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I. COMPARATIVE ANATOMY AS A PART OF THE MEDICAL CURRICULUM.

II. ON THE TEACHING OF ANATOMY TO ADVANCED MEDICAL STUDENTS.

BY

HARRISON ALLEN, M.D.,

PROFESSOR OF ZOOLOGY AND COMPARATIVE ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA.

presented by the author

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PREFACE.

THESE addresses are now reprinted in order that those who are interested in the subject can read them in a convenient form. The views therein expressed have been held by the author for many years. In reassuming the duties of the Chair of Zoölogy and Comparative Anatomy in the University of Pennsylvania, he hopes that his long-cherished plan of having medical biologists as systematically trained as are those who elect the more general field of natural history may in some degree be realized.

The first essay was read before the American Association for the Advancement of Science, in Boston, August, 1880. The second was read before the Association of American Anatomists, at Washington, September 22, 1891, and appeared in *The Medical News*, of Philadelphia, December 26, 1891.

Since the last-named address was delivered a class of five advanced students has been formed in the Biological Department of the University. Three of these are graduates in medicine, two are special students in the biological work. Three accept anatomy as a major in the Department of Philosophy in preparation for its degree.

Any person desirous of taking this advanced instruction will please communicate with Professor Horace Jayne, Secretary of the Faculty of Arts.

I.

ON COMPARATIVE ANATOMY AS A PART OF THE MEDICAL CURRICULUM.

[Extracted from Transactions American Association for the Advancement of Science, 1880.]

If I am correctly informed, the meetings of this Association prove valuable to its members not only by reason of the facilities afforded for the announcement of discoveries, but also by the opportunities presented to teachers, and others interested in education, to discuss the best methods of conducting courses of instruction in natural science. It occured to me in this connection that a short account of an experiment in teaching comparative anatomy to medical students might not be unwelome, particularly since the experiment was conceived upon the didactic plan, and is now finished. I desire to emphasize the didactic nature of the experiment, for it is not likely that a similar series of lectures will again be given—at least while the drift of opinion for teaching by demonstration conjoined with laboratory work continues to be so influential.

Comparative anatomy was founded by John Hunter, a practising physician and surgeon. The researches of this remarkable man tended at all times

toward his own profession. With him the study of the structure of animals was a part of the self-imposed task, the performance of which made him not only the great comparative anatomist and physiologist, but the great surgeon as well. No name is more revered in the annals of English medicine than that of Hunter—Harvey alone excepted. It is doubtless largel y owing to this circumstance that comparative anatomy has so long held a place in the medical curriculum of the British schools, and that the institutions in this country, based upon the British model, early introduced it. The University of Pennsylvania—which imitated the University of Edinburgh—in its early history essayed such a course of instruction, but subsequently abandoned it. The McGill University, at Montreal, naturally imbibed the English methods of teaching. It yet continues to exact of her candidates for the medical degree satisfactory proof that they possess a fair knowledge of the anatomy of the lower animals. In our colleges, efforts have from time to time been made to introduce comparative anatomy, but without the exercise of any great vigor. As a rule it may be said its claims have been ignored, and, indeed, for various reasons actively attacked. The objections thus far urged have come from three separate directions. First, from the teachers in the preparatory schools, who claim that the study of animal structure and habit should be completed before the student matriculates in medicine. Second, from physicians not interested in comparative anatomy, who do not believe that the subject is of sufficient importance to take the time of the student

who is preparing for the difficult practical art of healing, and who is already overworked. Third, from those who believe that the medical man is all the worse for possessing the knowledge, and should under no conceivable circumstances be encouraged in getting it.[1]

In 1865, Dr. George B. Wood, of Philadelphia, founded a chair of Medical Zoölogy and Comparative Anatomy in the University of Pennsylvania. It was particularly enjoined by its founder that these subjects should be taught with special reference to their medical relations. The course was not to be a part of a preparatory training to medicine, but one coincident therewith. Dr. Wood had been a distinguished professor in the medical department,—having held the chairs of Materia Medica and Practice of Medicine. He wished special attention to be given to the parasites of man and to the articles of the materia medica procured from animals. Acting upon this instruction, I gave an outline of the animal kingdom, and elements of medical zoölogy in each course of lectures, giving in all between the years 1865 and 1879 thirteen courses of lectures, of thirty-six lectures in each. I made prominent in the lectures the features already mentioned—but added thereto expositions of the great generalizations that have been from time to time announced in general anatomy and biology. Thus separate lectures were given upon the subjects of bilateral symmetry; on the

[1] See Report of Professor Huxley's Address at the Opening of the Johns Hopkins University. N. Y. Tribune extra, 1876, No. 36, p. 10.

meaning of the terms "generalization" and "specialization;" on homology; on evolution. Attention in addition was directed *in extenso* to the tendencies exibited by the hard tissues of animals, such as the bones in vertebrates and the axial rods in various invertebrates, to undergo transverse segmentation; to the tendency of portions of such rods to be twisted upon themselves; to the causation of articulations, etc. I deemed it my province to direct the attention of medical students to the importance of these topics, and, with the object of making the series of direct value to them, drew my illustrations, whenever practicable, from human anatomy, physiology, and pathology.

A separate group of subjects was next treated. It embraced the themes of variation, teratology, compensation, etc. In this group instances of variation in the human subject were taken up, described and explained. The object of this series was to awaken interest in the study of variations of human anatomy as met with in the dissecting-room or the practice of medicine, and to enable the medical man properly to appreciate and describe the various congenital monstrosities that may come under his notice. In addition to these, I usually gave one lecture on the medico-legal value of a knowledge of the skeleton (pointing out the characteristics of the bones of the different classes of vertebrates as determined by the study of fragments of bone), as well as one on medical credulity: in illustration of which subject, I pointed out fallacies in medical observation. Every physician who has become identified with biological studies can mention many

instances in which his services as expert have been requested upon subjects as simple in their nature as the error in observation has been gross and mortifying.

It will be remarked that the medical emphasis is everywhere insisted upon in a course of lectures such as that which has been briefly outlined. Would it not be entirely improper to attempt the delivery of such a course before classes of young men in the literary departments of our colleges? Doubtless instruction in comparative anatomy as a branch of general education, or one preparatory to medicine, is of great value. But I am anxious that such a course should not be held to be identical in character with the one I have thus described. The student who proposes to attend, to the best advantage, a course of such lectures should already have attended a general course in biology, and have familiarized himself with the rudiments of human anatomy aud physiology. It has been commonly said to me by my students—most of whom had already studied two years—that the lectures were difficult to follow. If it so proved to advanced pupils, it is easy to foresee what would be the result of lecturing on such basis to classes preparing for matriculation, or even for studies of the second year. The explanations of the generalizations of biology, the "variations" of human anatomy, the abnormalities of structure—involving the most abstruse problems in biological science—cannot be essayed with advantage to other than advanced students. I have again and again stopped in the course of a demonstration and remarked that if there were

any gentlemen present who felt themselves to be imperfectly prepared upon the human anatomy of the subject under consideration, such had best retire from the lecture-room, for it would prove for them a waste of time to remain. It was my custom to name at the close of each lecture the subject for the next, to invite special attention to the points to be therein treated, and to request my pupils to consult their text-books before reporting for the lecture. By this plan I was free from the necessity of first demonstrating the anthropomorphic features before taking up the comparative.

The conviction that remains after having given much thought to the matter is, that the outline of the structure of animals as taught in our colleges of general education, or in preparation for the special medical course, does not meet the end in view, but that a supplemental course should be given after the first or second session. If the time of the curriculum does not permit such instruction, one of two ways is open—either to make the course post-graduate or to lengthen the session. This is a matter of detail which need not interfere with the main point I advocate, *i. e.*, that the kind of comparative anatomy a student of medicine needs cannot with advantage be offered him until he is advanced in his special studies.

II.

ON THE TEACHING OF ANATOMY TO ADVANCED MEDICAL STUDENTS.

[Reprinted from THE MEDICAL NEWS, December 26, 1891.]

THE importance of anatomy to the physician and surgeon has caused the method of teaching this science to be largely determined by practitioners. The student is taught the elements of histology, the shapes and numbers of organs, the outlines of regions, and their mutual relations. Other facts than those named belong in a very remote degree to the needs of practice; and when the great number of medical topics is considered, which is of necessity brought to the attention of the student, it is no wonder that governing bodies are disposed to disregard all phases of instruction that do not have direct claim upon the physician's time and service.

But science is rarely pursued for practical good. The acquisition of knowledge for its own sake—the determination of general principles that reveal the existence of law—awakens and maintains pleasures and interests in the mind of the anatomist compared with which the practical uses that he can make of

the knowledge appear to be poor and mean. With as much propriety one might say that navigation is the highest use that can be made of the study of astronomy, as to assert that the chief end of the study of anatomy is to apply its tenets to medicine. These statements are made not to lessen the dignity and importance of practical work, but respectfully to claim that such work does not comprise all the value, indeed scarcely more than a small fraction of the value, that pertains to the whole.

In his *New Atlantis*, Lord Bacon says: "We have three of our fellows that bend themselves, looking into the experiments of others, and cast about how to draw out of them things of use and practice for man's life, and knowledge, as well for works as for plain demonstration of causes, means of natural divinations, and the easy and clear discovery of the virtues and parts of the bodies. These we call dowry-men or benefactors. Lastly, we have three that raise the former discoveries by experiments into greater observations, axioms, and aphorisms. These we call the interpreters of nature."

I hear a response to the foregoing statement that the structure of animals exhibited on a broad scale is already taught to classes in the scientific schools, and that, in the scheme of a university education, the biological subjects are as well advanced as any others in the curriculum. This is an imperfect, if not misleading, presentation of the facts. It is true that the rudiments of the structure and functions of animals and plants are taught. But to students already advanced by general training and by preliminary work in natural history, little is pre-

sented that prepares them to discuss the more intricate problems.

To my mind the scheme of university work is unsatisfactory until opportunity is afforded to men, who, after completing their biological and medical training, may desire to still further advance. Conceding that the question of maintenance has been settled, either by the possession of private means or by endowment of fellowships, what courses of instruction are afforded these advanced men? As a rule, nothing, or next to nothing. It is customary for such novitiates to reside abroad for several years, where amid numerous centers of learning are found one or more masters, the disciples of whom they become. The advantages of travel being considered, it may be said that with the comparatively easy means of obtaining the best instruction the present scheme is on the whole adequate. With such a conclusion I cannot agree. If it were true, we might in reason have stopped long ago in our lines of university expansion. Independence in intellectual as well as in political life should be the object of American citizenship.

First, and always, let us remember that medical investigators are those it is desired to train. It is for men that are already imbued with the desire to pursue their researches in anatomy that I appeal. They stand in this field with what preparations can be given them for usefulness. They are medical biologists—medical anatomists. They are not restricted to the problem of the relief of suffering, and yet they are occupied with those other problems upon which the true solution of all depends.

For such instruction I would have a specially-designed museum and a specially-equipped laboratory. It may be assumed that in every great medical school, from among the large number of matriculates (men already trained and of the best quality), two or three of the type described will present themselves for an advanced course in anatomy. I am prepared for the objection that this is too large a number. But, so far as I know, no one has attempted to ascertain how many men in each class of graduates would come forward, and my impressions are based upon the number of workers in the general field of biology—some of whom, at least, would have pursued these or similar studies had any systematized course been presented to them. I will, therefore, begin with three men a year. To this number may be added as many young teachers, tutors, curators, and prosectors, who would avail themselves of the instruction. The work might be initiated in either of the halls of biology or of medicine. If the course were well established, it would be well to institute a laboratory and museum distinct from any on the university grounds. I am of the opinion that the administrative success of such separation of collections would be assured. All must approve of the ethnological collection of Harvard being distinct from the Museum of Comparative Zoölogy, and of both in turn being set apart from the museum in the Medical School. In like manner I assume that there is no reason why series of specimens arranged in illustration of principles that are not taught either in the preliminary or in the proper medical courses, should be necessarily connected

with one or the other museum. The collections should be in the main designed to accommodate the preparations that are used in the illustration of general lectures. Museums that teach by the specimens being removed from the cases to the lecture halls are radically distinct from museums that teach by the conservation of series that are arranged and labelled for instruction as they stand, and which should be rarely, if ever, disturbed.

The following, treated in some detail, embrace the topics that occur to me at this time as appropriate subjects for instruction: The study of the human brain; especially the study of the mammalian and avian brains, both of the gross and the minute anatomy, the localization of functions, etc. The study of muscular anomalies and their homologies in the normal myology of the vertebrates. The study of animal locomotion and its application to the morphology of the vertebrate limb, and in general the application of photographic methods in studying animal locomotion.[1]

[1] Instantaneous photographs have given us definite conceptions of the behavior of the manus and pes in terrestrial and aërial movements. I had the honor to point out as a result of a study of the negatives taken by Mr. E. Muybridge under the auspices of the University of Pennsylvania, that the ground is touched by the outer border of the foot and is left by the inner border, and that the impact represented by this transition is expressed by an oblique line that extends from without inward (ecto-entad) across the metapodium. Prof. H. F. Osborne by studying the carpus and tarsus in extinct forms of mammalian life has found that this conclusion is of value in studying the evolution of the parts. From this we can conclude that, as a result of a photographic plant in connection with advanced anatomical work, discoveries could with some confidence be anticipated.

Studies in craniology, especially the comparative studies of human and mammalian crania. The study of osteological variations, with a similar application to the normal anatomy of the lower animals and the beginning of morbid processes. The study of nutritive processes on tissue as correlated to age.[1]

In addition, courses of experimental morphology might be essayed. Such investigation could be encouraged without encroaching on the domain of physiology, as the votaries of this science somewhat arbitrarily restrict it. Indeed, much of the study of animal locomotion would be experimental, as would also be the study of protoplasm in viscid media, under rotation, compression, etc. The effects of light, temperature, water in motion and at rest, etc., on organization, would naturally find a place. Experiments on mutilation of embryos might also be undertaken.

Lectures on correlation of structure, on vegetative repetition, on the relation existing between phyllogenetic and teratological processes, could be given, as well as the study of the laws of heredity, especially in attempting to answer the question of the transmittal of acquired characters.

The teeth are so responsive to the constitutional peculiarities of the individual that their peculiarities can be seen and readily detected. The method of procuring accurate impressions can be applied,

[1] This would form a morphological study on the nature of age, and would more particularly embrace a consideration of the immature and senile forms as compared with the typically adult, as well as the retention of juvenile characters in the adult.

and the plans of preserving the form of teeth be easily accomplished.

As is known to the zoölogist, the parts involved in the act of mastication are important in the classification of the mammalia, the slightest departure in the form, number, position, and rate of development of the teeth being for the most part correlated with other variations in the economy, while the shapes of the lower jaw and of those portions of the skull that afford surfaces for attachment of the masticatory muscles are of importance. No structures of the body resemble the teeth in the character of their response to morbid impressions; no other organs are arranged in progressive series; and none other than these are evolved after birth. Hence the effects of disease and accidents to which the teeth are subjected are sure to be recorded in the shapes of the crowns and roots.

If the student of heredity were to have placed at his disposal a collection of the casts of the permanent teeth of three generations—that is to say, of the parent of the subject, the subject himself, and the children of the subject—and if a clinical history were secured of the diseases and accidents that these persons had incurred, a tenable argument might be established as to the significance of the contrasts or resemblances in the forms of the teeth.

Thus, if three generations were expressed by the letters A, B, C, and if B is the subject of an acquired character (let us say from scarlet fever or measles), the new form of structure seen in the second and third molars may be transmitted to C. But in order to prove this it is necessary to know the pecu-

liarities of these teeth in A. Hence, the teeth of the ancestors and descendants of the person who exhibits the acquired character must be known. A somewhat similar plan of observation could be made on the teeth of the lower animals. It is strange that those teeth with endless pulps, in which growth is rapid and interference with their relations causes permanent records to be made in malformation, should not have been used in studies of nutrition.

In connection with myological studies a number of minor problems suggest themselves; such, for example, is the nature of white and red muscles. It has been noted that in ostriches that have been confined in zoölogical gardens the muscles of the leg undergo fatty degeneration and become white in color; it is also known that the pectoral muscle in many of the gallinæ is white, presumably from the fact that they are used but for short and infrequent flights. How evident is the conclusion that a systematic study of all muscles of active birds living in enforced confinement, as compared with the relatively active muscles in feral forms, might be undertaken with a fair prospect of throwing light upon the nature of the process, and with a hope that the subject of fatty degeneration (even if by this method not elucidated) may have its study placed on a broad basis by subjecting its tenets to the tests of systematized experiment and observation!

The morphological study of the results of diseased action might also be undertaken. The differences that obtain between normal individuals and those

the subjects of hereditary disease must be of importance to the anatomist and the pathologist.

The variations in the forms of the bones, as found in medical museums, are of a character that suggest their relation to inherited causes. Every clinical observer has noted the peculiar shape of the chest in families in which pulmonary phthisis is hereditary, even though the special tuberculous deposits are absent in some of its members. The clubbing of the finger-nails is a sign of the same disposition. Some writers, indeed, claim that in this class of subjects a special arrangement of the fibers of the pneumogastric nerve exists. Are these and similar morphological characters susceptible of being also gathered so as to contribute to the discussion of the transmission of acquired characters? Are not opportunities here presented for the medically trained biologist to study the subject of heredity in a line so important and, alas! with material so abundant? Other hereditary diseases, such as struma, syphilis, and gout, are less strongly marked than is the tuberculous, but even on this obscure horizon landmarks are detected that are of sufficient definiteness to guide the observer to well-defined plans of study. The animals of zoölogical gardens exhibit examples of acquired struma, the effects of which more especially distinguish the skeleton. Can any of these characteristics be transmitted? How would the skeleton of a tiger, let us say, born in captivity in the third and fourth generation differ from that of a feral type? After what manner may one expect taxonomic characters modified in these generations of prisoners?

The nature of malignant growths, it is not improbable, would find a solution in a line of research based upon a similar proposition. What proportions of malignant growths, such as the sarcomata, are met with in the feral state of quadrupeds as compared with those in the domesticated or the captive state? Can experiments be devised by which we may expect to cause these growths to appear by creating the favoring conditions? Can we study the genesis of the sarcomata to better advantage than has hitherto been done, by outlining the biography, the lineage, and to some extent possibly the destiny, of these tumors, by applying to them experimental methods of research?

Medically trained men are not apt to become pure morphologists. The underlying thought is of *function* through which *structure* is modified. In its best sense, therefore, Physiological Anatomy is the branch of science that would be most developed. Let us suppose that John Hunter had lived in 1891 and had essayed his work by all the aids of modern science, and had undertaken a plan of investigation for the continuation of his labors: might he not have accepted some such scheme as I have here feebly attempted to portray? With the admiration we feel for his genius, let us not only have Hunterian orations, but in each medical center a Hunterian laboratory and a Hunterian museum.

"I am so utterly opposed to those cloud-builders who would divorce physiology from anatomy," says Haller, "that I am persuaded that we know scarcely anything of physiology that is not learned through

anatomy." (Quoted from R. Cresson Stiles's *Life and Doctrines of Haller*, New York, 1867.)

In Solomon's House in the *New Atlantis*, in which Bacon essayed a scheme for intellectual advancement, we read of "parks and enclosures of all sorts of beasts and birds, which we use not only for view or rareness, but likewise for dissection and trials, that thereby we may take light what may be wrought upon the body of man; we have also particular pools where we make trials upon fishes, as we have said before of beasts and birds."

I hear objections that this scheme is visionary and impracticable. How is the money to be obtained by which it can be rendered feasible? Where is the teaching-force to be recruited? My answer is that if the need of establishing such a course be acknowledged, the accomplishment of the end in view is no more difficult than in any other branch of pure science. A few years ago the establishment of seaside laboratories would have been thought chimerical. Now they are assured successes.

If I am told the results obtained will appeal to but few, I reply that important projects must be supported in proportion as they so appeal, until such time as they shall have proved their right to exist.

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