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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE APPLICATION OF SCIENCE TO THE PRACTICE OF MEDICINE*

THE practice of medicine is generally described by that time-worn phrase as being an art and a science. This definition infers that although the practice of medicine is an applied science, there is something beyond the realm of science that is needed in the discharge of the functions of the physician in his relation to his patients. Every one is ready to concede that this is true, but there is no clearly defined idea as to where science leaves off and where art begins, nor have the terms science and art as applied to medical practice received an exact definition.

Professor John Dewey[1] has written:

> Just in the degree in which a physician is an artist in his work he uses his science, no matter how extensive and accurate, to furnish him with tools of inquiry into the individual case, and with methods of forecasting a method of dealing with it. Just in the degree in which, no matter how great his learning, he subordinates the individual case to some classification of diseases and some generic rule of treatment, he sinks to the level of the routine mechanic. His intelligence and his action become rigid, dogmatic, instead of free and flexible.

Professor Dewey presents the idea that it is the accurate and discerning application of science to meet the needs of the individual patient that constitutes the art of medicine.

There seems to be, however, another meaning to the phrase "art of medicine," which is associated with the so-called force of personality, knowledge of human nature and prestige by which a physician is often able to persuade or command or influence or even mislead a patient into a better state of health and comfort. The enormous following given to "healers" who make no use of the application of science in its usual sense testifies to the fact that human needs may at the present time be satisfied by systems of practice that have no basis in the natural sciences. Every intelligent person, however, recognizes the fact that although science is not related to many of the

* Address of the president and vice-president of Section N—Medical Sciences—American Association for the Advancement of Science, New York, December, 1928.

[1] John Dewey, "Reconstruction in Philosophy," p. 168, New York, 1920.

methods used by physicians and "healers" in alleviating human ills, scientific knowledge should reign supreme in the great problem that forever presents itself to the human race, namely, of making man a more comfortable, a happier and a more efficient being and of waging a continuous battle with disease. If scientific knowledge does not to-day fulfil all that it should in the practice of medicine, where does the fault lie? Is there sufficient exact, well-established and classified knowledge to form a satisfactory basis for medical practice? Is scientific knowledge applicable to the practice of medicine as fully as possible incorporated in medical practice? Are the methods of applying scientific knowledge to the problems of medical practice properly established? It is to a brief consideration of these questions that attention is directed. If an affirmative answer to these questions were justified, then the force of personality in practice, the so-called art of medicine as the term is usually used, could be put aside as a negligible factor in the functions and methods of the physician. If the practitioner of medicine had at his command a sufficiently comprehensive body of facts to meet all the variable complexities that he encounters in dealing with each individual patient and if he also had knowledge of all the methods of applying these facts to meet the great variety of conditions that may come before him, then could he be a great artist in the sense of the word as used by Dewey.

This body of facts would include knowledge not only of the chemical and physical forces operating in the human body necessary to keep it in a state of normal function and equilibrium, but it would include also a knowledge of the various disturbances of these forces that may occur, of the causations of these disturbances and of the means of their prevention or correction. Analysis alone would not fulfil all the requirements, as the physician would need to understand the synthesis of those forces that go to make up the individual man and to maintain him in a condition of strength and well-being.

The breadth of knowledge that is required in order to conduct the practice of medicine in what may be called a truly scientific manner goes beyond that which is now considered the natural sciences. The responsibility of the physician for the care of patients, as stated in the recent report[2] of the commission on medical education, calls as well for "a keen insight into a large variety of human, psychological, emotional, economic, social and environmental factors, which often determine successful diagnosis, treatment and prevention."

The physician has constantly before him, whether he is conscious of it or not, many problems that defy analysis into questions that can be answered by existing knowledge. It is of course self-evident that the accumulated results of scientific investigation do not at present and doubtless never will furnish all the knowledge that can be profitably applied in the practice of medicine, and it is not likely that medical practice can ever be reduced strictly to a state of applied science, such as engineering. It would be futile to discuss this question, as it is clear that the more that is known, the more urgent becomes the need for greater knowledge, and the larger are the number of avenues for research that are revealed.

In regard to the second question as to whether existing knowledge, capable of application, is as fully as possible incorporated into medical practice, here again a negative answer may be given without fear of contradiction. But this is a matter more profitable for discussion. It is worth while to consider some of the factors that hinder the proper application of science to medical practice and to note some of the means that tend to promote the application of scientific knowledge to the needs of individuals requiring medical care.

Practice has always lagged behind the available science, and in times gone by medical tradition was so strong, and scholasticism so deeply rooted that medical practice became entirely divorced from even the meager scientific facts that then existed. An example of the attitude of mind which has retarded the progress of medical practice was long ago satirized by Molière when the physician Diafoirus in "The Imaginary Invalid" recommends his physician son by saying: "But what I like most in him is that he blindly follows the opinions of the ancients—in which he takes after his father. Indeed he will not so much as listen to the arguments or hear of the experiments and pretended discoveries of the present century—on the circulation of the blood and like nonsense." This was written over forty years after the publication of William Harvey's immortal work.

Medical practice even to-day, as conducted by the rank and file of the profession, is overloaded with empiricism and with methods that are maintained, especially in therapeutics, by the force of tradition, sometimes in the face of well-established facts that should bring something better in their place. Much of medical practice has been developed by gallant attempts on the part of physicians to meet the needs of suffering humanity by means that have been improvised where science has nothing to offer or where scientific facts and principles have not yet penetrated into the realm of practical medical knowledge.

The life of the successful physician is usually full of activity and in the majority of instances, especially away from the centers of medical progress, practice soon falls into a routine which is not often seriously

[2] Commission on Medical Education. Third Report, p. 27, October, 1928.

disturbed by innovations. The younger men, fresh from the schools, may resist the plan of practice of their elders, and so bring down upon themselves and upon their schools disfavor. Many succumb to the force of example and precept of their older colleagues. They may soon learn to do without the scientific basis that had been given them more or less thoroughly. In order to prepare students of medicine to resist in after life the force of empiricism and tradition, scientific habits of mind must be firmly driven in. The result of an attempt to do this is often the cry from the profession that medical education has become "too scientific," whatever that may mean. A sympathetic attitude between the investigator in the medical sciences and those whose task it is to apply the results of research to the welfare of the individual patient is desirable and indeed essential. An antagonism, however, may exist on the part of the workers in science because of an apparent lack of appreciation by the physicians of the facts and methods of science, and on the part of the physicians because of a feeling that the results of scientific research are impractical and that scientific workers fail to appreciate the complex and varied problems constantly encountered by the medical practitioner.

This antagonism, however, is being rapidly replaced by mutual respect and collaboration wherever conditions have been set up that favor contact and coordination of clinicians and investigators. A group of workers is developing that belong both to research and to practice, and members of this group are serving as the middle men, so to speak, between science and practice. This group is developing in those universities which have been able to establish their entire medical schools on a true university basis and in those institutes for medical research which have included clinical medicine as a field for their activities. The members of this group, many of whom are well trained in some field of science underlying medicine, are best qualified to evaluate scientific knowledge in its application to practice, and are best prepared to devise methods for its application. The development of what is often called "academic medicine" is of great value both for the progress of practice and for the furtherance of medical knowledge.

It is perhaps beside the point to emphasize the importance of such a group in the teaching of medicine, but it may be said that by combining men who are constantly at work studying the problems of disease in patients with those whose main activities are devoted to the practice of medicine, a strong teaching force may be established. This combination tends also to create a means of easy communication between the laboratory and the bedside.

The most significant aspect, however, of the development of academic medicine in this country is the creation of conditions which afford opportunities for a truly scientific career in clinical medicine. Human disease presents numerous problems that are complex and extremely varied. These problems are encountered by workers in no other field but that of clinical medicine, and their solution can not be left to workers in other fields. The status of medicine as an independent science has recently been discussed by Cohn,[3] who has argued for the acceptance of the idea that medicine deals with unique phenomena and that it is entitled, not by courtesy, but by the nature of things, to its high status as an independent natural science. Human disease may be studied and should be studied as other phenomena of nature. The practical results for the time being need not be the paramount issue, and therapeutics need not be the acknowledged goal.

Cohn has written:

> By the term "medicine" I mean the discipline which is engaged in recognizing, in distinguishing and in studying diseases; the subject-matter of medicine is the sum total of human ailments. It is devoted to the study of disease in the living, fostered by whatever means may appropriately be employed. It is not coexistive with any method, such as experimental pathology, but utilizes data so obtained, whether analogical or inferential, for its own purposes. . . . It appears now that medicine is concerned with knowing about disease, a very different thing from making efforts to cure it.

Cohn presents the idea that there is a science of clinical medicine which is not necessarily a part of medical practice. However, nothing will do more to bring scientific thought and method more rapidly and thoroughly into the field of practice than the further development of means and opportunities for the pursuit of research in human disease directly by those trained to observe the patient and to use the various methods that are applicable to the study of man from many angles. There are of course many limitations put upon those who undertake the study of human disease, and these limitations must always be respected. The true spirit of the physician can never be put aside by those who would observe successfully the nature of disease in human beings. Marchand described the true spirit when he wrote:

> Seek truth. Discover causes. Learn how they disturb life and how order is reestablished. By science and persuasion preserve men. By science, gentleness and firmness combat death and reduce suffering. Guide, encourage and console in a brotherly and tolerant spirit. This is medicine.

Here is set forth the method and purpose of science as applied to medical practice. But here is com-

[3] Alfred E. Cohn, "Medicine and Science," *Journal of Philosophy*, 1928, xxv, 403.

bined with science the spirit of medicine, the force from within, arising from a sympathetic appreciation of the needs of the individual.

Let those who enjoy the thrills of creative thinking and experiment toil without thought as to how the new knowledge that they may reveal will find its place in human application. Let those who choose the field of medical practice make sure that they apply established facts with discernment and wisdom and run not after strange gods and fallacies. And let those who can do so approach the problem of disease in the spirit that has always proved productive in science, of seeing clearly the problem and seeking the truth by any means that may be serviceable to their purpose. But let us be sure that a means is constantly preserved by which whatever is usable in science finds its way, pure and unperverted, directly and swiftly to the needs of the individual man.

The workers who are coming forward to spend their lives in the small and newly tilled field of clinical research have a large share in keeping clear the way by which science finds its application to medical practice. This field needs further cultivation and should have the encouragement and respect of both workers in the natural sciences whose fields are well defined and organized and of the ancient order of physicians to whom is given the task of bringing the results of science to the needs of the individual.

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A NOTE UPON THE PROBABLE MODE OF EVOLUTION

WHEN in any group of related organisms, such as a family or higher category in the natural system, the genera are plotted to the number of species they contain—provided only the genera be not too few to justify statistical treatment—a curve of characteristic form is obtained.

The fact was first observed by Dr. J. C. Willis in his statistical studies of recent floras and faunas. Mrs. E. M. Reid showed that analysis of Tertiary floras yields the same result. It may be noted, in addition, that the data regarding such groups as Trilobites, extinct since the Palaeozoic, Tetrabranchiate Cephalopods—with the exception of *Nautilus* now extinct—and Brachiopods, of which a considerable number of species still live, when plotted as stated yield additional examples of the same curve. This, then, is a graphic expression of some universal phenomenon in the organic world. Rather, the "hollow curves" of Willis are a class, which, as parabolas in their variety define the paths of projectiles moving under the influence of gravitation and their initial velocity, record the detail in which this universal process has expressed itself in the particular groups of organisms to which they respectively apply.

Drs. Willis and G. Udny Yule at first identified this enigmatic curve as that of a geometric series. There is much to justify such identification. When, for example, instead of the actual numbers of genera being plotted to their respective numbers of species, the logarithms of the numbers of genera are plotted to the logarithms of the numbers of their species, the hollow curve is transformed, and the curve obtained as a result of the transformation is, throughout a considerable portion of its length, approximately a straight line. Moreover, the earlier and larger numbers in the series from which the curve is directly plotted yield, when each term is divided by that immediately preceding it, a series of quotients approximating 1/2 more nearly than any other such simple fraction.

The curve obtained, however, by the substitution of logarithms for natural numbers is *not* a straight line. Nor does the one limb of the original curve, or the series of numbers from which it is plotted, more clearly bear the stamp of $1/2^n$ than the other bears that of a series whose common ratio lies near unity. The hollow curve, we may therefore reasonably assume, results from some sort of compounding of a series of geometric series of different common ratio, but all lying between the limits of 1/2 and 1.

Now the series $1/2^n$ in its successive terms shows, for example, what proportion of a group of individuals tossing pennies for the longest run of heads would eventually be distributed in each class by achievement—how many would throw no head, one or two heads, and so forth, till even the longest probable sequence had been broken. A different ratio would give the distribution similarly of another group in which the chances of making a comparable gain were different.

With these ideas in mind it is clear that if we might know how many groups were playing a game of chance, the number of individuals in each group and the chances of winning upon any one play in each, the authentic curve showing the final distribution of all players by number of successes scored might be constructed very simply. It would be a graph the first ordinate of which would be proportional to the sum of the first terms of a series of geometric progressions of differing common ratio, the second ordinate proportional to the sum of the second terms, and so to the end. It is upon this system that the geometric series to which the hollow curve owes its peculiarities appear to be compounded.

There is one patent indication regarding the hypothetical series, whose nature and relations it must be