other men. Each is necessarily a member of a society—a community of men much like himself. Even the most austere and secluded man of science must have some audience in his mind—why else should he publish his results? He derives knowledge and ideas from his predecessors. He discusses his work with his colleagues. They criticize it. For some of his data he must depend on his co-workers and assistants and even on his opponents. Movements are greater than men; let us then follow them rather than the mere sons of Time. I have, for once, excluded all names from my narrative. The reader will doubtless supply them for himself.

The intellectual motives which lay at the root of medicine between 1850 and 1900 differed very considerably from those of the following half-century. To one who would contrast them with as little trouble and as much pleasure as he may, I would say: "Read two magnificent novels dating from the middle of the two periods, *Middlemarch* (1872), by George Eliot, and *Martin Arrowsmith* (1925), by Sinclair Lewis." A comparison of the characters and careers of the medical heroes in these two masterpieces, Lydgate and Arrowsmith, will go far to attaining the purpose of this number of the *British Medical Journal*.

In the decade around 1900, with which I must end my story, there were several highly significant redirections of medical thought. I am not now concerned with these. My task is rather to indicate how there arose the intellectual and scientific situation which determined them. It will be a generation before anyone will be able to say with assurance whether this year of 1950 and its surrounding years can also be regarded as a critical period for the history of medical science—for medicine is now indeed a science, which it was not in 1850. But to make history intelligible we must somehow divide it into periods. It is, then, truly the case that the years around 1900 provide a favourable and convenient opportunity for beginning to take stock of the state of medicine now. 1900 or a decade or two earlier is, moreover, about as far back as the scientific memory of living individuals usefully extends. On the other hand, 1850 is not a very tractable beginning, and I

wish that I could have chosen another year for that purpose. In considering nineteenth-century medicine it must be remembered that the British medical schools have a peculiar history that differs fundamentally from that of the Continental schools. The British schools were later in coming into being. They arose actually, or by imitation, or by tradition, from a system of apprenticeship. The Royal Colleges in Britain, which came largely to control medical practice in the nineteenth century, were formed with the ancient Guild Companies of Craftsmen and Merchants in mind. An actual apprenticeship was once part of the normal career of a medical practitioner. The influence of the universities on medical thought and on medical education in Britain was trifling. It was also slightly artificial, except at Edinburgh. The great majority of students and a large proportion of teachers took only the examinations of the Colleges. The teachers in each school formed a close corporation. On the Continent, on the other hand, it was the medical faculties of the universities that were the effective agents of medical education. They too were the natural centres for scientific and medical research. Continental universities were under governmental control and had governmental financial support, conditions then quite unknown in this country. In nineteenth-century England the only branch of medicine that was the object of attention from the State was that known as "preventive." Towards the very end of the period tropical medicine also aroused some official interest.

Administrative Interest in Medicine

The great Public Health Act and the Nuisances Removal and Diseases Prevention Act were passed in 1848. They came to be operated by a new Government department, the General Board of Health. The work of this Board was taken over, for administrative and political reasons, by the Privy Council. The Medical Department of the Council became part of the Local Government Board (1871), the functions of which were, in the twentieth century (1919), absorbed by the new Ministry of Health.

Just as the General Board of Health came into action there was an outbreak of cholera in England, of which some 54,000 persons died. Statistics available under the new system made possible the deduction that the infection was conveyed by drinking-water. This led to suitable precautions. It is one of the many instances in which preventive practice preceded any knowledge of the organic cause of a disease, or indeed any direct knowledge of disease germs at all. Unfortunately, such successes—which were not a few—were often misinterpreted in such a way as to encourage faith in an attitude wrongly described as "practical." With this vague and foolish word ignorant men have comforted themselves for centuries. With it they have sought to conceal from themselves and from others their destitution of anything in the nature of general

ideas. They have done this from the days of Plato to our own, and their repetitive eloquence has often succeeded. Medicine in England has suffered sorely from "practical" men. Until the present century they kept in a relatively subordinate position the study of the basic sciences of pathology and bacteriology, while these studies were rapidly developing in Continental schools.

The Scientific Atmosphere

Let us turn now to consider the general scientific atmosphere about the middle of the nineteenth century. Men were then coming under the overwhelming influence of certain conceptions on the nature of our world which profoundly impressed almost every department of mental activity. Of these ideas the first in importance, though not in time, was the doctrine of energy, its conservation, its indestructibility, and its transformability. This view began to emerge clearly in the 'forties, and by about 1865 had taken full possession of the scientific field. Above all the velocity of light, determined in 1849, was shown in 1867 to be identical with that of electromagnetic waves. Some decades earlier the atomic view of matter had become generally accepted and had been linked with the molecular theory. By 1870 the discovery of periodicity in the properties of the chemical elements held out hope for a completer synthesis of the physical sciences. The idea of the transmutation of forces was by then a commonplace. Thus by the middle of our period there had fully developed the classical "billiard ball" view of the material world. This, it was held, consisted of untold numbers of spherical, impenetrable, inelastic, indestructible atoms. They were arranged in molecular groups in an all-pervading medium of "ether." The weightless, perfectly elastic ether in some mysterious way transmitted, transmuted, or stored forces which acted on the atoms. The older medical men who are now living were reared in that conception. It prevailed until almost the dawn of the twentieth century and induced the "positive" attitude that ultimate scientific truth was only just round the corner. This suited well the medical temper of the age. Its collapse corresponds closely in time to the end of our period.

To this "billiard ball" theory had to be fitted a very imperfectly formulated conception of the nature of life in general and of the life of higher animals in particular. The fit was a poor one, though the successful synthesizing of one organic compound after another repeatedly gave rise to hopes of finding a "physical basis of life." But the incompleteness of the fit was almost forgotten in the enthusiasm aroused by the attractively publicized doctrine of evolution. By the mid-'sixties the evolutionary origin of organic forms had come to occupy most biological thinking. Especially it stimulated interest in animal structure. Human anatomy thus became, as of old, healthily allied to comparative anatomy. It was more intelligently studied.

This was not entirely a gain to medical education, since anatomy now assumed an excessive share in the medical curriculum. The great physiological advances of the period were of high significance for medical practice, yet they produced no general idea comparable in arresting power to that of evolution. Moreover, anatomy was the necessary discipline for surgery. Vast improvements in surgical technique came with the dramatic introduction of anaesthetics from about 1850 and of antiseptics from about 1870. Anatomical detail thus gained a prestige out of all proportion to its application in general practice. The brilliance of the surgical revolution blinded men to the statistical evidence that far more lives could be saved by preventive measures than by even ideal surgery. In most English schools, too, anatomy was taught by surgeons—normally a

prosperous class. If the reader adds to these things that the stipends of the teachers of preclinical subjects were paid from students' fees, that medical and surgical teachers were unpaid and depended for their livelihood on patients sent to them by past students, and that the teachers were effectively a self-electing body, he will find a diagnosis of the defects of English medical education between 1850 and 1900 no very difficult task. It was a bad system, and it is well that it has gone. Like all systems, good and bad, it produced some excellent men.

Developments in Knowledge of Function

During the second half of the nineteenth century certain fundamental generalizations on function were giving hope of a much more synthetic view of the workings of the body than any yet conceived. The hope was disappointed, but I would select as specially significant a few of the lines of development that were then current.

First was the cellular view of life and the allied doctrine of protoplasm. From these emerged two important results. One was cellular pathology. This has remained as a useful theoretical and practical foundation for the study of diseases. The other was a knowledge of what was then a wholly incomprehensible series of nuclear phenomena. This was to determine the whole conception of heredity, and indeed of life itself, in the next century. It is often forgotten how well known were the phenomena of nuclear mitosis long before meaning could be attached to them.

Second was the study of metabolism and nutrition. Important opening events here were the demonstrations, in the decade 1848-58, of the glycogenic functions of the liver and of the action of the pancreas. The 'sixties and 'seventies revealed many enzymes and their actions, involving an unexpected complexity of the digestive processes. In 1880 a new type of pancreatic and later of gastric fistula provided convenient means for a much wider range of research, leading to the conception of "conditioned reflexes." It was not till the twentieth century that the study of nutrition assumed its national and international significance.

Third was the progressive demonstration of the primacy of the nervous system, leading to the doctrine of the neurone. It stamped upon medicine the conception of an immensely complex series of systems for the transport of nervous impulses which determine the activities, the reactions, the whole life of the organism. This new knowledge of the nervous system entirely changed the direction of thought in many departments of medicine. The integration of the nervous system barely came within the nineteenth-century purview.

Fourth was the attainment, very late in the century, of some understanding of a relation of mind and body based on the study of conditioned reflexes. Parallel with this, and also from it, grew systems of psychology, physiological and other, which have since steadily increased in practical medical importance.

Fifth was a movement, with roots far back in time, which sought to apply purely chemical criteria to all forms of vital activity. It was near to what we now call biochemistry. In the last twenty-five years of the century the great exponents of chemotherapy were in Germany, where there were chairs of medical chemistry from the 'seventies.

Clinical Advances

The second half of the nineteenth century was rich in inventions of physical and chemical devices to aid the clinician. Some of these were hardly improved till the twentieth. General anaesthesia by chloroform, ether, and nitrous oxide gas was introduced shortly before 1850. The

methods of administration did not substantially change in the ensuing fifty years. Soon after the introduction of these drugs attempts were made to secure a painless state without unconsciousness. They were not successful until cocaine was adopted for the purpose in the middle 'eighties. Neither this drug nor its mode of application was much improved, except by injection into nerves, until the end of our period. Of anaesthetics as a great specialty the nineteenth century knew nothing. Of drugs of chemical origin of the period there are still in use such forms as chloral, the bromides and iodides, sulphonal, paraldehyde, and many others. To these must be added many antiseptics, chiefly those related to carbolic acid, and, above all, many alkaloids and other active principles of drugs of vegetable origin. The medical application of x rays comes almost outside the period here treated. It is one of the series of landmarks that divides the two centuries.

Of all medical advances of that time perhaps the most lasting will prove to be the revolution in the status and mode of recruitment of nurses. This began with the Crimean War in 1854. I hesitate to discuss it here, for it demands far more attention than I can give it. But somewhat parallel to the nursing revolution, and perhaps partly conditioning it, was the rise of specialization. It hardly existed in 1850, except in the sense that the departments of medicine and surgery, and to some extent of obstetrics, had long been rather artificially separated. Such further specialization as existed was mostly hardly more than quackery. True professional specialization was largely of Viennese origin. It came to England rather late, but became necessary with the diffusion of instruments that were difficult to use, as the ophthalmoscope (invented 1851) and the laryngoscope (invented 1855). The development of aseptic surgical technique in the 'seventies and 'eighties made possible a much wider range of operative procedures, which soon gathered their special exponents. Medical specialization, except for dermatology and to a minor degree paediatrics, hardly appeared in Britain till the twentieth century. Dentistry, like nursing, is of such universal importance for human welfare that it demands separate treatment.

The Outstanding Triumphs

The outstanding medical triumphs of the second half of the nineteenth century centre round the establishment of the doctrine of the germ origin of disease. It might be thought that here, if anywhere, specific discoveries must be ascribed to specific persons, yet it is really not so. The more the historian investigates the actual sequence of events the less inclined will he be to attach men's names to specific discoveries or to distort the picture of a great and continuous stream of thought by misrepresenting it as a series of steps—a Jacob's ladder leading to Heaven. In so small a compass as ours, we are employed better in indicating movements than names.

In fact long before 1850 it had been shown that certain diseases are associated with micro-organisms. Some even then believed them to be the causative factors. For generations many had strenuously denied that micro-organisms are ever spontaneously generated. But in 1859, as a culmination of centuries of experimentation, it was proved, as well as a universal negative can be, that the organisms of putrefaction and fermentation never arise *de novo*, but always from those of a kind like themselves. In 1863 the formation of highly resistant spores of the organisms of butyric fermentation was demonstrated, and somewhat similar spores in organisms of silkworm disease in 1869. Shrewd guesses regarding the essential nature of all infections were by then rife in scientific conversation.

The real advance of the age was, as usual, less in ideas and suggestions than in techniques and demonstrations.

Much essential work at this time was concentrated on anthrax. Its bacillus had been seen as early as 1850. During the next decade or so it had been shown that the violence of an attack of this disease was in proportion to the number of organisms present. In 1871 the organism was proved to have a causative relation to the disease; anthrax bacilli were filtered off from infected juices, and the disease was found not to be produced by the filtered juices (which were nevertheless toxic) but only by the remaining bacilli. The organisms were obtained in pure culture in 1875. Highly resistant spores were demonstrated in them in 1876. The existence of these remarkably permanent minute bodies provided an explanation of many puzzling phenomena in the recurrence of this and other infectious diseases. By 1888 it was generally realized that the poisonous substances produced by the action of some organisms were specific for those forms. For these substances the word "toxin" had been introduced (1886). All this work was contemporary with the rise of the new surgical technique.

With knowledge of the life history and pathogenicity of the anthrax organism as model, investigators turned eagerly and successfully to other diseases. The pathogenic relations of the causative organisms of leprosy were revealed in 1874, of many organisms of wound infection in 1877 and the following years, of gonorrhoea in 1879. In 1882 came the great demonstration of the bacillus of tuberculosis, itself the brilliant culmination of a long series of investigations by many workers in different departments and notably in the microchemistry of dyes.

Infection and Immunity

The study of the infectious diseases now entered a new phase. The enemy was in clear view and was known for what he was. Solid media were fully available, and pure cultures were therefore much more easily obtainable than formerly. The introduction and improvement of aniline dyes as stains made the organisms more readily observable. Bacteriology thus arose as an independent science: it had its own exponents, far more numerous in Germany than in Britain. The twentieth century had dawned before bacteriologists were recognized in every English medical school.

An organism was satisfactorily demonstrated as having a causative relation to typhoid in 1880-1. Tetanus, cholera, and diphtheria followed in 1883, glanders in 1885, cerebrospinal and undulant fevers in 1887, the plague in 1894, and so on. Many organisms of disease were transmitted to animals, recovered from them, and transmitted again, producing the same disease with each inoculation, thus removing any chance of error about their causative relation. The last twenty years of the nineteenth century produced many bacteriological results in the laboratory that were destined to be extensively developed and widely applied during the subsequent period. Notably there then arose the scientific study of immunity.

"Active" immunity had been known for centuries. The conception became quite familiar with the introduction of variolation at the beginning of the eighteenth century and of vaccination at the beginning of the nineteenth. The word "immunity" passed into general use about 1880, when there was much discussion of the specific infectious fevers, their incubation periods, their statistical incidence, their mode of spread, their probable microbic origin, and the subsequent "immunity" conferred by their attacks. Methods of obtaining attenuated viruses for chicken cholera and anthrax, and their use as preventive vaccines, were

attained in France at this time. A triumph of active immunization was the preventive vaccination against typhoid fever introduced tentatively in France in 1888. Later it became more practicable, and was applied extensively to the army in India (1898-1900). No less important was the discovery of the agglutination of typhoid bacteria by the serum of infected patients in 1896 and its immediate application to the diagnosis of the disease.

During the last fifteen years of the century, and beyond, a preponderance in this type of work passed to Germany. This is a striking historic phenomenon related to certain social factors which we cannot here discuss. The years 1890 to 1894 were critical. New methods were being devised for attenuating toxins. It was demonstrated in 1890 that the blood serum of animals immunized against attenuated diphtheria and tetanus toxins can be used for preventive inoculation against these diseases in other animals—in other words, these animals were not only producing “antitoxins” but were also producing something which itself excited the production of antitoxins. In 1894 this method, as applied to diphtheria, was used on a major scale on human beings and was very successful. It was soon widely adopted. The induction of such “passive” immunity in diphtheria and in other diseases is now very familiar. There was from the first, and there still is, much discussion on the biochemical nature of the processes involved.

Tropical Diseases

Investigation of the so-called “tropical diseases” has always occupied a somewhat special place in medical thought. Owing to colonial commitments it was naturally a peculiarly British interest. We now recognize that some of the most important of these diseases are due to organisms other than bacteria. Some fungal and helminthic parasites of relatively little pathogenic importance for men had been known long before 1850. More important are the protozoal parasites.

The first protozoal disease to yield its secret was relapsing fever. The condition had been known in Europe since the eighteenth century. In 1847-8 and 1868-73 there had been outbreaks in London. The disease is world-wide. Its spirochaete was described in 1873. In 1879 the disease was reproduced by direct inoculation of infected blood. The insect vectors were not proved until 1904, though they had been suggested as early as 1857. Similarly, the spirochaete of syphilis was not adequately known till the twentieth century, though it had probably been figured in 1836 and the disease transmitted to apes in 1878.

For organisms so accessible and so easily seen, the history of the knowledge of the causative organism of amoebic dysentery is more intricate than might be thought. The reason for this is twofold. First, the species of parasitic amoebae were not adequately distinguished, for only certain of them produce the disease. Secondly, only certain cases of “dysentery” are due to amoebae. There are accounts of amoebae in human intestines from 1860 onward. These parasites were also found in liver abscesses. In 1889 the pathogenic forms were differentiated from the others and found in sections of ulcers and in stools. They were used to reproduce the disease experimentally. In 1899 cysts of the amoebae were described, and it was shown that these too could be used for infecting animals. The clearer definition of the amoebic disease naturally led to the more accurate distinction of bacterial dysentery, the organisms of which were isolated and cultivated in 1897.

Several naturalists in the 'sixties and 'seventies devoted themselves to the study of parasitic worms. They showed

that certain of these, *Filaria* in particular, change their host during their life history. In 1878 *Filaria bancrofti* was seen to go through part of its development in an *Anopheles* mosquito and was traced into the blood of man. This was the first direct conviction of an insect as a disease carrier. Soon afterwards the malaria parasite was seen in human blood (1880) and its significance was grasped. Much research was now done on the malarial organism in human blood to elucidate the parasite's life-cycle there. Its general character was clear by 1897, when other stages of the life history of the parasite were located in the stomach wall of *Anopheles* mosquitoes which had fed on the blood of malarial patients. Within a few months the spores of the parasites were shown to be concentrated in the salivary glands of the insect. The secret of malaria was out.

At the end of the nineteenth century much scientific attention was being concentrated on the protozoal organisms known as “trypanosomes.” A species had been seen in the frog in 1843, and between 1880 and 1890 several species had been reported in a large number of mammals in different parts of the world. In 1901 trypanosomes were first found in man associated with sleeping sickness. Similarly the protozoan *Babesia* was found in ungulates from 1888 onward. In 1895 it was found in cases of Texas fever and was proved to be transmitted by a tick, the first disease after filariasis to be demonstrably charged to an arthropod carrier. Malaria, as will be seen above, was chronologically the third.

Demographically one of the most formidable parasites is the hookworm, *Ankylostoma*. This creature is now known as the cause of “tropical chlorosis,” “miners' anaemia,” and conditions under various other names. That it was pathogenic had been known since 1866. In 1898 it was shown that it can penetrate the skin and reach its final home, the intestine, by devious routes. The interest aroused by this led to the investigation of numerous worms parasitic in animals and men. Many have been shown to have extremely complex life histories, involving several hosts. Parasitology became an independent science in the twentieth century.

Some Foreshadowings

In ending, we should refer to two other small adumbrations of great things that were to come. In 1892 there was a plague of field mice in Thessaly. It was eradicated by means of the *Bacillus typhi murium*, the first example of the deliberate use of a disease against a pest. In the same year it was shown that the mosaic disease of tobacco will pass the finest filters. In 1897-8 the same was found true of foot-and-mouth disease, the beginning of the study of filterable viruses in mammals and man.

The years round 1900 were, for science, about as critical as any in its long history. It suffices to mention the theory of relativity, the quantum theory, the revelation of the atom as a structure, and the evidence for the particulate nature of inheritance (rediscovery of Mendelism). These appeared within a few months of each other. Medical thought, too, was engaged on themes which were to develop out of small beginnings. Such was chemotherapy, the theory of immunity, the application of x rays and of radiation, the development of protozoology, the integration of the nervous system, vitamins, the psychology of the unconscious, the study of filterable viruses, and so on. It is not my task to treat these, but it is well to end, as I began, by reminding the reader that they represent drastic changes in the direction of medical thought. The year 1900 marks as definite a period as can be found anywhere in the vast annals of medical history.