MEDICAL SCIENCE, ITS PAST, PRESENT AND FUTURE*

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In agreeing to speak upon this subject I accepted a large order, but I assure you that I have never entertained serious notions of filling it. In these days when defaults are so common on everything from such trivialities as teachers' salaries to such important things as bankers' dividends, I felt sure that I would not be held strictly to my bargain. What I really propose to do is to touch some of the high points of medical history, recent and remote, germane to my theme, which might perhaps better be stated as "The Road to Medical Progress".

The art of medicine had its beginnings in the earliest dawning of human development, since the practice of medicine is the inevitable consequence of the existence of disease. It is natural that the attempt to practice the art should be as old as man, since disease in general is not a special product of civilization but is an integral part of the picture of life from its earliest beginnings. The earliest man had the problem of illness to beset him, according to evidence from fossil and other relics. Studies of the pathology of the remains of our remote ancestors are largely confined to those aspects of disease which are apparent from changes in the bony framework of the body and the teeth. The fossil remnants of some of our earliest men give clear evidence of the prevalence of disease of various types. For example, the Rhodesian man found at Broken Hill, which seems to be dated as early Pleistocene or late Pliocene, according to Dr. Hooton, shows, among the fifteen teeth which were found, ten with rather characteristic dental caries. The surrounding bone changes gave indication that there were alveolar abscesses. In the femur which was found with this skull there were abnormalities characteristic of rheumatism. And in the skull itself there is also a peculiar perforation about one-fourth inch in diameter in front of the orifice of the left ear indicating a discharging abscess. In this man one sees the same sort of picture of disease that is prevalent today. His tooth decay could scarcely have been due to abuse of cooked and prepared soft foods, for he lived somewhat prior to the era of oatmeal and corn meal mush. He lived on nuts, raw meat, crude cereals and fresh greens, if evidence from other sources does not lead us astray. But he suffered from the same sort of illness that our more pampered civilization finds itself heir to.

When primitive man began to think about the ways of combating disease in himself, his methods were those of the empiricist. He tried one and another of the means that occurred to him in attempting to rid himself of pain and weakness, and to forestall the death which he had seen his fellows suffer under similar circumstances. Whether his first approach to therapy was through an appeal to mysticism and to the supernatural by the medium of the witch doctor, or whether his earliest attempts were by the

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use of herbs and strange concoctions of rare and oftentimes repulsive substances, one can only speculate. This much is certain, that he struggled with this meagre grasp of the facts to find a remedy for his ills whether it was through incantation or medication. What the earliest man lacked was not a desire to be healed or the willingness to use his best reasoning in finding a way to be healed. Rather it was a dearth, or one might say total absence, of knowledge concerning the causes of disease that frustrated him in his attempts at cure.

Furthermore, the methods employed in attempting to solve the problems of disease and its treatment were not promising. The attempt to cure disease without a knowledge of its cause could scarcely be called scientific. Healers became known as fakirs because of the obvious chicanery and fraud which they practiced. The spirit healers and the witch doctors inevitably failed except when the real nature of the complaint of their patient was nervous and could be affected by the emotional state of the individual. So too, after the herb doctor by trial and error found amongst the plants certain ones which had powerful effects upon the animals or men who happened to eat them, he discovered to his sorrow that for the most part his potions were fruitless. The art of healing in the absence of knowledge of the cause of disease was as apt to be productive of results as the search for the needle in the hay stack. In the almost infinite complexity of types of disease and the equally great variety of procedures for their control or cure the likelihood that by random chance successful measures would be happened upon is extremely small.

The science of medicine may be said to have begun when man began to accumulate knowledge concerning the intimate mechanism of disease, and to try to apply that knowledge to the search for ways and means of curing it. There is no date in history that one can set as the beginning of medical science, because it began very gradually. Knowledge applied to medicine did not become important, however, until late in the recorded history of human civilization, and in truth one may say that a really producitve medical science dates only from the Renaissance. The early Egyptian civilization gives definite evidence of an attempt having been made to study human disease by somewhat exact methods. The Greeks made further progress, but not until after the end of the Middle Ages can it be said that any notable applications were made of the knowledge of physiology and pathology to the treatment of disease. This is largely due to the fact that not until the rebirth of learning in recent times has there been widespread use of the experimental method in biological science.

What are the exact methods by which progress has been achieved in the medical sciences in recent times? How has the treatment for thyroid disorders been discovered? How were the methods developed for the control of Addison's disease, diabetes mellitus, diabetes insipidus, pernicious anemia, syphilis, small pox, diphtheria, to mention only a few of the many diseases with which medical science is now able to cope? I should like to be allowed to sketch hastily the methods by which several important discoveries were achieved. A recent discovery about which nearly everyone knows, is that of insulin for the control of the metabolic disorder, diabetes mellitus. Most of you know that Frederick Banting and J. J. R. McLeod were awarded the Nobel prize for the discovery of insulin, but probably few know how it came to be discovered. Banting and McLeod are credited with this achievement, and they were not, to be sure, without great merit for the part they played in it; but they are no more solely responsible for it than it was "the medical corps that won the war". About a half century before Banting, McLeod and their co-workers put the finishing touches on the job,

Minkowski and von Mering found that removing the pancreas from animals produced diabetes. The story is told that these experimenters came upon this knowledge by accident. They had removed the pancreas from animals for another reason and noticed by chance that insects were unusually attracted to the urine of these animals, which they found on examination contained great quantities of sugar. For the next forty years workers tried to extract a substance from the pancreas which would control diabetes. Time after time the attempts failed, largely because the pancreas also produces in great quantity the proteolytic enzyme trypsin which is extremely toxic to living matter. Then one day a young pathologist at the University of Minnesota, whose name I feel rather sure you have not heard in this connection, Dr. Barron, found that by ligating the external secretory duct of the pancreas and allowing the animal to recover, all the enzyme secreting cells degenerated and left only the cells in the islets of Langerhans. Since no diabetes resulted it became apparent that these islet cells elaborated the substances necessary for proper carbohydrate metabolism. When Banting began to think about curing diabetes he knew of the discoveries of Minkowski and von Mering, and of Barron. He merely took the next step and with the help of a young graduate student whose name is now a household word, Charles Best, he made extracts of such islet tissue, which they found to their satisfaction were not too toxic to be used, and did control diabetes. But they were not chemists, and the problem of extracting the material, which they called insulin, from the islet tissue, was too intricate a problem for them to master completely. So they called in the biochemist J. B. Collip to complete the trick for them. And what did Professor McLeod do? Aside from accepting a share in the Nobel prize, history will record that he judiciously discouraged his ardent young assistants from expecting results too easily. The real story of insulin is a drama of scientific progress, of human foibles, and a beautiful illustration of the place of step by step progress of knowledge in the arrival at practical fruition of scientific results. Insulin required Minkowski and Mering, it needed Barron, McLeod, Banting, Best and Collip, to contribute their small part each to the sum total of scientific fact that now forms the basis for the treatment of diabetes.

Another important recent advance in applied medical science has been the development of our knowledge of the accessory food substances, or vitamins. The knowledge of vitamins had a romantic beginning, because the first definite evidence that substances important to nutrition were absent in certain diets, thought to be adequate with respect to the known nutritional requirements, came from observations of sailors making long voyages without supplies of fresh food. Some very interesting clinical observations were made on the relation of dietary inadequacies to the occurrence of beriberi in seamen. Beriberi is a disease of the peripheral nerves. Its victims become easily fatigued and depressed, their skin becomes sensitive, there is swelling and edema, and the mortality in the disease is very high. It was the scourge of seafaring men in the early days of ocean sailing and not until a scientific analysis of its cause had been made was its occurrence brought under control. Empirical methods of treatment instituted in the years around 1880 pointed the way for a thoroughgoing investigation of the problem, and today there is no longer any reason why sailors or others living upon highly refined and restricted diets need suffer from beriberi. The classical proof of the role of an accessory food substance or vitamin in this disease was made in 1897 by Eijkman, who was medical officer to a prison in Dutch Java. Beriberi was common in that prison and Eijkman noticed that the poultry which were fed on the garbage of the hospital died with a disease picture very similar to that of his own patients. He was therefore

led to investigate this problem thoroughly and fed pigeons some rice in the natural condition, with the husk on the grain, and others on rice from which the husk had been removed, but still retained the outer layer or silverskin, and the embryo or germ. Still others were fed on polished rice from which these latter parts had been removed. He found that all the pigeons fed on polished rice died of polyneuritis or beriberi, while those fed the whole grain or the grain still retaining the outer layer and the germ did not develop the disease. He therefore proved that the absence of the material removed in milling and polishing rice was responsible for the disease. He thought erroneously that it was the silverskin itself which contained the substance which protects against beriberi, whereas, as a matter of fact, we now know that this substance is in reality concentrated in the germ of the seed which he removed with it. His practical deduction, however, was correct, that rice polishings, when fed, protected against beriberi. At the time of his studies two-thirds of the people in the large cities of the East Indies suffered from beriberi. Among prisoners as many as eighty per cent showed symptoms of the disease in institutions where polished rice formed the main article of the diet. The disease has all but disappeared since unmilled rice has been substituted in institutions, and the incidence in the population at large is diminishing rapidly with the dissemination of popular information concerning the cause and cure of the disease.

The antiberiberi substance is now known as vitamin B. More recent work by McCollum and Hopkins showed that the lack of vitamin B causes a retardation of growth and it has been indicated by chemical studies that there are really at least two substances included in what was thought to be vitamin B, the absence of one of which leads to the human disease beriberi, another leads to inadequate growth, while a third may be related to the disease pellagra.

The development of knowledge concerning the vitamins presents a story of the application of the experimental method in biology and medicine which is scarcely excelled in any other instance. Knowledge has been acquired by painstaking observations of apparently inconsequential details. In these times when the scientific method as a whole has been attacked by persons in high places in academic life, it may not be amiss to point out that we would not have any of our important knowledge of the vitamins if scientists had disdained to spend months, and even years, of their lives studying carefully the minute details of the nutritional requirements of common laboratory animals.

The scientist has been accused of being anti-intellectual in that he places his reliance on observations rather than logic. If it is true that placing reliance on observed facts, instead of abstract logic, is anti-intellectual, then I, for one, wish to challenge the significance of the word intellectual. If intellectualism requires blindness to reality in subservience to logic, then certainly intellectualism is a sterile formula. I suspect that those persons who have criticized the experimental method as the sine qua non of progress in science have confused intellectualism with pedantic scholasticism. A further surmise may be permissible that the modern pedantics who rail at the "blizzards of facts" which modern science has contributed to knowledge, find themselves in a "state of bewilderment" because they themselves are incompetent to grasp the true meaning of the observations which experimental science has placed in the hands of humanity.

Nor is it a new complaint for scientists to hear that the experimental method is essentially anti-intellectual. The dark ages were full of such talk, and the rebirth of learning, with its general acceptance of the experimental method, did not in itself endow the entire human race with enough intelligence to be able to appreciate its significance.

The question may be asked as to why the use of the experimental method in biology has been so tardy in coming to fruition. In the biological sciences there are numerous serious difficulties standing in the way of experimentation. In the first place, analytical study requires the use of living animals and frequently requires that changes in their environment and their make-up must be produced in order to permit controlled observations of individual phenomena. In order to experiment on animals effectively, means had to be developed for producing anesthesia. Before the discovery of anesthetics, experimentation on animals was confined largely to those observations which could be performed without inflicting pain. It can truthfully be said that the advent of anesthesia was the greatest single advance ever made in the development of tools for biological research. It should be noted, in passing, that the development of anesthesia, which was itself a result of animal experimentation in pharmacology, was also one of the greatest boons to mankind directly that science has ever accomplished. For us to consider the practice of medicine and surgery today without the use of narcotics and anesthetics is to consider a practice so archaic as to be absurd. The possibility of safe anesthesia is undoubtedly as important to mankind as any other result of modern science.

After speaking at length of the importance of animal experimentation, it seems necessary to consider briefly the problem of the ethics of the use of animals in this way. Living in such a homocentric civilization as we do, it may seem to some that there could be no room for argument concerning the propriety of taking the lives of the lower animals for the furtherance of human welfare. Of course, in the history of mankind there seems never to have been any very strong sentiment against the use of animals for man's purposes. Long before animals were domesticated our savage ancestors employed animals of all sorts for their food, just as we, as a matter of fact, do to large extent today. In other words, man has collectively always felt justified in using the lower animals for his food, as his beasts of burden, and even, one may add, for his enjoyment in hunting, fishing, racing and fighting. It is a strange paradox that in our civiliation, which has never questioned the right of man to slaughter animals for his food and enslave them for his convenience, there should actually grow up a strong sentiment amongst a small minority against the use of animals for the furtherance of knowledge and of health. Surely there can be no logical grounds for denying the right of men to employ animals for the highest good known to man—that is the furtherance of knowledge, particularly in relation to problems of health—when the propriety of almost wanton destruction of animal life in hunting and fishing, to say nothing of the orderly business of slaughtering animals for human food, is accepted as correct. There are, as a matter of fact, many experimental biologists who are perfectly willing that animal life should be sacrificed for the real good of mankind in connection with the provision of food and with the increase in knowledge who are strenuously opposed to the destruction of animals by relatively cruel methods in hunting and fishing. It seems, to the mind of one who believes that scientific research in biology and medicine has been of great value to human welfare, that so long as the thesis that animals may be used for human welfare at all is maintained, there can be no question about the propriety of animal experimentation.

The opponents of animal experimentation attempt to prejudice the issue by referring to it as vivisection. There is a certain emotional reaction aroused by the idea of cutting up live animals that is unwarranted by the actual facts of the case. The serious scientist does not conduct experiments which are apt to produce pain without the use of anesthetics, except when

it would be absolutely impossible to obtain valuable information in any other way. In almost all experimental work, whatever cutting of tissues is to be done is carried out under adequate anesthesia. Even if it could be shown that in rare instances a scientist has been known to carry out experiments in an unnecessarily painful manner, either by error or by intention, there is no ground for criticizing all experimental biologists by the same token. It is, undoubtedly, true that occasional instances have occurred where a scientist has not observed all due precaution to avoid pain and suffering. These instances are exceedingly rare, however, in proportion to the number of experiments performed by biologists as a whole; and what one should do is perhaps to criticize the individual scientist for his indiscretion; but to condemn the whole practice of animal experimentation on the basis of occasional abuse is as intelligent as it would be to criticize the whole practice of civil government because an occasional officer of law enforcement is unreasonable in his application of law to specific instances. No sane person denies the necessity and value of an ordered society simply because certain agents of an organized society abuse their privileges and power. Neither should one criticize the practice of animal experimentation in the welfare of humanity simply because an occasional individual has been known to carry on unnecessarily painful experiments. It should be emphasized at this point that instances of such indiscretions on the part of biologists are as a matter of fact exceedingly rare, but it cannot be too strongly insisted that there is no one who regrets their occurrence at all any more fully than do the rank and file of biologists themselves.

The activities of the organized groups opposed to animal experimentation are a menace to the progress of science because they would make it impossible for biologists to do any effective experimental work. One is led to inquire as to the motives that prompt the so-called antivivisectionists in their fight against biological work. The antivivisectionists include three major groups. The first are the antimedical bloc; the second are the professional agitators interested in the movement because it affords them a living; and the third are a group of very well intentioned, but misguided, people who support the movement because it claims to be humanitarian, and they are opposed to anything that could be considered to be inhuman or cruel, as the first two groups have portrayed animal experimentation as being.

The antimedical group are the Christian Scientists, the chiropractors, the osteopaths, naturopaths, and those following the other "paths" that are not quite straight and narrow. They are attempting to embarrass medical science by every means, legal and extra-legal, at their command and are using this as one method of achieving their ends. The sane portion of the population will surely never allow this unbalanced group of people to deprive humanity as a whole of the benefits which are accruing and will undoubtedly still accrue in the future from observations on animals.

The second group of professional agitators comprise the paid officials of the various propaganda organizations against biological research. These persons are supported, some of them rather lavishly, by the first group mentioned, and, unfortunately, also by some of the well meaning people in the third group, to be discussed in a moment. Many of these agitators have admitted that they have no interest other than a commercial one in antivivisection propaganda. These paid propagandizers are the most vicious element in the group. They are the lobbyists who attend every session of the state legislature and even of the National Congress, having bills introduced, pulling wires, and altogether exerting as much influence as they can in a political way, to embarrass legitimate biological research.

The third group amongst the rank and file of antivivisectionists is the large number of well meaning, but misinformed, individuals who are led by those who have an axe to grind. It is of this group that we should be particularly solicitous. They are largely people who have simply never been informed about the real situation. They have listened to an inaccurate or exaggerated account of scientific experiments on animals out of the mouths of the promoters, the quacks, and the mentally unbalanced. What these people need is information concerning the realities of the situation. They should be taken to see experimental laboratories. They should be told of the benefits of animal experimentation to mankind. They should be reassured that animal experimentors in science are probably as solicitous of the welfare of animals as any other group of people in the community. The checking of the growth of the power of the antivivisectionist movement depends upon winning these misled people away from their biased, bigoted, and unscrupulous leaders.

Finally, a word should be said about the possibilities for the future of medical science. It would be futile to attempt to predict exactly what lines of investigation will prove fruitful within any specified period of time. There is only one point that it is really worth while to make concerning the future of medical science, namely, that progress is possible only by the further application of the experimental method to its problems. We shall not achieve new successes in the field of medicine comparable to the discovery of insulin, to the conquest of rabies, to an understanding of the methods of control of smallpox and typhoid fever by arm chair research. We have a vast amount of information in the biological sciences which is, at present, uncorrelated, to be sure, but its correlation does not wait for a master mind to put two and two together. Rather, it waits for the filling in of missing links in the structure of our knowledge. It is incomprehensible to scientists who are working in the field that the discoveries which have already been made and applied for human welfare could have been accomplished in quiet contemplation without the use of the experimental method. To be sure, a well reasoned experimental approach is the secret of practical success in scientific work. No scientist would be so blind as to deny the value of logic in the planning of experiments, but anyone who insists upon the superior importance of *a priori* reasoning over observation is simply entirely blind to the whole history of scientific progress. We can look for a ripening of the fruits of scientific labors only by continuing assiduous cultivation of the experimental method.

In summary, I should like to review the ground that I have tried to cover. I have attempted to show, by what has necessarily been a very meager group of examples, the methods by which achievements have been made in biology and medicine. I must apologize for having drawn all of my examples from the realm of physiology. I have chosen to do so only because of my greater familiarity with that field. Equally important examples could be drawn from the field of bacteriology, from pharmacology, or from anatomy. It has seemed obvious that in all of the instances cited the addition bit by bit of observational knowledge has been the basis of scientific progress. I have tried to show that all of this progress has depended upon the use of animals in experimental work, that the sacrifice of animal life to this end is justifiable for the welfare of humanity. Since, in general, the human race has insisted that its interests are paramount to the interests of any other species of animal life, there seems to be no question but that a sacrifice of animals for the increase of scientific knowledge is entirely justifiable on ethical grounds. Until the population at large becomes vegetarian and forgoes the use of animals for all domestic and

commercial uses, the scientist should not be required to justify his use of animals for the welfare of humanity. I have tried to call attention to the menace of the organized vivisectionist movement, and I have pointed out the ulterior motives animating a large share of the people back of this movement. Finally, I have stressed the importance of continued animal experimentation in furthering medical discovery. I hope that I have made clear how intimately the progress of biological knowledge is connected with the employment of the experimental method which is in jeopardy by virtue of the activities of the antivivisectionists. The future of animal experimentation is the future of biological science, and it behooves those who are interested in the latter to foster, encourage and protect the former.