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ANATOMY AS A SCIENCE[1]

By Professor S. R. DETWILER

COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY

ON behalf of the College of Physicians and Surgeons, which I have the honor of representing to-day, I wish to extend to you, the members of the first year class in medicine, a most hearty welcome.

Since I have the privilege also of representing on this occasion the newly organized department of anatomy in this institution, and since, in the course of a few days, you will be actively engaged in anatomical studies, I thought it might not be inappropriate for me to speak to you about the subject of anatomy, with respect to a few of its past developments and to its present status amongst the biological and medical sciences.

[1] Address delivered at the opening exercises of the College of Physicians and Surgeons, Columbia University, New York, September 25, 1929.

In the preparation of this address I have drawn freely from the following sources: R. G. Harrison, "Anatomy; Its Scope, Methods and Relations to Other Biological Sciences," *Anat. Record,* vol. 7, 1913; W. A. Locy, "Biology and Its Makers," Henry Holt and Company, 1910.

An anatomical laboratory is no doubt frequently thought of as a place characterized by the presence of a morgue and large vats filled with formalin-soaked specimens; a place where boxes of rattling bones reside upon shelves to be doled out to beginning students in order to revive their powers of memory which they may have largely lost during the more or less care-free activities of their academic careers.

Based upon the experience of others, it may be regarded as a place where thousands of tedious facts must be learned and later forgotten before the gratifying emoluments attending the practice of medicine may be fully realized.

An anatomical laboratory does possess what I have mentioned—a lot of dead things—but if this were all that characterized the place, anatomy as a science would be as dead as the cadaver which is placed at your disposal in order that you may hack out the necessary morphological slices preparatory to the practice of surgery.

Anatomy is very old. Throughout the ages it formed the keystone around which systems of medicine were elaborated. As far back as the reign of the Yellow Emperor, Huang Ti, over two thousand years before Christ, anatomical charts were assembled which formed the basis for the curious art of needling or acupuncture which has been practiced throughout centuries and even to the present day in China. Anatomy was studied by the Egyptians, the Alexandrians, the Persians and the Greeks ages before its dawn in medieval and modern Europe.

Although the study of the natural sciences had evidently attained a high grade of development among the Greeks, it underwent steady decline in the hands of the Romans.

During the Middle Ages the science of anatomy as well as all other natural sciences sank to an amazingly low level. One of the chief causes which was responsible for the cessation of scientific thought and investigation was the dominance of the priesthood in all intellectual as well as in spiritual life. The world-shunning spirit of the early Christians developed an attitude which was hostile to observation. As a result, the observation of nature came to be looked upon as proceeding from an impious curiosity. The priests who had access to the books assumed direction of the intellectual life. They were largely employed with the analysis of the supernatural, without the wholesome check of observation and experiment. Consequently, mythical explanations were invented for natural phenomena, and metaphysical speculation became the dominant form of mental activity.

A very striking characteristic of science in the Middle Ages was the great reverence for authority. In this atmosphere controversies over most trivial points were fostered and the ancient writers were quoted as sustaining one side or the other. All this led to the referring of questions, as to their truth or error, to authority as the source of knowledge. It was an epoch of great importance, therefore, when men began again to observe natural phenomena and to trace the relation between cause and effect in the universe.

In this uncongenial atmosphere men like Vesalius, Descartes and Galileo established the new movement and overthrew the reign of authority. This was particularly striking in the field of anatomy where Vesalius overthrew the authoritative reign of that supposedly great anatomist, Galen, which had lasted for twelve centuries.

The way in which anatomy was taught in the Middle Ages was characteristic of all science teaching of that period. Instead of being taught by observation, the writings of Galen were expounded from the desk, frequently without demonstrations of any kind, and his work came to be recognized as the unfailing authority on anatomical knowledge. Just as the scriptures were accepted as the unfailing guide to the spiritual truth, so Galen and other ancient writers were made the guide to scientific truth and thought.

A successful revolt against slavery to authority in anatomy was accomplished largely through the efforts of that great anatomist of the sixteenth century, Vesalius. The story is old, but nevertheless striking, which relates how Vesalius, as a student at his third lecture in anatomy in the amphitheater of Sylvius, pushed aside the clumsy surgeon barbers who did the dissection and himself exposed the parts of the body as they should be. He could not be satisfied with the writings of the printed page, but must grasp through his own handling the facts of anatomical structure. And it is said that when he later began to teach anatomy, he would not intrust to the ignorant barbers the task of laying before the students the secrets of the human body, but with his own hand he unraveled the structures with which he was dealing. He employed Galen's writings, but the body on the table disagreed with what Galen had written, so he eventually cast Galen's writings aside and taught only what he himself could see and what he could make his students see. Thus he brought into anatomy a new spirit, and scores of students attended his lectures and demonstrations. For five years Vesalius labored ardently disentangling the pattern of the human body, trusting to words of no master, and at the end of five years he published a monumental work entitled "The Structure of the Human Body," which created an epoch in the progress of science.

With this very sketchy historical account of a period in the development of anatomy, let us pass on to some more recent considerations of this subject. Situated as it is, its scope overlaps that of many of the other biological sciences, not to mention its important applications in medicine and surgery. The greatest danger to anatomy as a science, however, as was pointed out by Harrison more than fifteen years ago, lies in the very fact of its practical importance. It was this circumstance—particularly in England and America—that threatened to make the science entirely subservient to practice. In any quarter where anatomy is viewed solely as a handmaid to surgery it becomes robbed of that quality which makes any science living, namely, science for its own sake. But with the long background which anatomy has had you may ask, "What is there left for the anatomist to do, since in the past centuries all the details of the human frame and its variations have been carefully worked out and are available for study in the numerous text-books and atlases which adorn every dissecting room?" In response to such a hypothetical question I would cite a paragraph from Sir William Osler's "Leaven

of Science," which was an address delivered at the opening of the Wistar Institute of Anatomy at the University of Pennsylvania in 1894. Osler cites the following story, told by Sir Robert Christison, about Barclay, one of the leading anatomists of the early part of the nineteenth century. Barclay spoke to his class as follows:

> Gentlemen, while carrying on your work in the dissecting room, beware of making anatomical discoveries; and above all beware of rushing with them into print. Our precursors have left us little to discover. You may, perhaps, fall in with a supernumerary muscle or tendon, a slight deviation or branchlet of an artery, or, perhaps, a minute stray twig of a nerve—that will be all. But beware. Publish the fact, and ten chances to one you will have it shown that you have been forestalled long ago. Anatomy may be likened to a harvest field. First come the reapers, who, entering upon untrodden ground, cut down great stores of corn from all sides of them. These are the early anatomists of modern Europe, such as Vesalius, Fallopius, Malpighi and Harvey. Then come the gleaners, who gather up ears enough from the bare ridges to make a few loaves of bread. Such were the anatomists of last century—Valsalva, Cotunnius, Haller, Vicq d'Azyr, Camper, Hunter and the two Monroes. Last of all come the geese, who still contrive to pick up a few scattered grains here and there among the stubble, and waddle home in the evening, poor things, cackling with joy because of their success. Gentlemen, we are the geese.

And, as Osler says,

> Yes, geese they were, gleaning amid the stubble of a restricted field, when the broad acres of biology were open before them. Those were the days when anatomy meant a knowledge of the human frame alone; and yet the way had been opened to the larger view by the work of John Hunter, whose comprehensive mind grasped as proper subjects of study for the anatomist all the manifestations of life in order and disorder.

With the long background which anatomy has had, it has not advanced nearly as rapidly as many of the other biological sciences. This may be due in part to the restricted sense in which anatomy has been viewed, but more probably to the failure of the anatomists to employ earlier, experimental methods. It is clear to every one, I believe, that the sciences which have employed experimental methods have advanced by leaps and bounds over those in which phenomena have been studied merely as nature presents them.

Anatomy, however, has accomplished great things in the past. "By giving us a definite knowledge of the arrangement of the parts of the human body, it has done more than any other science to banish superstition and mysticism from medicine." In providing us with the concept of homology or of morphological equivalence it has brought order out of chaos. In the cell theory with its modifications it has made a generalization of first magnitude in giving a descriptive term applicable to all parts of all organisms, and it has made great achievements in the field of development.

The method of "comparative anatomy" which has been in vogue for decades has yielded the great generalization of "homology" or similarity of plan in the structure of organisms, and comparative embryology has shown a similarity in the mode of origin. Whereas the comparative method has rendered great service in the past, it has done little to reveal causal relations. With all the efforts devoted to the study of comparative anatomy and embryology, the dynamics underlying development and the production of organic form were left practically uninvestigated, and they present to us to-day problems which can be approached only by the experimental method. Problems of organic form are problems of the anatomist. Since organic form is the product of protoplasmic activity, the problems dealing with organic form must find their ultimate solution in the dynamics of living matter. Fortunately anatomists are coming to realize this more and more, and the science, which was first investigated by means of the scalpel and later by the microtome, is now in the hands of various instruments of experimentation, and can truly be said to have passed from a science of statics to one of dynamics. Consequently, most modern anatomical laboratories are no longer characterized solely by the presence of cadavers, formalin-preserved specimens and bone boxes, but with such pieces of physical and physiological apparatus as are necessary to an experimental study of the dynamics of living organisms as they bear upon the problems of organic form and function.

In stressing the importance of the experimental method in anatomy, we would not belittle many important facts which have been discovered by observational methods. There may be many uncritical experiments the results of which lead nowhere, whereas carefully weighed observations may lead to highly important results. Furthermore, many subjects are not directly amenable to experimentation, such as anthropology and others. Yet we know that, in general, the conditions in nature are so complex that many phenomena can not be resolved, whereas through experimentation, which provides for a controlled variation of conditions, effective analyses are much more readily made.

In this connection I should like to cite to you a case in which a critical experimental analysis led to the solution of a very fundamental problem in anatomy that had been studied rigorously by many noted anatomists for three score years and ten by observational methods without convincing results. I refer to

the solution of the mode of origin of the nerve fiber. When the cell theory was established, neuro-histologists set for themselves the problem of ascertaining the genetic and morphological constitution of the nerve fiber in terms of the cell doctrine. A three-cornered controversy arose which was waged for seventy-five years, now in favor of one party, now in favor of another, but at no time set to rest by unanimity of opinion. The ablest anatomists of Europe, including such men as Schwann, Balfour, Wilhelm His, Ramon y Cajal, Bethe and many others, tried by observations upon the developing embryo to show whether a nerve fiber is a product of many cells or whether it represents a protoplasmic outgrowth of a single cell. With the aid of remarkably fine methods of histological technique and with the most critical powers of observation which these men possessed the problem could not be solved to the complete satisfaction of all parties. In 1905 Herman Braus, a noted German anatomist, used the method of embryonic tissue grafting as a means of solution. This method had been employed previously in experimental problems by Harrison of this country. Although the experiments by Braus were ingeniously carried out, his interpretation of the results was soon after shown by Harrison to be incorrect. Harrison repeated the work of Braus under more critical circumstances and was able to produce powerful evidence foreshadowed in the work of His and Cajal that the nerve fiber is a protoplasmic outgrowth of the embryonic nerve cell. But there were still doubters as there always are. In order to place this discovery beyond the doubt of the opposers, Harrison invented tissue culture or the growth of tissues outside the body. He placed living embryonic nerve cells in clotted lymph on a microscopic slide, sealed the preparation against bacterial invasion and placed his preparation upon the stage of a microscope. There he was not only able to see with the eye the nerve fiber growing out from the cell as a protoplasmic extension, but he was able to measure the rate of growth. This critical experiment has had far-reaching results. It provided the basis for a definite concept of the genetic and structural architecture in the nervous system which has been of immense importance to neurology and the associated sciences, psychology and psychiatry. Furthermore, it was the beginning of a new method in the biological sciences, *viz.*, tissue culture, which is now extensively employed in nearly every research institution which aims to study cellular physiology.

If time were to permit I could cite to you other examples of the important results that have been attained by the critical usage of the experimental method. The importance of this method in the study of problems in endocrinology is a matter which you will hear of first hand from my colleague, Professor Smith, who has done such brilliant work in this field.

Medicine is no doubt headed towards the stage of exact science, and its ultimate success lies not in the treatment of symptoms, but rather upon the cooperative investigation of causation. Every patient is a research subject and every malady a research problem. The intelligent study of cause and effect in diseased organisms must be preceded by a working knowledge of cause and effect in the production of normal or essentially normal organisms. Medicine is thus demanding more and more the cooperative efforts of all scientists who venture to inquire into the matter of causation in the biological world. As a result, departmental barriers are rapidly crumbling save perhaps for the purposes of administration. Consequently, we find bacteriologists working under the roof of surgery, neurologists in obstetrics, physicists in general biology, chemists in anatomy or pathology and so on.

During your first year in medicine much of your time will be consumed in the study of the human body in the more restricted sense, as a background for pathology, medicine and surgery, and you will have little time yourself to indulge in the scientific end of the subject. We hope, however, that the present staff in anatomy will be able to present matters to you with a view-point that will make the subject of anatomy living in spite of your necessary occupation with a dead organism.

Whether you become an anatomist, a bacteriologist, a surgeon or a practitioner of general medicine does not concern us so much as does our desire to give you your morphological training in such a way that you will pass on, not only with a dynamic concept of anatomy, but with an acquaintance and appreciation of the methods in biological investigation which you will later use as necessary instruments in your endeavor to advance the field of medicine.

SYMPATHETIC MAGIC IN MODERN GUISES

By Dr. KNIGHT DUNLAP

THE JOHNS HOPKINS UNIVERSITY

FROM the earliest ascertainable periods of human activity and thought the assumption that a cause in some simple way resembles its effect has been the great obstacle to progress. Of course, the terms, "cause," "effect" and "resemblance" *may* be defined in such a way that the assumption is true, but the