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A HALF CENTURY OF AMERICAN MEDICINE[1]

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THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

BY a happy coincidence it is just a half-century since I entered the University School of Medicine at Louisville as a student. For fifty years, therefore, I have been an observer of the medical developments taking place in this country, and during much of this time I have also followed the developments going on abroad. It is my purpose on this occasion to attempt a brief and rapid review of American medicine of this period in relation to European medicine as it existed at the same time.

But first I must express to you the happiness I feel in returning here to my Alma Mater and to the city of my birth and young manhood. I am moved to salute you on the celebration of the hundredth anniversary of your foundation, to congratulate you on your past, and to wish you ever greater achievements in the future.

The early history of the Louisville Medical School is an integral part of the history of the American frontier and the winning of the West. Abler and better-informed writers have recorded the beginnings of the school, brought it into relation with Transylvania University, from which the first nucleus of its faculties came, and followed its later vicissitudes. The school was an important link in that historical chain of peripatetic schools which, before the middle of the last century, attracted the experienced physicians and surgeons of the day who wandered up and down the country from east to west, doing their part, and a very significant part, in subduing the wilderness. It is a pleasure and an inspiration to recall some of the remarkable men who taught here, among whom were Daniel Drake, Samuel D. Gross, Austin Flint, Elisha

[1] Address delivered on April 3, 1937, at the celebration of the one hundredth anniversary of the founding of the School of Medicine of the University of Louisville.

Bartlett, Benjamin Silliman, Jr., Charles Caldwell and the elder Yandell and Palmer. These men left an impress on the school which endured long beyond their days. They anticipated the later practice of calling outstanding teachers from one institution to another, too long suspended subsequently when the schools had hardened into fixed institutions, each with its local faculty. Indeed, this innovation waited full half a century until the medical schools of the country progressed sufficiently to achieve real university status.

Fifty years ago the pioneering period in medical education had come to an end. The riding of the circuit by wandering teachers was over. One can picture the glamor of the free life led by these men in their young manhood as they rode without haste through a primeval and often beautiful country, and the thrill and pleasure they experienced in meeting one another again after months or even years of separation. That a warm companionship grew up among them could be safely assumed, and letters of the period tell this story. Elisha Bartlett, one of the rarest and most delightful of men, who taught at the Berkshire Medical Institute in Pittsfield, Mass., as well as in Louisville, wrote in 1836, referring to Willard Parker: "He was in to see me a few minutes after my arrival, with his sunny face and hearty welcome. It does one good to meet such men." Bartlett, by the way, taught in nine schools, as also did another peripatetic, John Delamater, the founder of the Medical College of Western Reserve University. That the peripatetic doctors, when they were men of ability, should have become highly experienced teachers follows from their unexampled opportunities. They enriched, therefore, the medical literature of their time and some of their writings have become the classics of our profession.

The Louisville Medical School in my day still bore the impress of these teachers. It was a school in which the lecture was everything. Within the brief compass of four winter months the whole medical lore was unfolded in discourses following one another in bewildering sequence through a succession of long days; and lest the wisdom imparted should exceed the student's power of retention, the lectures were repeated precisely during a second year, at the end of which graduation with the degree of doctor of medicine was all but automatic. Of laboratory instruction there was none; the anatomical laboratory provided the one place where practical instruction was given, and yet the students managed somehow to become doctors, and ever so often good doctors at that.[2]

The saving grace was the preceptorial system, virtually an apprenticeship, in which older, experienced men taught the methods of their art to the student doctors during the eight months between courses. The apprentice served his master as druggist, operation assistant, and in many other ways; rode with him on his rounds, took his place when he was ill and at times in the blustery nights, and supplemented him when epidemics swept the countryside. That unusual skill should sometimes have crowned so imperfect an educational discipline justifies the comment made by an eminent teacher, Dr. William H. Welch, himself a product of the old order, that "the results were often better than the system." A profession based on so faulty a system of education could not survive in a country developing materially, becoming conscious of its intellectual deficiencies and sensitive to the opinion of the larger world of which it now formed an integral part. That forward steps should originate in the East, longer settled and more prosperous, and that the first step should have been taken at Harvard College need excite no wonder. One of the revolutionary acts set in motion by President Eliot when he took office in 1869 was the regeneration of the Harvard Medical School, which, to all intents and purposes, corresponded to this school as I knew it just twenty years later. President Eliot improved the student body by raising the entrance requirements and the school by prolonging and grading the courses of instruction and by introducing practical methods of clinical teaching and even laboratory training. But the Harvard school, like all the other schools of the period, lived on students' fees. By raising the standards, giving the school a real university status, and by arousing public interest in the reforms undertaken, President Eliot soon secured aid from the citizens, justifying his dictum that "the first step toward obtaining an endowment is to deserve it."

The decade from 1870 to 1880 is a highly significant one in the medical educational history of this country. It was a preparatory period, the full effects of which were to be realized a few years later. The first ventures in medical instruction made in colonial times were sound. They were based by John Morgan and his associates in Philadelphia on the Scotch system; and the rules laid down by them as qualifications for the "bachelor's degree in physic" arouse admiration even to-day; they include some knowledge of the Latin tongue and such branches of mathematics and natural and experimental philosophy as shall be judged requisite to a medical education. A hundred years were to elapse before a corresponding standard of educational

[2] In my day there was no pathology and of course no bacteriology at the Medical School. In 1889 Dr. Edward R. Palmer, the professor of physiology, announced a course of lectures in bacteriology. They consisted of readings from a fascinating small book, Prudden's "Story of the Bacteria," which had just appeared. I present this book in its first edition to your view. Need I add that I bought the book to read instead of attending lectures in order to hear it read in weekly instalments. This was doubtless the beginning of bacteriology in the school.

preparation for the study of medicine was again instituted.

The modern developments in American medicine are of German origin. The Scotch, English and French schools had attracted ambitious American students in the eighteenth and early part of the nineteenth centuries. The rise of the German medical schools to pre-eminence began with the appearance on the scene of two remarkable teachers, near contemporaries. One was Johannes Müller, born in 1801, and the other Justus von Liebig, born in 1803. Müller, the son of a shoemaker of Coblentz, was anatomist, physiologist and pathologist. He studied at Bonn and at Berlin and became professor in both these universities, and was the teacher of great men, among whom were Schwann, the founder of the cell theory, Henle, the anatomist who formulated precisely in 1840 the germ doctrine of disease, Traube, the experimental pathologist, Helmholtz, the physicist and physiologist, and Virchow, the originator of the cell doctrine in and the father of modern pathology. Liebig's father dealt in colors and with the aid of his small son manufactured them by the elementary methods of the day. Chemistry thus came naturally to the youth who was to establish the student's laboratory, a decisive factor in making German science, including medical science, supreme. As early as 1824, Purkinje, the physiologist, started a laboratory in his own house in Breslau, but it was in Giessen in 1825 that the important step was taken when Liebig's laboratory was opened there in the university. It is interesting to recall that it was Alexander von Humboldt, the insatiable traveler, who was responsible for this great innovation. The gifted young Liebig, in 1822 at the age of nineteen, studied in Paris. At that time there did not exist in Paris, or indeed anywhere in the world, a single public laboratory for students in chemistry or physics. Through private influence Liebig secured entrance to the personal laboratory of Gaultier de Claubry, where he worked on explosives and by chance met Humboldt, who was deeply impressed by him. Thereafter all doors and all laboratories opened to him as if by magic, and he was soon at work with the eminent Gay-Lussac; and it was Humboldt also who brought Liebig to the little University of Giessen.

Liebig's chemical laboratory quickly became celebrated and copied by the German universities generally and in other countries. The first two men who devoted themselves entirely to laboratory teaching in this country in a medical subject were Henry P. Bowditch at the Harvard Medical School and Newell Martin at the Johns Hopkins University. This was in the years from 1870 to 1876. Both had studied abroad, Bowditch at Leipzig with Karl Ludwig and Martin at Cambridge with Michael Foster, the founder of the English school of physiology. There had, however, been a full-time teacher at the Harvard Medical School before Bowditch. Oliver Wendell Holmes taught anatomy and physiology there from 1847 to 1871, holding, as he later said, "not a chair, but a settee."

In the decades from 1860 to 1890 pathology in Germany reached its height under the stimulus given it first by Virchow and then by Cohnheim. Pathological anatomy was everywhere assiduously pursued, but it was at Berlin under Virchow and the clinical teacher Traube that pathological experiment was placed in its impregnable position in the development of pathological physiology. But in the seventies another school of great strength in experimental or physiological pathology arose at Breslau under Cohnheim, a pupil of Virchow's who also was a pupil of the physiologist and chemist Kühne of Heidelberg. These two centers—Berlin and Breslau—vied with the new German university at Strassburg in attracting American students, and hither in the middle seventies went such men, afterwards to become teachers and investigators in pathology, as William H. Welch and T. Mitchell Prudden.

They returned to this country before 1880 and neither of them found an opportunity to teach pathology in an adequate way. Hence they engaged in a variety of pursuits to gain a livelihood—practicing medicine, performing autopsies, quizzing medical students, doing a kind of hack literary work, with only odds and ends of time left for practicing their chosen profession.

But great changes were imminent. A small beginning was soon made at Bellevue Hospital in New York, where Dr. Welch offered the first course in microscopical pathology given in America and where he met Austin Flint, who was not long in discovering his unusual abilities. I like to connect these important events with the history of the Louisville Medical School, at which Austin Flint taught in pioneer days. It is a fact of history that Welch wrote the pathology for the fifth and sixth editions of Flint's "Practice of Medicine" and in so doing produced one of the first treatises on pathology worthy of the name in this country. The sections on pathology in the sixth edition have not, in my opinion, been surpassed in any language and they are unique in the breadth of treatment given them. This edition was published in 1886, or in the midst of the Koch or bacteriological period, so that it covers not only pathology in the usual sense, but also pathological physiology reflecting the Cohnheim influence and embodies the principles of the new bacteriology. Prudden started in practice in New Haven, but in 1878 was called to the College of Physicians and Surgeons in New York, where he opened the first

pathological laboratory in that school in a basement room which had been an ice-cream parlor. It was not until 1884 that Welch was called to Baltimore and not until 1892 that Councilman, who had studied with Cohnheim in 1883, was called to Harvard Medical School to fill the chair of pathology, the first professorship in this institution to be filled from outside Boston.

More important, however, for the impending developments was the founding of the Johns Hopkins University and Hospital. Mr. Hopkins, a Baltimore merchant, left his entire fortune of seven million dollars to the support of the university and the hospital. Daniel C. Gilman was made president of the university. A medical school, part of the university and attached to the hospital, was in contemplation. The university opened in 1876, and Thomas H. Huxley delivered the inaugural address, in the course of which he said:

> At present young men come to the medical schools without a conception of even the elements of science. They learn for the first time that there are such sciences as physics and chemistry and physiology and are introduced to anatomy as a new thing. . . . There is not the least reason why this should be so. . . . There is not the slightest difficulty in giving sound elementary instruction in physics and chemistry and the elements of physiology in the ordinary schools. . . .

These fateful words fell on prepared soil. President Gilman had graduated from the Sheffield Scientific School of Yale College and in 1870 was instrumental in arranging there a premedical course in the physical sciences. It was natural, therefore, that such a course should be offered immediately at the Johns Hopkins University; moreover, it was supplemented with courses in modern languages. Prudden had been a student at the Sheffield Scientific School in the early seventies and had taken, as part of his regular instruction, this preliminary medical training, and Welch, having graduated from the arts college, returned after a year of school teaching to spend an extra year at the Sheffield School before entering on the study of medicine at the College of Physicians and Surgeons in New York.

The decade 1880 to 1890 has been called "the most wonderful, perhaps, in the history of medicine." Pasteur's famous labors were drawing to a close with the dramatic demonstration in 1885 on the Alsatian lad, Joseph Meister, that he had perfected a means of preventing rabies or hydrophobia. Koch and his pupils had discovered the germ causes of tuberculosis, Asiatic cholera, diphtheria, typhoid fever and other infectious diseases. A revolution in medical thought had been brought about by the discoveries of this epoch, and those living to-day can hardly realize the enthusiasm and youthful spirits which were stirred by these advances not only among medical men but among the public.

The eastern medical schools and the University of Michigan had responded to these influences. The most significant advance had been made at the Johns Hopkins University, to which Dr. Welch, a pupil of von Recklinghausen, Ludwig and Cohnheim, was called as professor of pathology.[3] The Johns Hopkins Hospital opened its doors to patients in 1889, the entire major clinical staff having come from outside Baltimore. The names of these men—Osler, Halsted, Kelly—have become household words among doctors. This was an innovation indeed. For the first time in educational history in this country a medical faculty had been chosen on strictly university lines.

Untoward circumstances delayed the opening of the medical school for another five years. When it was established the laboratory faculty was chosen on the same broad principles of scientific attainments. Moreover, the requirements for entrance on medical studies adopted were essentially those laid down in Professor Huxley's address, and the school avowedly accepted the thesis that its responsibility for the instruction of students and the training of doctors was no greater than its responsibility for the advancement of knowledge by research.

By the end of the nineteenth century several medical colleges were equipped with laboratories manned by specially trained teachers and had secured larger clinical facilities; and at the beginning of the twentieth century the pursuit of science, including medical science, had been given a great impetus in this country through the intelligent action of certain laymen. The Rockefeller Institute for Medical Research was founded in 1901 and the Carnegie Institution of Washington in 1902.

Now there is nothing peculiar about the medical sciences. They are only biology, chemistry and physics directed toward particular ends, namely, the understanding of disease and its prevention and cure. The successful prosecution of medical research depends, therefore, on knowledge of the underlying sciences. Medicine had progressed so far in America because

[3] Pathology had a development in America differing from its German prototype. It included normal as well as pathological microscopy (histology), bacteriology during the Koch era, experimental medicine or pathological physiology, and sometimes even clinical microscopy. The several subjects included ranged about the microscope, which was used in all. Whether pathological physiology became a part of the chair depended on the particular master with whom the occupant had studied in Germany. It was not until academic or full-time clinical chairs were established at the Hospital of the Rockefeller Institute in 1910 and at the Johns Hopkins Medical School in 1914 that experimental medicine was studied in the clinic as Ludwig Traube had done in Berlin before 1850.

the fundamental sciences fortunately had already been cultivated, although inadequately. According to ordinary perceptions it was little hazardous to found an institution for pure research in the physical sciences and extremely adventurous to attempt to do this for medicine. I doubt whether any medical man would have made this venture. To do so called for the courage of laymen who managed somehow to see the wood unobstructed by the trees. Let us recall that the bacteriological era from 1880 to 1890 had been succeeded by the immunological decade of 1890 to 1900, which saw diphtheria and tetanus or lockjaw robbed of their main terrors by antitoxin and typhoid fever prevented by inoculation. The times were stirring ones and hope for the eventual and not too long deferred conquest of the germ-caused diseases ran high.

The higher medical education already achieved in the last quarter of the nineteenth century, although not yet on a country-wide basis, made possible the experiment about to be undertaken with an institution devoted wholly to medical research. In retrospect a parallel can now be discerned between the establishment of the Rockefeller Institute and the Carnegie Institution in this country and the founding of the learned societies—the Academy of Sciences in France and the Royal Society in England—in the seventeenth century. In both instances the demands of scientific growth and exploration had outgrown the provisions in the universities. A broader base of operations was necessary; the encroachments upon the time of teachers by enlarging routine duties had become menacing; the requirements in elaborate and expensive apparatus had often exceeded the abilities of the universities to supply the needs. The new institutions, which in time came to be generously endowed, filled the gap, and they are justifying themselves as the country's opportunities enlarge more and more, by drawing able men from the universities, enhancing their training and often returning them to the universities increased in power, skill and value.[4]

In the early part of the twentieth century many medical schools were still far behind the advancement which had taken place in some of the more favorably situated institutions. Two logical developments now took place. The Council on Medical Education of the American Medical Association and the Association of American Medical Colleges entered the field shortly before 1910 and succeeded in leading professional opinion on medical standards and, by exerting a kind of moral pressure, brought about much-needed reforms in the backward schools. A second factor was the Carnegie Foundation report on medical education issued in 1910. This report, which many of you will recall, was prepared by my brother, Abraham Flexner, and speaking of it in his Harvey Lecture of 1915, Dr. Welch states: "I consider it to be one of the most remarkable and influential publications in educational literature. It has had not only a large influence upon professional opinion, but especially a large influence on the universities and on public opinion. It is to be characterized as one of the important factors which indicate this remarkable advance in medical education."

Philanthropic organizations now entered on the liberal support of medicine. The General Education Board and the Rockefeller Foundation especially contributed large sums to the further strengthening of the existing stronger schools, the regeneration of others and the establishment of new schools at strategic geographic locations; and the general public responded also, so that in an incredibly short space of time a vast improvement in the medical schools in all parts of the country took place. President Eliot's remark that "the first step toward obtaining an endowment is to deserve it" had been shown to be more than ever true.

The rewarding nature of endowments to advance medical education and research has been shown in many concrete instances; and one could scarcely cite a more impressive example of the power of modern medicine to abate anxiety and to remove the danger of disastrous epidemics than your own recent experience in the confused days of the flood calamity by the application of bacteriological methods of the prevention of disease.

The laboratory branches of anatomy, physiology, pharmacology and biochemistry were well advanced in this country before the end of the second decade of this century. Many more of the medical schools had established laboratories for teaching and for research in charge of trained teachers. Hospitals had been improved and clinical instruction made more effective. But at its best the clinic lagged behind the laboratory and usually was in charge of local practitioners engrossed with practice. Selection according to special qualifications, as was now customary with the laboratory, was highly exceptional. It was not until 1912 that a clinical professorial chair at Harvard Medical School was filled from the outside. Finances had much to do with this defect, but there were and still are other difficulties not yet overcome.

The clinical side of medical education is the central

[4] Germany, from which ambitious young American doctors drew inspiration and training between 1870 and 1900, turned to the United States for the model of its institution of scientific research established at the end of the first decade of the twentieth century. The Kaiser Wilhelm Institute, with its 30 different laboratories, which has just celebrated its twenty-fifth anniversary, is avowedly modeled on the Rockefeller Institute and the Carnegie Institution, founded ten years earlier.

feature toward which the training in the laboratory branches aims. This is not to say that the laboratory subjects have not an interest and scientific purpose of their own. Far less had been done to make the clinic branches strong and effective than had been done for the laboratory subjects. Moreover, the load of responsibilities on the clinical teacher is far heavier than on the laboratory teacher. A head of a principal clinical department is responsible for the patients, for the teaching and in theory for the stimulation of research, while he is also engaged in the onerous and absorbing practice of medicine. The burden is heavier than any one can bear in the modern medical school, where teaching and research and the care of patients in the hospital now involve the many methods of precision which are constantly increasing in number and complexity.

The recognition of the difficulties just alluded to led the Johns Hopkins Medical School in 1914 to a courageous move. Through financial aid provided by the General Education Board, chairs of academic, sometimes called full-time, instruction were established in medicine, surgery, obstetrics and pediatrics. Several other schools have now found the means to institute similar academic professorships. The precise form taken by these new establishments varies somewhat, as is desirable in order to determine what is the most successful and practicable system. The academic teachers are distinguished from the usual clinical teachers mainly through the command of their time for more intensive study of clinical problems arising in connection with patients and for the conduct of laboratory investigations bearing on problems in clinical medicine. No school has tried to or can or should dispense with part-time clinical teachers, who continue to carry as they always have done an important and substantial part of the instruction of students.[5]

The academic clinical professorship is an American invention, but it is attracting the attention and the study of foreign universities. Only a short time ago Oxford University received a gift of ten million dollars for the purpose of endowing these professorships in medicine and surgery.

Up to the last decade of the nineteenth century no scientific medical journal existed in this country. This fact alone speaks for the state of medical science in America forty years ago. The *Journal of Experimental Medicine* was founded in 1896, with Dr. William H. Welch as editor. There was much doubt expressed whether there were enough technically scientific papers being produced to keep the journal alive. No limit was set as to the kinds of scientific papers acceptable; the only exclusion contemplated was that of the practical, clinical paper for which other means of publication already existed. As experience quickly proved, the potential scientific medical richness of the country had been underestimated. In a very few years, the *American Journal of Physiology* was started, and then successively followed journals devoted to pharmacology and therapeutics, infectious diseases, biochemistry, bacteriology, immunology, etc. I have examined the Quarterly Cumulative Index Medicus, and have marked more than thirty journals of technical scientific medical character now being published in this country. The first medical periodical to be published in America was the *Medical Repository,* started in 1797. Just a hundred years were to elapse between the publication of this clinical journal and that of the first scientific journal in this country.

Medicine to most of us means human disease. The definition is a narrow and insufficient one, as all living things suffer from disease. There is no line of division between disease in man and in the lower animals and in plants. Disease in man has of course a special importance for us, just as, economically considered, certain diseases of animals and plants have a higher value than others since man is so dependent on animals and plants for his survival and comforts. But to the true pathologist disease, wherever it appears, presents a series of challenging problems, the solution of any one of which will aid in the solution of others. The pathologist looks at the diseases of man, the lower animals and plants as forming an inseparable chain, and as the knowledge of the nature and causes of diseases continues to grow, this chain becomes more and more intricate and interrelated. The growth of medical knowledge and the improvements in medical education in this country in the last half century have influenced federal and state governments in providing schools in which the diseases of animals and plants can be investigated as human diseases are studied. As early as 1884 the federal government established the Bureau of Animal Industry and in 1887 the enactment of the Hatch act created the agricultural experiment stations. It was at the Bureau of Animal Industry that Dr. Theobald Smith, a medical graduate, made some of his most important discoveries, and although they related to diseases of animals, they affected in a remarkable and beneficent manner the development of human pathology.

The centennial of the founding of the Army Medical Library was celebrated a few months ago. The history of that library is bound up with the history of American medicine in the last half century in a highly important way. Scientific knowledge including medical knowledge is contributed to by all countries; a great library is essential, therefore, to the growth of

[5] This is not to say that clinical teachers did not in some instances conduct experimental investigations before this change. Halsted and his pupils are a notable case in point.

the scientific spirit. Now the Army Medical Library is supreme among medical libraries of the world, and a part of this supremacy arises from the publication of the Index Catalogue, four series of which have appeared between 1880 and 1936. This catalogue is one of the most monumental if not the most monumental bibliographical work ever produced. The history of the library has been told recently by Major Hume, the librarian. In this very interesting paper he reports a conversation with Dr. Welch, who was a regular user of the library, which bears on our theme and which I grasp eagerly in bringing this address to a close. In response to an inquiry, Dr. Welch said:

I have been asked on more than one occasion what have been the really great contributions of this country to medical knowledge. I have given the subject some thought and think that four should be named:

(1) The discovery of anesthesia;

(2) The discovery of insect transmission of disease;

(3) The development of the modern public health laboratory . . .

(4) The Army Medical Library and its Index Catalogue.

The discovery of anesthesia falls outside the period we are considering. Theobald Smith discovered the tick transmission of Texas fever of cattle at the Bureau of Animal Industry in 1890, and in so doing opened one of the most important chapters in modern pathology. We need only think of the mosquito carriage of malaria and yellow fever to appreciate the tremendous significance of the discovery. And virus and still other diseases of animals and plants also are carried by insect agents.[6]

The development of the public health laboratory had its beginning in 1887, or just fifty years ago, at the Federal Marine Hospital on Staten Island, being transferred to Washington in 1891. The appearance of cholera in New York Harbor in 1892 led to the opening of the first municipal laboratory, and between 1890 and 1894 the diphtheria diagnostic and antitoxin and the tuberculosis diagnostic laboratory was established in New York City under Dr. Hermann M. Biggs and Dr. William H. Park. From these modest beginnings public health laboratories, an essential adjunct to public health administration, have spread over the entire country, being supported by state, county and city funds. The campaign to eradicate the hookworm disease, financed by Mr. Rockefeller in 1910, gave a great impetus to the founding and improving of such laboratories in the southern states.

To these four great American contributions to medicine made during the last half-century I would add a fifth which is so new and indeed so startling that we can only begin to speculate on its importance. It has arisen out of the application of methods, some only just perfected, to the study of the agents causing the infectious diseases. The first advance I shall refer to is the discovery that the specific properties of disease-producing bacteria are of chemical origin. The active chemicals are crystalline in nature and the germs deprived of them become harmless. They take part not only in producing disease, but also in producing immunity from disease.

The second advance is as remarkable, but in an entirely different way. It relates to the viruses, those invisible, elusive, disease-producing agents of which one hears so much to-day. In number they exceed apparently the disease-producing bacteria, and like the latter are responsible for destructive diseases in all orders of living things. As an illustration of the interrelation of disease in man, animals and plants, I may remark that our knowledge of the viruses began with a plant disease—mosaic of tobacco—in which they were first discovered in 1892–93; the next virus disease discovered was foot and mouth disease of cattle, which occurred in 1897; and the first human virus disease to be recognized was yellow fever in 1901. Now, we have learned that infantile paralysis, or poliomyelitis, belongs in this category.

The viruses, as they occur in nature, are revealed to us only as they produce disease. That is, we know them not as such, but through their effects. As this proposition is first stated, it is rather disquieting and one may wonder whether such indirect knowledge is in the true sense knowledge at all. A similar and no longer disquieting case is that of the atom and the still smaller electron, which also are known only through their effects. No one imagines the atom to be a living thing, but pathologists are deeply concerned with the question of whether the invisible viruses are or are not living entities. Can all the phenomena of life—assimilation, respiration, multiplication—go on in such minute particles of matter? The question is still unsettled; but what has recently been found is that some viruses are definite chemicals; for example, the virus of tobacco mosaic disease which has been obtained in crystal form. And as the solution of one such major problem always raises others, we are now confronted with the question of the possibility of inanimate matter multiplying enormously in the body.

[6] There must be persons in this audience who can recall as I can the periodic outbreaks of yellow fever in our southern states. The demonstration of the mosquito carriage of the disease by Major Reed and his small group of volunteers by experiments made on themselves has put an end to those disasters. A quarter of a century later Adrian Stokes laid down his life in Nigeria, Africa, in showing that the monkey can be given yellow fever. Since then knowledge of the disease has grown rapidly. One of the great practical gains has been a method of protective inoculation. The perils of a journey to epidemic places in South America and Africa have now been removed and yellow fever is to be classed among the preventable diseases.

An infinitesimal amount of crystalline mosaic virus introduced into a tobacco plant increases greatly. But we may well leave that problem for the present, feeling that its solution will come in good time.

The viruses differ among themselves in size as measured by physical-chemical methods, and in stability—some are so delicate that they do not withstand chemical reagents. But the invention of the vacuum ultracentrifuge is making the investigation of the nature of these labile viruses possible. These centrifuges are capable of amazingly high speeds which yield a pull as great as 300,000 times gravity. Hence excessively minute bodies can now be aggregated so as to be brought under physical biological study. And by means of the x-ray photographic device, even their structure may be defined.[7]

I seem to have wandered far afield in closing this sketch of the medicine of America of the past half-century. In reality I have not strayed at all. These new discoveries are American in origin and they relate directly to medicine. Moreover, they illustrate in a particularly enlightening manner the interdependence of the physical and the medical sciences. I have already said that there is nothing peculiar about medical science, that it is only biology, physics and chemistry applied to a particular end. In these final examples there is nothing but physics and chemistry used to elucidate problems in comparative pathology—that is, the pathology of all living things. And pathology is merely the basic subject of how disease comes about—how it is initiated in the first instance, through what changes in structure function is impaired, and then finally through what retrogressive alterations health is restored. Just as anatomy and physiology together show us the relation of structure and functions in the normal body, pathological anatomy and pathological physiology or experimental medicine together show us the related altered structure and function in the diseased body. As these subjects come to be better understood, the diagnosis and treatment as well as the prevention of disease will become more scientific and successful.

We have followed some of the developments which in the space of half a century have raised American medicine from a low state to a leading position in world medicine. There is nothing accidental in this great change. What we are witnessing is merely the continuation of the movement westward which has marked the diffusion of knowledge since the revival of learning in the fifteenth century.

"We are like dwarfs," said Bernard of Chartres in the twelfth century, "seated on the shoulders of giants. We see more things than the ancients and things more distant; but it is neither due to the sharpness of our sight nor the greatness of our stature; it is simply because they have lent us their own."

[7] Method has always had a determining influence on experimental science. With every important advance in methods, new discoveries have been made or old ones perfected. Modern medicine owes a great debt to the physical sciences for the new and improved methods they have introduced. But it has the merit of having advanced itself by the discovery of methods applicable in the clinic and in the laboratory through which the diagnosis and treatment of disease have been enhanced.

SCIENTIFIC EVENTS

THE POLAR EXPEDITION OF THE U.S.S.R.

THE daily press reports that a Soviet airplane made a successful landing at the North Pole on May 21, and established a permanent weather and scientific station as the first step in the plan for regular air communication between Russia and America by way of the polar region.

The expedition is in charge of Dr. Otto J. Schmidt, professor of mathematics at the University of Moscow, director of the Soviet Arctic Institute and head of the Northern Sea Route Administration. The flight was made from Rudolph Island, about 82 degrees north and 60 east (or about 560 miles from the Pole). A. V. Vodopyanov was pilot of the plane.

The radio message sent to the U.S.S.R. government at Moscow follows:

We send you, through the Dickson Island radio station, greetings from the North Pole.

Aboard the Soviet plane, *USSR N-170*, we crossed the pole at 11:10 Friday morning. In order to obtain the best results we passed a little beyond the pole seeking a landing field.

We first crossed the pole at 1,750 meters and then came down to 250 meters through the clouds, seeking a place to land. At 11:35 A.M. we landed.

We are sorry to report that difficulty with the radio apparatus delayed our reports to you.

We are about twenty kilometers beyond the pole and a little to the west of the Rudolf Island meridian. We are on an ice floe, but it is possible to bring other planes here to establish a polar station.

Our regards to the government and the party.

Four men plan to remain at the station for about a year. They are Ivan Papanin, who will be in charge; Ernest Krenkel, radio operator; Pyotr Shirsov, hydrobiologist, and Eugene Federov, magnetologist. They will use a carefully planned folding house about 12 feet long by 9 feet wide, and 6½ feet high, which has been elaborately insulated. It weighs only 353 pounds and, in case the ice shows signs of breaking, it can be moved to a new site without dismantling.