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BY

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SHOULD COMPARATIVE ANATOMY BE INCLUDED IN A MEDICAL COURSE?

In his address at the formal opening of Johns Hopkins University, Prof. Huxley used the following language:

"In many medical schools of the present day young men are set down to spend three or four valuable months of the year in the study of zoölogy and comparative anatomy, and botany, and materia medica—that is, a knowledge of drugs and what they come from, and the animals and plants that yield them. If I had power in this matter, I should cut all these subjects out ruthlessly. . . . When the time which a man possesses to become familiar with the structure of the human body is so limited, what earthly business has he to be studying the anatomy of star-fishes, and crabs and lobsters?" (1, 11.)[2]

To these expressions—which, by the way, should be qualified by the speaker's more carefully-worded discussions of

[1] Introductory lecture at the Medical School of Maine, February 15, 1877.

[2] The references are to a list of papers at the close of this article.

the subject [1]— exception is taken by Prof. Harrison Allen, M. D., of the University of Pennsylvania:

"I am a teacher of comparative anatomy in its relations to medicine, of ten years' standing, and, as such, I respectfully protest against the views so conspicuously announced by Prof. Huxley in his recent address at Baltimore. Now, I contend that no good teacher of comparative anatomy to medical students dwells at length upon any such topic as the anatomy of star-fishes and lobsters. He confines himself to the consideration of general principles as they apply to all structure" (2).

As stated in an extended review of his recent work upon "Medical Education in Germany," Prof. Billroth thinks that "zoölogy and comparative anatomy should be taught together; and that the latter, if well taught, is especially adapted for giving breadth of view, and producing the habit of thought best suited to the investigator of Nature." (Review 3,553.)

The foregoing may be taken as fairly representing the present unsettled state of opinion upon this question. The custom of the great majority of medical colleges is presumably in conformity with the general sentiment of the profession. Comparative anatomy is taught in many English schools, but Prof. Huxley would exclude it. It is taught in very few American schools, but Prof. Allen thinks it essential. I do not know to what extent it is taught in German medical schools, but Prof. Billroth has laid especial stress upon its value.

In attempting to decide when such doctors disagree, I can only hope that a somewhat varied and extended connection with medical schools, and with zoölogical teaching, may enable me to consider the whole subject with impartiality. I shall, at any rate, take pleasure in showing that the differences be-

[1] Since this lecture was delivered, Prof. Huxley's lecture on the study of biology has appeared (16). Toward the close occurs the following passage: "To all those who intend to pursue physiology, and especially to those who propose to employ the working years of their lives in the practice of medicine, I say that there is no training so fitted, or which may be of such important service to them, as the thorough discipline in practical biological work, which I have sketched out as being pursued in the laboratory hard by." (See also 18 and 19.)

tween the views of the distinguished anatomists already mentioned are really slight, as compared with the antagonism between them and the opinions current with the profession and the public respecting the requirements of a sound medical education.

The full consideration of the question involves the following points:

I. What is comparative anatomy?

II. What special advantages does it offer to the student of medicine?

III. To what extent should it be pursued?

IV. When should it be pursued?

I. *What is comparative anatomy?*

Etymologically, anatomy designates the study of structure, which must be *dissected*, as opposed to the study of outward form. It may refer to any organism, but is commonly restricted to the animal kingdom. The study of the structure of man is human anatomy, or *anthropotomy;* of the horse, *hippotomy*, etc. In comparative anatomy two or more animals are compared as to their structure. Now since, in some respects unfortunately, the human body has been first thoroughly investigated, and has thence become the standard for comparison, and since the parts of oysters and star-fishes, beetles and lobsters, are not readily identified with those of man, the signification of comparative anatomy is usually restricted to the great branch of the animal kingdom to which man belongs—the *vertebrates*.

There is another kind of comparative anatomy, or rather, it is comparative anatomy pursued in a different way: I mean *embryology*. For, while we hold that a bird is such from the egg, yet at its beginning that egg could not be distinguished from that of a snake or a fish; still later, the embryo could not be distinguished from an embryo lizard or turtle; and even later, the young chicken has webbed feet, like the duck. The tadpole, the young of the frog and toad, has a tail and gills, like some salamanders. The young gar-pike (*Lepidosteus*) has first a *protocercal* tail, like that of *Polypterus;* then the tail becomes *heterocercal*, as in the sharks and sturgeons; by degrees it attains the almost *homocercal* condition

which led some early observers to suppose it similar to the tail of ordinary fishes. (Wilder, 24.) So, too, we hold that the human being is such from its conception. Yet the human ovum is, to our eyes, identical with the ovum of a cat or a dog. For a time the embryo has a short triangular tail, and even after certain parts, as the face, the hands, and the feet, have assumed human characteristics, yet the arms are as long as the legs, and for some time after birth the limbs of the child are semiflexed, as in the monkeys, and it has no more waist than the adult chimpanzee. Hence has arisen the generalization that higher forms, in the course of their development, pass through stages resembling more or less nearly the adult conditions of lower related forms. When, therefore, we trace the successive transformations of a single species, we are, in a limited but most suggestive way, studying comparative anatomy.

II. *What is to be gained by the medical student from the study of comparative anatomy?*

1. It may be regarded as a desirable element of *general culture*, upon the following grounds:

(1.) The contrast between the lower animals and ourselves renders more apparent the advantages of the human form.

(2.) The similarity of our organs and functions to those of animals should teach us consideration and humanity for those which serve us; and, whatever may be the case with those who, brutal by nature, and rendered more so by the horrors of the ordinary dissecting-room, dignify, under the name of science, unnecessary and unproductive tortures, I believe that, as a class, none are more kind and humane than those whose occupation requires them to occasionally take the life of animals.

(3.) The essential identity of the mode of development and the plan of structure of the human body with those of other vertebrates, and the probability that the highest has been gradually evolved from the lowest, should both encourage us to hope for yet further development, mental and physical, in time to come, and fill us with humble adoration of the Power which could, from such unlikely beginnings, create a habitation for the immortal soul of man.

2. It serves as a means of *mental training*. Surely mental training of any kind, and by any method, implies the acquisition or cultivation of the following powers:

(1.) Accuracy of observation.

(2.) Thoroughness of comparison.

(3.) Logic of conclusion.

(4.) Clearness of definition.

(5.) Desire for verification.

(6.) Discrimination between the proved and the merely probable.

(8.) Respect for, yet absolute independence of, authority.

The educational value of the natural history sciences has been, of late years, often insisted on, and by none more emphatically than Prof. Huxley, in the "Lay Sermons" and elsewhere. Indeed, the claim has been more or less fully allowed by nearly all excepting those who, having studied books alone, seem unable to conceive that any good thing can come out of that which hath not been printed, or at least written, by a man.

Life is so short, and his art is so very long, that the physician, like the naturalist, is generally forced to look upon purely linguistic studies as means to an end, as tools for his work. Still, it is to be hoped that few medical men have been obliged to literally adopt the suggestion contained in the following passage:

> "Any lawyer or doctor who cannot learn by heart, in a week, all the technical terms and phrases of Latin origin which he encounters in his common professional occupation, has not wits enough for his calling." —*President Eliot, Inaugural Address.*

I should, indeed, be the last to insist that the study of languages may not likewise subserve the mental training of those who, on other grounds, may select them as their especial field for cultivation; for I have endeavored to show the striking similarity of linguistic and natural-history studies in respect to the number and importance of exceptions to nearly all general rules, and even to the exceptions themselves (23).

It is the knowledge of exceptions, and the readiness to accept them, which distinguish the mere teacher from him who "professes" to have derived his information from Nature her-

self. The former is apt to be very certain of many things; the latter is absolutely sure of a few things, and has well-defined doubts respecting a large part of what passes in the community for knowledge. "In order to know a few things well, he must be content to remain ignorant of a great deal." Compare, for instance, the modesty, yet precision, with which Dr. Ferrier states his conclusion that the anterior cerebral lobes seem to be the seat of a certain inhibitory power, with the pretentiousness with which traveling phrenologists, "most of whom have never seen a brain," locate all your faculties upon the outside of your skull, and, for a consideration, determine the past, the present, and the future of a human being in a quarter of an hour!

3. Comparative anatomy naturally *leads toward* the *medical sciences.* Perhaps the converse is even more frequently the case; but there can be no doubt that many who have commenced with the desultory observation of the lower animals have, by degrees, drifted into the systematic study of medicine, either as a mere means of livelihood, or from a natural aptitude not recognized in earlier years.

The foregoing considerations are based upon the assumption that the physician should be primarily a man of culture, intellect, humanity, and religious sentiment. We have now to inquire what are the special advantages which the study of comparative anatomy may confer upon him who undertakes to know the body of man, and to maintain its integrity.

4. *The methods of zoölogical investigation are those which are required in the study of disease.* This is well stated by Billroth, as follows:

> "What better preparatory school can the physician have than the study of the natural sciences? The method by which he examines all the parts and all the functions of an animal is the same which he must apply to the investigation of disease. . . . Zoölogy and comparative anatomy should be taught together; and the latter especially, if well taught, is one of the most valuable subjects for giving breadth of view, and producing the habit of thought best suited to the investigation of Nature" (3, p. 553).

Nor need we, with Dr. Cotting (10), be fully convinced that "disease is a part of the plan of creation," to recognize

in its phenomena an orderly sequence and correlation which entitle it to be regarded as a branch, though a distorted one, of the great natural-history tree.

Comparative anatomy furnishes many illustrations of the saying, "Appearances are deceitful," and so teaches us to look below the surface. Linnæus supposed the whale to be a fish, not knowing that it had lungs, that its blood is warm, and that its young are nourished with milk. So, the flying-bat may readily be mistaken for a bird. Nor are there any external peculiarities of the Australian quadrupeds which would lead us, at first sight, to infer the existence of the pouch in which the young are carried, and the smallness of the corpus callosum.

The second pair of lobes of the ordinary fish-brain have usually been called hemispheres, implying an identity of structure with the hemispheres of reptiles. Yet both comparative anatomy and development teach that the essential feature of a hemisphere is its cavity or *ventricle*, and no ventricle has ever been found in the so-called hemisphere of the teleost or ganoid brain. Müller first showed the solidity of these lobes in a figure of the cross-section of the brain of *Polypterus*.

So, in the diagnosis of a disease, the physician finds that its real nature is not always indicated by the more prominent symptoms; and it is not improbable that the early medical training of Owen gave especial significance, in his own mind, to the following aphorism: "The prominent appearances which first catch the eye are not always the best guides to the true affinities of an animal. It is as if truth were rather whispered than spoken by Nature."

It may be said that the advantages above mentioned may be derived from the systematic pursuit of any branch of natural history, or from the anatomy of insects or other non-vertebrated animals. But there are additional and very considerable reasons why the medical student should select the comparative anatomy of vertebrates. These reasons may be variously stated, but they all depend upon the fact that man, as to his body, is a vertebrate, and that the regions, organs, and tissues of the human body have essentially the same structure, the same relative position, and the same mode of development,

as those of fishes, frogs, turtles, birds, quadrupeds, and monkeys; in a word, because the *human organs are homologous with the organs of other vertebrates.*

5. From the above, it follows that comparative anatomy enables us to make *instructive comparisons.* It was said by Dr. Gould (himself not only an able physician but a distinguished naturalist, and author, with Agassiz, of "The Principles of Zoology"), that "the anatomical structure is only to be fully and understandingly acquired by comparison of the structure of one animal with that of another" (6, p. 8). But this comparison must be made within certain limits. It may be interesting to contrast the arm of man with the tentacle of a cuttle-fish, but, excepting that both are living, either might almost as instructively be compared with an arm of the sea. So, the wing of a bird may be contrasted with the wing of a butterfly, but their structural similarity is hardly greater than that between either and the wing of a house. These are only analogies, more or less remote; while, in spite of their outward dissimilarity, the arm of man, the wing of a bird, the front-leg of a cat, and the flipper of a seal, are all homologous; and even the wide-spread wing of a bat is, at its first appearance, a little flattened pad, undistinguishable from the paw of the embryo kitten or pig (25). There is, in these cases, essential resemblance, with outward difference in adaptation to the needs of each species; and the collocation of the two is the more instructive, just as the relations of two friends, or of a married pair, are more enjoyable and productive when their real affinity is hidden from the world by a diversity of temperament, capacity, or occupation. Perhaps no better illustration of this "unity in variety" could be given than the close and long-enduring mutual affection and esteem which united the distinguished mathematician of Harvard University with his colleague, the late Prof. Agassiz—pure zoölogy and pure mathematics hand in hand.

Aside, however, from the instructiveness of comparisons between man and the lower animals, there are certain practical reasons for dissecting the latter before the former. These may be combined by saying that:

6. *Comparative anatomy forms a convenient introduc-*

tion to human anatomy. The accomplished human anatomist must have made the following acquirements:

Firstly. Skill in manipulation, including not only dissecting, but injecting, and microscopic examination.

It is probably not too much to say, that the student's first dissections rarely do credit to himself or to the long-suffering demonstrator. Now, a human subject is costly, unwieldy, and, before it is disposed of, apt to answer more or less accurately to Mr. Mantalini's prophetic description of what he would be after being drowned—"a demmed damp, unpleasant body;" yet, upon it the tyro must begin, or do nothing in practical anatomy. In no other trade or profession is the most valuable material placed in the hands of the beginner; and it is only one of the anomalies of medical education, apparently resulting from an unwillingness to admit that this mysterious profession can have anything in common with other human occupations, that all kinds of anatomical manipulation are not learned by long practice upon cats and dogs and rabbits, which may be had at little cost, which are easy to handle, and at very slight expense may be preserved for an indefinite period.

Why should not the anatomist take a lesson herein from the physiologist? Much has been learned from accident and disease, and some simple experiments may be performed upon the human body; but how much would there be left of modern physiological science if all that has been attained by experimentation upon animals were suddenly to be erased from record?[1]

Secondly. The anatomist must become familiar with the *technical names of parts.* It is usually not difficult to have access to a human skeleton, and the bones should be learned before the student enters the dissecting-room; but the skeleton of a common quadruped will serve a very good purpose as a beginning. The same is to be said of the principal muscles, vessels, and nerves, so that they can be identified by means of

[1] Recent legislation has left England in the anomalous position of placing considerable restrictions upon the acquisition of precise physiological knowledge by trained experimenters, while an ignorant brute may, at the expense of a few shillings, maltreat his wife and children.

the works on human anatomy; minor points can be overlooked in the earlier dissections. Finally, the viscera, which are usually disorganized before they are reached in the dissecting-room, may be had fresh in a newly-killed quadruped, and may then be examined histologically, as well as in respect to their visible structure.

The general structure of the heart can be learned just as well from that of a sheep, which costs a few cents, and is perfectly fresh, as from that of a human subject, which is less easy to obtain, may be full of injection, probably has an "ancient and fish-like smell," and, not unfrequently, presents certain pathological conditions which are worse than useless to the beginner in anatomy.

Thirdly. The student must learn the *relations* of parts to each other, to the surface, and to the surroundings. These relations are essentially the same in all vertebrates; but, in order to compare the parts of man with those of a cat, the latter must be placed erect, or, which is more convenient, the human body must be reduced to the horizontal position. It is also necessary to note that the so-called "knee" of the horse is really the *wrist*, and that the true knee is near the trunk; while the heel, with most quadrupeds, is greatly elevated. Keeping these, and some minor differences, in mind, the student is soon enabled to identify the muscles, vessels, and larger nerves of a quadruped, by means of the figures and descriptions in his "Gray" or "Quain."

At a later period, a monkey will be very useful as presenting more nearly the human arrangement of parts; and, although medical students are apt to think such a tiny subject beneath their notice, a child, or fœtus at term, answers a most useful purpose.

Not only do such materials as these cost less themselves, they also involve much less expensive accessory arrangements.

7. *In some lower vertebrates the tissues are coarser and more easily examined.* This is especially the case with the *Amphibia*, and the late Prof. Wyman used to say that "frogs seem to have been made for anatomists." The frog is an almost typical vertebrate, occupying a position between the fishes below and the air-breathing groups above. It is easy

to breed, to keep, and to kill. Its very skin is as if only "basted on," so as to be readily stripped off. The muscles are distinct. The *membrana tympani* is at the level of the head. More than this, the red-blood corpuscles are nearly three times as large as those of man. The white corpuscles are large, and their amœboid movements very active. Ciliated cells can readily be scraped from the roof of the mouth, and the zoösperms are not only easily obtained, but also larger than in man. In some respects even the frog is excelled by a tailed Batrachian, the *Menobranchus* or *Necturus* of New York and westward, whose red corpuscles are more than eight times as large as those of man, and whose zoösperms are more than ten times the length of the human.

8. *Comparative anatomy enables us to understand certain human structures more readily.* So far as I know, this use of comparative anatomy has never been distinctly presented. It depends upon the fact that, with certain of the lower vertebrates, organs which are very complex in man present a simpler structure and arrangement.

To some this statement may appear either as self-evident, or as, at any rate, requiring no qualification. But, in fact, the generalization is far from being universally correct. For instance, the deltoid muscle, which in man is a single triangular mass, in cats and dogs forms three quite distinct muscles, which have received as many names; the same is the case with the *trapezius;* and all quadrupeds have, just beneath the skin, a sheet of muscle, the *panniculus carnosus*, which is represented in the human body only by the *platysma myoides*, the muscles of the ear and of the face. So, too, the bones which support the upper incisor teeth are separable from the rest of the jaw with quadrupeds, and are called the premaxillaries, or intermaxillaries. The stomach of a sheep or a porpoise is much more complex than that of man. The heart of an alligator presents peculiar characters. Finally, beside the skull of a cod, the human skull is simplicity itself.

The cod is, in fact, a typical member of a very large group of vertebrates, the Teleosts, or osseous fishes, which are highly *specialized* in adaptation to a certain mode of existence; and, as a rule, specialized groups should not be brought before the

notice of the medical student. Whatever may have been its value in pure comparative anatomy, I cannot but feel that the anatomical side of medical education twenty years ago suffered a serious drawback from the supposed necessity of understanding the skull and skeleton of the fish before studying those of man.

But the so-called "generalized" groups of vertebrates frequently illustrate in a very simple way the more complex conditions of the human body which we wish to understand; and, in first making ourselves familiar with them, we act in accordance with the following aphorism:

> "In all departments of investigation it is right to commence with the study of that which is common, simple, and regular, and thence to proceed to inquire respecting that which is unusual and irregular" (Bucknill and Tuke, 22).

For instance, when the student is told that man, like other vertebrates, consists of two parallel cavities, a dorsal or neural, containing the cerebro-spinal axis, and a ventral or hæmal, containing the nutritive and reproductive viscera, and that the alimentary canal is essentially a tube from one end of the trunk to the other, he may accept the statements upon authority; but if you place in his hands a lamprey-eel, and tell him to make a transverse section at the middle of its length, he may then, at a glance, satisfy himself of the correctness of your description of the arrangement of organs which is characteristic of the vertebrate subkingdom.

Descriptive anatomy teaches us that there is one heart, and that it lies between two lungs, the right and the left; also that the vessels enter the lungs and come out of them. From a physiological point of view the lungs are a single thin walled diverticulum of the alimentary canal, *over* the walls of which the pulmonary vessels ramify; and that this single lung lies between the two hearts, the right and the left.

The student finds it hard to see it in that light—the light of human anatomy. But show him the heart of a manatee or a dugong—still better, the admirable Auzoux model thereof—and he sees that there the two ventricles are almost wholly separated.

Now, as the blood comes to the lungs from the right ven-

tricle, and returns from them to the left, it follows that the lungs are, physiologically, between the right and the left hearts. The lungs of a frog are nearly simple sacs hanging from the anterior aspect of the throat; and, at their first appearance even in man, they are a little bilobed pouch or diverticulum from the alimentary canal.

How the student dreads an examination upon the cranial nerves! and how is the confusion worse confounded by the double nomenclature of Sömmering and of Willis! He takes an almost revengeful delight in being assured that neither system is correct, for the auditory (VIII.) and optic (II.) are nerves of special sense, the latter, at any rate, being direct outgrowths from the brain; and the olfactory (I.) is not a nerve at all, but a lobe of the brain, quite large in quadrupeds, and containing an obvious prolongation of the lateral ventricle; in the hag-fishes and lamprey-eels it is larger than the hemisphere itself; while in some sharks the olfactory lobes seem to be distinctly formed before the true hemispheres, as if with these voracious fishes the scenting and recognition of food were more urgently required than any subsequent reflections respecting the mode of its acquisition, or the dangers attendant thereupon.

Nine pairs of cranial nerves remain. If the student has condescended to throw light upon his path by taking the initial letters of *anterior*, *motor*, *posterior*, *sensory*, and prefixing *L.* thereto, he will look for motor nerves upon the ventral or anterior aspect of the medulla, and for sensory upon its posterior aspect. But when he is told that in frogs there are only five pairs, and that in some others there are only three, he begins to realize that the *motor communis* (III.), the *trochlearis* (IV.) (miscalled *patheticus*), the *abducens* (VI.), and *facial* (VII.), with the smaller root of the *trifacial* (V.), are really dismemberments of the motor roots of a great nerve, of which the rest of the *trifacial*, with its ganglion, forms the sensory root; that the two, therefore, constitute a single modified nerve like those of the spine. After this it is not difficult to suppose that the spinal accessory (XI.) and the vagus (X.) form a second pair, and that the hypoglossal (XII.) and the glossopharyngeal (IX.) constitute a third.

This is the arrangement proposed by Dalton, and it is at least convenient, and easy to remember. But it can hardly be considered conclusive, because with frogs the hypoglossal is a regular cervical nerve with motor and sensory roots, which leaves the glossopharyngeal to unite with the vagus.

It is probable that, in course of time, these relations will be more fully understood, and that the present artificial nomenclature will be discarded.

Even more appalling than the cranial nerves is the brain itself. Men have been graduated without being able to remember the difference between the *corpus callosum* and the *corpus striatum;* and probably few can state with certainty, off-hand, whether the optic lobes are in front of the thalami or behind them. It is easy to see that the medulla is a modified enlargement of the cord, but the exact and personal knowledge of the average student rarely extends beyond the *pons Varolii*, which has thus become a veritable *pons asinorum.*

No doubt part of the difficulty arises from the peculiar nomenclature which has been left to us by our anatomical forefathers. I apprehend that *peculiar* will be admitted to be a very mild characterization of the system according to which a narrow passage about an inch in length became known by two such appellations as "aqueduct of Sylvius" and "iter a tertio ad ventriculum quartum;" especially when neither of them expresses the fact that this passage is the contracted representative of the cavity or ventricle of the optic lobes, a primary subdivision of the brain.

But whatever difficulties of nomenclature the student may have to contend with, I believe the failure of most medical students to gain a clear conception of the arrangement of brain-parts is even more largely due to a faulty system of teaching and of study.

In the first place, since a human brain is not easy to get at all, and almost impossible to obtain perfectly fresh, there are reasons of convenience and economy for examining the brain of some common animal. In the second place, the human brain is so large as to be easily torn by its own weight, or, if hardened, to require much fluid, and time, and attention.

But more than either of these considerations is that of the *complexity* of the human brain, and the disproportionate size of certain parts by which others equally essential are concealed. I shall give you, hereafter, the description of the typical structure and mode of development of the brain which will be most useful to us from a physiological point of view, and will now refer only to the *hemispheres*. These, with man, are so large as to cover all the other portions when the brain is seen from above, and their numerous convolutions have not yet been reduced to a perfectly satisfactory pattern. With cats and dogs and monkeys, the hemispheres are relatively smaller, and their fissures are less numerous. With some of the lower monkeys, as with rabbits, the hemispheres are almost smooth. With moles, as with reptiles, they do not wholly cover the optic lobes. Finally, in frogs they are simple elongated masses lying side by side, but wholly separate from each other, between the olfactory lobes and the thalami, and hardly larger than the optic lobes.

In short, the hemispheres are here reduced to their proper morphological condition as lobes of the brain. Yet their cavities are, as in man, the *lateral ventricles*.

By availing ourselves of the other kind of comparative anatomy, namely embryology, we may, in a series of fœtal pigs, readily procurable from any slaughter-house, not only trace the hemispheres back to their smaller and smoother condition, but also at last, or rather at the first, to the state of minute hollow buds or protrusions from the anterior vesicle of the embryo brain, which itself becomes the thalami. Strange to say, the gigantic hemispheres of man are not only the homologues of the insignificant second lobes of the frog, but, in the earliest condition of the brain, they have no existence at all, and are merely secondary formations from the thalami, which they afterward outgrow, as when a diminutive father is overtopped by his stalwart son.

Now, this is not simply curious, and, I trust, interesting; it is *valuable* to the student who would master the arrangement of parts of that organic labyrinth, the human brain. Let him learn the names of the lobes and their ventricles in the frog from behind forward, and I can assure him, from experience,

that he will afterward have little difficulty in understanding the other and less essential parts and complications by which the brains of higher forms differ from those of lower.

So greatly, indeed, does this comparative-anatomy method facilitate the study of the brain, that I can only account for Prof. Huxley's non-reference to it in his address, and upon other occasions, by the fact that to him, more than to any other, is due the credit for placing (17) the labors of embryologists and comparative anatomists in an intelligible English dress.

III. *To what extent should the study of comparative anatomy be pursued by the medical student?*

Assuming, first, that no one can know too much, and, secondly, that the average student is apt to learn no zoölogy at all, we should endeavor to define the amount of acquaintance which shall be at the same time most useful and most easily acquired.

The student should have a good general knowledge of the animal kingdom, including the names and leading characteristics, external and internal, of the great primary branches. Neither the Radiates (star-fishes and sea-urchins) nor the Mollusks and Molluscoids (clams, snails, and cuttle-fishes) need long occupy his attention. The same is to be said of the Crustacea (crabs and lobsters) and worms, though certain kinds of worms have a practical importance. He should know the difference between the spiders and the true insects, and what kinds are liable to injure by jaws or sting.

But among the vertebrates his knowledge should be much more extensive. He should know that a salamander and a lizard are members of two separate classes, the Amphibia and Reptiles; and that among the so-called "fishes" are forms differing from one another as widely as do turtles from birds. He should know that a bat is not a bird, not only from having hair in place of feathers, but also because the young are nourished with milk; it has two occipital condyles; its brain possesses a *pons Varolii*, a *fornix*, and a *corpus callosum;* and its red corpuscles are round and non-nucleated. But he should also know that in one group of mammals, the camels and llamas, the red corpuscles are oval, as in birds and reptiles.

But while the student should learn, at any rate from lectures, the names and distinguishing features of the vertebrate classes, so as to appreciate the bearing of any generalization that may be presented to him, and while he would certainly be profited by the dissection of a lamprey, a shark, a sturgeon, and a perch, as types of certain groups, as he would by the examination of a reptile or a bird, yet he should bear in mind that these are of scientific rather than practical value. He should confine himself mainly to such forms and such organs as may facilitate the study of human anatomy and physiology in respect to convenience, intelligibility, or economy of time or expense; and with these forms his acquaintance can hardly be too practical or extensive.

Among all these forms the *frog* is the most useful, especially as a beginning. Indeed, had Prof. Huxley never done anything else in aid of the diffusion of biological knowledge, we should owe him gratitude and honor for the concise summary of the structure of that animal which was prepared under his direction in the "Elementary Biology."

The cat, dog, and rabbit may be dissected by a human anatomy; but something has been done toward furnishing manuals for the examination of these quadrupeds. A descriptive anatomy of the rabbit has been published in German by Krause (20).

The bones, muscles, and ligaments of the cat have been described and elegantly figured by Strauss-Durckheim; but the text is in French, the descriptions are too long for practical purposes, the nomenclature is artificial, and the plates are inconveniently large. Reduced photolithographic copies of the outline plates, with an explanatory text by Mr. H. S. Williams, have been published by Putnam's Sons, of New York.

Directions for examination of the rabbit or dog are given in Foster and Langley's admirable "Practical Physiology." Finally, similar directions are given in Morrell's little work (21) for dissections of the heart, brain, and head of the sheep, and the ox's eye.

Now, these are average mammals; and the frog is an average vertebrate, midway between the higher and the lower

But, upon the same principle as that which leads the teacher to contrast the two ends of his class, the genius and the dunce, it may be worth while to glance from man to the opposite extreme of the vertebrate series. The lancelet is worth examination, if only to convince ourselves that the same essential arrangement of organs may exist in the little fish three inches long and the whale of sixty feet. In fact, during my lectures I shall so frequently employ the *Amphioxus* for odious comparisons with man, that I fear some of you may be inclined to spell it with an initial "D."

If the reasons for recommending the dissection of the above-named forms are sound, they are equally cogent for the exclusion of all peculiar and "specialized" groups. Hence, neither birds nor ordinary fishes (Teleosts) should be especially studied by the medical student. They present other and unusual combinations, and tend to confuse, rather than simplify, the ideas which may have been derived from more generalized forms.

In the letter already referred to (2) Prof. Allen has suggested some other ways in which a knowledge of comparative anatomy and zoölogy may be of use to the medical student:

> "An exact knowledge of the venomous animals—of internal and external parasites—the relations of food-animals to one another and to man, are all of great importance to the physician."

I think this will be admitted by all; but the real question is, How wide and how general should be the physician's knowledge upon these points? He should certainly know very thoroughly the structure and transformations of the *Trichina* and the tape-worm, to the extent, for instance, described and figured in Dalton's "Physiology." But, in order to learn their relations to the other members of the immense class of worms, the student would have to neglect something else; and very likely that something else would be the *treatment* of the disorders produced by these parasites.

So, too, he should know the names and habits of venomous insects and serpents, and be aware that the bite of a jumping-spider (*Salticus*) is more apt to do harm than that of its larger but less vigorous relative, the garden-spider (*Epeira*);

also, that the so-called water-adder of the Middle States has no poison-fangs or glands, and that its bite is therefore not apt to cause serious injury.

But, to learn these things, he need not dissect a spider or a snake, or even hear the whole of their structure described in a lecture. Much less need he know the precise zoölogical relations of these to the other articulates or vertebrates. He will, of course, be none the worse for such, or any other, information; but, as a medical man, he should keep in mind that his business is to learn, and *remember*, how the venom acts upon the system, and what may be done to counteract its effects.

I say *remember*, for to have known a fact is a very different thing from knowing it now and always. We all learn a great many things, and some of them may come back when wanted; but some others should be ever present—should form a part of our mental constitution, ready for use at any time.

Prof. Allen further says:

"If the doctrine of evolution has any practical value, it must lie in the application that the medical philosopher may make of it in explaining the significance of variations and malformations in the anatomy of man."

Certainly this is a very fascinating subject, and of great scientific interest. But, for practical purposes, is it not enough that the student be told that many muscles, vessels, and nerves are liable to variation, and that some of these variations closely resemble the normal condition of the parts in monkeys and other animals? At any rate, while personally interested in this very matter, and while advocating the incorporation of a certain amount of instruction upon such topics into a complete *preliminary* medical education, I should deplore the devotion to them of any of the lectures of the regular medical course.

Upon this point the following remarks have lately been made by Prof. Cleland, of Galway, himself an eminent comparative anatomist, as well as teacher of human anatomy in a medical school:

"There can be no doubt that a great and curious influence has been exercised on morphology by the rise of the doctrine of the origin of species by natural selection. Attention has thereby been directed strongly for a number of years to varieties; and probably it is to this doctrine that we

owe the larger number of observations made on variations of muscles, nerves, and other structures. Particularly elaborate have been the records of muscular variations, very praiseworthy, interesting to the recorders, very dry to most other people, and hitherto, so far as I know, barren enough of any general conclusions. So much the more credit is due to those who have worked steadily, in faith that beauty will emerge to gild their results some day" (13).

I regret that upon this matter my views do not altogether accord with those of my friend Prof. Allen. His position as teacher of comparative anatomy in a large medical school must afford far better opportunities than mine have been for observing the degree in which such instruction is useful to the average student. But my own experience and observation of others in several schools compel me to the conclusion that such instruction should either be received before entering the school, or, after entrance, rigidly restricted within very narrow limits, according to the practical advantages derivable therefrom.

This, as I understand his address in connection with his previous utterances upon the subject, is essentially the opinion of Prof. Huxley. Billroth's recommendations look in the same direction. And it gives me pleasure to quote, with his permission, from a personal letter from Prof. Allen, that he thinks "the medical student should have a general knowledge of biology before beginning his studies."

Perhaps I cannot better illustrate the extent to which, as a comparative anatomist, I believe the study of comparative anatomy should be limited in a medical course, than by a quotation from one of the oldest and most experienced as well as the wittiest of anatomical teachers.

He said, ten years ago:

"Is not the question why our young men and women so often break down, and how they may be kept from breaking down, far more important for physicians to settle, than whether there is one cranial vertebra, or four, or none?

"'But I have a taste for the homologies. I want to go deeply into the subject of embryology. I want to analyze the protonihilates precipitated from pigeon's-milk by the action of the lunar spectrum! Shall I not follow my star? Shall I not obey my instinct? Shall I not give myself to the lofty pursuits of science for its own sake?'

"Certainly you may, if you like; but take down your sign, or never put

it up. That is the way Dr. Owen and Dr. Huxley, Dr. Agassiz and Dr. Jeffries Wyman, Dr. Gray and Dr. Charles T. Jackson, settled the difficulty. We all admire the achievements of this band of distinguished doctors who do not practise. But we say of their work, and of all pure science, as the French officer said of the charge of the six hundred at Balaklava: 'C'est magnifique, mais ce n'est pas la guerre!'—it is very splendid, but it is not a practising doctor's business. His patient has a right to the cream of his life, and not merely to the thin milk that is left after Science has skimmed it off. The best a physician has is never too good for his patient." (Holmes, 5, 29.)

The following is likewise to the point under consideration:

"'I suppose I must go and earn this —— guinea,' said a medical man, who was sent for while he was dissecting an animal. I should not have cared to be his patient. His dissection would have done me no good, and his thoughts would be too much upon it. I want a whole man for my doctor, not a half one. I would have sent for a humbler practitioner, who would have given himself entirely to me, and told the other—who was no less a man than John Hunter—to go on and finish the dissection of his tiger. (Holmes, 5, 25.)

"Medicine is my wife, and Science is my mistress," said Dr. Rush. And Dr. Holmes adds, "I do not think that the breach of the seventh commandment can be shown to have been of advantage to the legitimate owner of his affections."

Let not the wit at which we smile prevent our reflection upon the solemn truth of this commentary. To the honorable physician science should be a kindly, helpful friend, but nothing more—unless, that is, he openly proclaims a separation from his profession.

IV. *When should this instruction be given?* It is necessary to repeat, that our object is to make competent *doctors*, not thorough comparative anatomists; also that, as to his body, man is a very peculiar and highly specialized mammalian vertebrate. In fact, so far from being in any respect a type of either vertebrates or mammals, he is, morphologically speaking, a monster.

While, therefore, the final end of medical education is a knowledge of the structure and functions of the human body, all the considerations hitherto advanced indicate the desirability of *preceding human anatomy by comparative.*

True, the custom is almost always the reverse, as has been stated in a late introductory lecture. "First, the student be-

comes acquainted with the structure and functions of the human subject, the subject of his future practice. Secondly, knowing one animal well, he is in the best position to proceed to the study of others, and so to comparative anatomy and physiology."

Fully admitting the truth of the clause, "Knowing one animal well, he is in the best position to proceed to the study of others," I hold that the general idea of the passage quoted is just contrary to what should be entertained respecting medical education. For the real object of the student is the anatomy of *man;* and for him to study human anatomy before comparative anatomy, is, in common language, to "place the cart before the horse."

But if, before undertaking the study of the human body, it is necessary to dissect an *Amphioxus*, a frog, and a cat; and if the examination of the human heart is to be preceded by dissection of the heart of a sheep; and if the human brain cannot be readily understood without previous study of the brains of frog, rabbit, cat, and monkey; and if, moreover, the performance of this preliminary work involves familiarity with the use of the microscope as well as of ordinary dissecting-instruments, it may well be asked: 1. When is time to be found for it all? and 2. Where are there offered any opportunities for its accomplishment?

In the United States the chief prerequisite to graduation in medicine is attendance upon two full courses of lectures upon the fundamental branches. These courses vary in length from four to nine months; the more usual period is between five and six months. We are not here concerned directly with the facts that in the profession, and before the law, forty lectures upon physiology, for instance, are accepted as equivalent to eighty lectures in another institution; and that, as stated in an editorial in the *Boston Medical and Surgical Journal* for April 27, 1876, p. 491, "at the ——— ——— Medical School any enterprising young man may, by a series of ingenious devices, obtain, at a merely nominal price, a medical diploma within the short space of nine months." What I wish here to insist upon is, that the two medical sessions are *already too full*, and that the introduction of comparative anatomy

would require either the omission of some subjects, or the reduction of the time now devoted to them.

Probably there is no respectable graduate, of ten years' standing, from any American medical college, who would not, if called upon to express an opinion wholly irrespective of its effect upon public sentiment, or upon the school with which he happens to be connected, affirm that the present term of instruction is too brief. This idea is the burden of nearly every impartial discussion of medical education; it has been forcibly expressed by Gould (6), by Reeve and McCook (7), by Wood, and others. The last announcement of the Medical Department of the University of Michigan contains the following significant paragraph:

> "The time usually spent in American medical colleges—always too short—is now entirely inadequate to that full, thorough, and repeated presentation of the subjects required in a proper medical education."

Finally, in a speech upon scientific education, Prof. Huxley has sharply questioned the sufficiency of the four or five years' course in English medical schools, holding that, "in nine cases out of ten, the first year is spent in learning how to learn" (4). It is obvious that, if this criticism is merited, it applies with greater force to the much shorter courses in our own country.

It may be suggested, by some who admit the value of comparative anatomy to the medical student, that a few hours might be diverted from human anatomy to the exposition of some animal structures. But this does not meet the requirements. The necessary information and training, especially the latter, cannot be gained in a few lectures, or even from lectures at all! What the student needs is an intimate, personal, and practical acquaintance with the organization of certain animals, so that he may thereby more readily and fully comprehend the human body, and profit by didactic instruction in human anatomy.

In the second place, even were the professors of anatomy willing to yield a portion of their time (and it is obvious that any such change does not commend itself to a professor under the usual system of our schools), I should urge that the

time so gained be given, not to comparative anatomy, but to physiology, and especially hygiene.

Now, I cannot claim to be wholly exempt from that form of human weakness which, in a council of war for the defense of a town, induced a tanner to declare that "for the building of fortifications there is nothing like leather;" and I hasten to escape the imputation of interested motives by the solemn affirmation that, although the words of physiology are on my lips, my heart belongs to comparative anatomy.

In passing, I may here express the opinion that the progress of students would be facilitated if the anatomical course should commence with the viscera instead of with the bones and muscles, following thus the order naturally adopted in the physiological course.

Since it is doubtful whether any additional studies can be embraced within the regular medical courses; and since, for many, if not most purposes, the comparative anatomy should precede the human anatomy, the question arises whether its study may not profitably be pursued before entrance into the schools.

It is now required, in the United States, that at least three years[1] be spent "in the study of medicine," under the direction of some regular practitioner or graduate.

If common report be true, the certificates respecting this period of study are sometimes equally trustworthy with those for "good moral character." The schools, however, rarely "go behind the returns," in order to ascertain just how this time has been spent.

At best, the student has "read anatomy," studied "the bones," and accompanied his preceptor upon his visits. Perhaps the first two occupations are not altogether unprofitable, though they are apt to be carried on in a leisurely and unsystematic way. But as to the last, I venture to express the belief that it represents time worse than wasted; that it is positively injurious, as tending to give the youth confidence in the powers of his *art*, before he has learned the *science* accord-

[1] It is stated that five years are required in Russia and Austria, and four in Germany. Billroth thinks five should be the minimum period of medical education (3, 580).

ing to which the art may be safely practised. Certain rules and formulæ crystallize into a therapeutic bed of Procrustes, from which his patients vary at their deadly peril. In no profession is a "rule of thumb" so totally out of place.

If, as is now generally admitted, diseases are perversions of normal functions; and if the investigation of any subject should proceed from that which is simple and regular to that which is more complex, then, upon the same ground that the study of the human brain should begin with that of the frog, the study of disease should be preceded by the prolonged observation of normal physiological phenomena. The study of medicine should commence without the mention of medicine or of disease.

The graded course of the Harvard Medical School[1] includes in the first year only anatomy, physiology, and chemistry; and a recent editorial in the *Medical Times and Gazette* (October 7, 1876, p. 418) urges that, partly for lack of proper preparation, neither the first nor second year students ought to visit the hospital wards. *See* also Gould (6, 8).

Why, then, should not the student spend some portion of his pupilage, not occupied in the exercises of the schools, *in biological work?* His preceptor may not be especially prepared to guide his labors, but this need not now be a serious impediment. Within the past two years there have appeared two little books, Huxley and Martin's "Elementary Biology" and Foster and Langley's "Practical Physiology." They are small and inexpensive. The medical student may be obliged to omit some portions of the biology, but together they form the most advantageous introductions to both medical and natural history studies which have ever been published.

Most of the work described in these two volumes may be accomplished by the student alone, if he be reasonably earnest and intelligent. But why, in every large town, should there not be formed a laboratory under the direction of one or more practitioners, wherein such work might be done by several students, and with the advantages of better material, micro-

[1] Graded courses have been more or less fully adopted in the Universities of Michigan and Pennsylvania and the Medical School of Maine.

scopes, and other apparatus, than could be afforded by single individuals? A year so spent, and in the study of a certain amount of chemistry, anatomy, physiology, and hygiene, would be worth far more than the same time devoted to all the medical sciences together, to the compounding of prescriptions, or to the service of a practitioner.

Particularly advantageous would it be to establish such a laboratory in connection with a medical school, or with a university possessing a medical department.

As an indication of the extent to which such instruction is desired, I may give some statistics respecting the anatomical laboratory of Cornell University, premising that my own inclinations are toward pure zoölogy rather than physiology, and that there is no medical department connected with the university.[1]

During the eight and a half years since the opening of Cornell University, nearly one hundred students have worked in my laboratory. Of these, about one-third were preparing to become teachers, or professional naturalists; the remaining sixty-seven have since entered medical schools, or are intending to do so. There is abundant evidence that such students are much better able to profit by their later medical training, and that, upon graduation, they more readily obtain positions of honor or profit in their profession.

Doubtless the same is true of students who have been thus prepared to study medicine in the laboratories of other institu tions.

I am not aware, however, that the need of a preliminary education especially adapted to the medical student has else where been so fully recognized as to lead to the arrangement of a separate curriculum, like the Natural History course in Cornell University.

The following summary of this course shows that, while studies for general culture are not excluded, four-fifths of the

[1] It is to be hoped that no proposition to establish a new medical school will be entertained, unless it include the assurance of an endowment such as may warrant an elevation of the standards for admission and graduation far above the present general level.

time is devoted to the sciences and to laboratory practice, including drawing.[1]

SUMMARY OF THE COURSE IN NATURAL HISTORY AT THE CORNELL UNIVERSITY.

REQUIREMENTS FOR ADMISSION.

1. English grammar.
2. Arithmetic.
3. Algebra through quadratics.
4. Plane geometry and trigonometry.
5. Latin (Allen's "Reader").
6. Greek (elementary).
7. Physiology (elementary).
8. Elementary French or German.

Four Years' Course.

	Exercises.	Actual hours.
General culture	552	
Physical sciences (including geology)	662	
Botany	282	
Zoölogy	502	
Total	1998	
Laboratory practice, including drawing[2]	546	1365

Studies for general Culture.

	Exercises.
French and German	352
English language and rhetoric	140
History of science	24
Free-hand drawing	36
Total	552

[1] It is to be hoped that, ere long, children shall learn to draw before they write; and that the practical value of the ability to make an outline diagram will be more fully recognized by not only naturalists but physicians, if only as an *auxiliary to practice*. The patient desires to learn where his trouble lies, and in what it consists. He is too ill, perhaps, or too anxious, to understand the language of the physician, even though the latter be clear in his idea and his expression. But a simple drawing may be intelligible to almost any one; and he who can make the drawing is understood, and, consequently, appreciated.

[2] An exercise requires two and a half hours of actual work.

Physical Sciences.

Physics	260
Chemistry, lectures	60
" laboratory practice	60
Geology and paleontology, lectures	96
" " " laboratory practice	186
Total	662

Biology.

Botany, general lectures	86
" lectures, and laboratory practice	122
" laboratory practice on special groups	74
Total botany	282
Physiology and hygiene, lectures	42
" laboratory practice	60
Zoölogy, lectures	30
" laboratory practice	80
Comparative anatomy, special lectures	20
Anatomy and physiology of domestic animals [1]	60
Medicine and surgery of domestic animals	100
Preparation of thesis, and laboratory practice in anatomy and physiology	110
Total zoölogy	502

Doubtless the foregoing course is open to criticism; and I hope that a place may be found for instruction in logic, the omission of which from the ordinary medical curriculum has, as pointed out by Prof. Dunster (8, 10), led to the most unwarrantable conclusions respecting the utility of a given method of treatment.

In speaking (1, 12) of the advantages of preliminary training in botany, chemistry, and physiology, Prof. Huxley says, "I believe we may consider it as practically doubling the time of professional study."

Sooner or later the demand will be made for the allowance of time so spent as equivalent to part of the three years of study. While it may be well to accede to the demand for the present, and to a certain extent, there can be no doubt that the best interests of the profession and the public will be subserved by gradually requiring of all students an extended

[1] For this, and the twe following studies, the student intending to become a *naturalist* may substitute work in botany or geology.

preliminary education in all branches which are directly subsidiary to the medical sciences.

It is to be regretted that the Articles of Confederation proposed to be conformed to by the American Medical College Association do not yet refer to the topic of preliminary medical education.

Meantime, for how long is to be allowed to continue the condition of things described in the following passage?

> "Any young man without mental training, without the slightest classical or scientific acquirement, without even a respectable English education, can enter upon the study of medicine unquestioned, and pass every portal leading to the profession unchallenged" (7, 14).

Consequently, while the professional schools are commonly supposed to stand upon a higher plane than the colleges, it is notorious that he who fails to pass the examination for entrance to the freshman class in a college may commence the study of medicine without impediment.

It is obviously the duty of the older and more flourishing schools to set the example in respect to requirements for admission. This has been done by a few,[1] but at the close of the opening paragraph of the last announcement of one of the largest New York schools are the words, "No PRELIMINARY EXAMINATION IS REQUIRED."[2]

So high, so noble, so responsible is the office of the physician, that entrance to the medical profession should be more difficult than to any other. And the non-preparation, or even mal-preparation, of the average candidate for his sacred calling of saving life is only to be compared with the non-preparation, or even mal-preparation, of the average parent when he performs the act of initiating the existence of a new human being.[3] And as, in consequence, the troubles of many people began nine months before they were born, when no one

[1] Harvard, Michigan, and, more recently, Pennsylvania.

[2] In contrast to this, I take pride and pleasure in stating that the Medical School of Maine, a "country school," this spring refused admission to several applicants, in consequence of failure to pass an entrance-examination.

[3] On this matter, *see* the conclusions of Prof. Law (15).

thought anything about them, so the conditions which determine the success or failure of the physician are too often determined long before his proper medical studies commence.

It may be urged that the requirement of entrance-examinations upon so many subjects will, at any rate primarily, lessen the revenues of the schools, and diminish the number of physicians. No doubt these are conclusions logically sound, but unattractive. Abstractly they commend themselves, but practically they fail to harmonize with the desires of the natural man both for flourishing schools and for a numerous and powerful profession.

To answer these objections in full would unduly extend this article. In brief, however, I will say that the schools should be *endowed*, as are ordinary institutions of learning; that the doctors should be fewer, but more competent; and, finally, that the public should be much better educated in physiological and hygienic matters, so as to avoid disease, and thus require less medical attendance.[1]

My conclusions may be stated briefly as follows:

1. Comparative anatomy, as usually understood, is the study of the structure of vertebrates.

2. In addition to uses common to all branches of natural history, comparative anatomy presents special advantages to the medical student. It forms a convenient and economical introduction to human anatomy, enabling the student to acquire skill of manipulation, and familiarity with organs and their names.

3. In particular, the comprehension of the general arrangement of organs and of their structure may be greatly facilitated by a previous examination of corresponding parts of simpler forms, especially the *Amphioxus*, the frog, the cat, and monkey.

4. Comparative anatomy for the medical student should be restricted to such forms and topics as may aid his special studies.

5. The courses of lectures in most medical schools, espe-

[1] These questions were discussed at some length in the lecture as delivered.

cially in the United States, are already too short, and afford no time for extended or systematic instruction in comparative anatomy. But it might well occupy some part of the time of medical pupilage which is not passed in the schools. Still better, it should form a prominent element of a *preliminary medical education.*

6. The preliminary education of medical students should be *general* and *special*. *General* in respect to mathematics, drawing, English, logic, French, and German, with a small amount of classics, and the sciences, especially biology; *special* in respect to more extended practical work in the comparative anatomy of vertebrates, including training in the methods of anatomical manipulation and physiological experimentation.

7. On many accounts it would be advantageous to extend the medical curriculum so as to bring the special training above described under the direct supervision of the medical faculty.

8. The elevation of the standard of medical education demands: *a*. High requirements for admission. *b*. Lengthening of medical terms to nine months, not so much in order that more may be taught, as to allow time for digestion and assimilation of what is already presented in four, five, or six months. *c*. Systematic gradation of studies, and exclusion of first-year students from clinics and hospital-wards. *d*. Increase of time for instruction in physiology and hygiene. *e*. Endowment of the chairs, making the salaries independent of the number of students or of graduates. *f*. Separation of the teaching-body from the licensing-power, the latter being under central and national control.

9. Finally, to return to the original question, if it be asked whether systematic instruction in comparative anatomy should be included in the two courses of lectures now required for graduation in most American medical schools, I would answer, unhesitatingly and emphatically, "No." But if it be asked whether this same instruction should be received at some time before graduation, I would answer, "Yes, and a great deal else which is not now required."

WORKS AND PAPERS REFERRED TO.

References are made upon the following plan: The figure after the name of the author designates the number of the work upon this list. The last number denotes the *page*, and the middle number, when there are three, indicates the volume.

1. Huxley, T. H.—On University Education. Address delivered at the formal opening of the Johns Hopkins University. Delivered at Baltimore, Md., September 12, 1876. Reported in the *New York Tribune* for September 13, and reprinted in the *Tribune Extra*, No. 36, pp. 7–14.

2. Allen, Harrison, M. D.—Criticism of Prof. Huxley's Views respecting the Value of Comparative Anatomy to Medical Students. Letter to the *New York Tribune*, about October 1, 1876.

3. Billroth, Theodor.—Ueber das Lehren und Lernen der medicinischen Wissenschaften an den Universität n der deutschen Nation, nebst allgemeinen Bemerkungen über Universitäten. Eine Culturhistorische Studie. Pp. 500. Wien, 1876. (Review in *Medical Times and Gazette*, November 11 and November 18, 1876, to which references are here made.)

4. Huxley, T. H.—Lay Sermons, Addresses, and Reviews. Pp. 378, 8vo. New York, 1871.

5. Holmes, O. W.—Teaching from the Chair and at the Bedside. An introductory lecture delivered before the Medical Class of Harvard University, November 6, 1867. Printed at the request of the Class. Pp. 45, 8vo. Boston, 1867.

6. Gould, A. A.—Search Out the Secrets of Nature. The annual address before the Massachusetts Medical Society, June 27, 1855. Pp. 56, 8vo. Boston, 1855.

7. Reeve, J. C., and McCook, G.—Report of the Committee on Medical Education. "Transactions of the American Medical Association," 1869. Pp. 30, 8vo. Philadelphia, 1869.

8. Dunster, E. S.—The Logic of Medicine. An address delivered on the occasion of the Twenty-fifth Anniversary of the New York Academy of Medicine, December 30, 1872. *New York Medical Journal*, March, 1873. Pp. 31.

9. Dunster, E. S.—The Relations of the Medical Profession to Modern Education. An address delivered at the commencement of the Medical Department of the University of Vermont, June 16, 1869. *New York Medical Journal*, December, 1870. Pp. 25.

10. Cotting, B. E.—Disease a Part of the Plan of Creation. The annual discourse before the Massachusetts Medical Society, May 31, 1865. "Medical Communications of the Massachusetts Medical Society," vol. x., No. 5, 1865. Pp. 45.

11. Bigelow, Jacob.—Self-Limited Diseases. The annual address before the Massachusetts Medical Society, May, 1835.

12. Mulheron, J. J.—Annual Address before the Wayne County (Mich-

igan) Medical Society, July, 1876. *Peninsular Journal of Medicine*, July, 1876.

13. Cleland, John.—Address to the Anatomical and Physiological Section (Department of the Biological) of the British Association, August 25, 1875. Pp. 9.

14. Maudsley, Henry.—The Medical Profession in Modern Thought. Introductory lecture at University College, London, October 2, 1876. *The Popular Science Monthly*, January, 1877, 330–348.

15. Law, James.—Hereditary Entailments in Domestic Animals, and in the Human Family. "Public Health Papers of the American Public Health Association," vol. ii., 1875. Pp. 18.

16. Huxley, T. H.—On the Study of Biology. A lecture delivered at the South Kensington Museum, December 16, 1876. *Popular Science Monthly*, March, 1877, 527–542.

17. Huxley, T. H.—Manual of the Comparative Anatomy of Vertebrated Animals. New York, 1872.

18. Huxley, T. H.—Universities—Actual and Ideal. Inaugural address of the Lord Rector of the University of Aberdeen, February 27, 1874. *The Popular Science Monthly*, May, 1874, 46–66.

19. Huxley, T. H.—On Elementary Instruction in Physiology. A paper read at the Domestic Economy Congress, July 17, 1877. *Nature*, July 19, 1877, 233, 234.

20. Krause, W.—Die Anatomie des Kaninchens, in topographischer und operativer Rücksicht. Pp. 271, 8vo, with 50 figures. Leipsic, 1868.

21. Morrell, G. H.—Supplement to the Anatomy of the Mammalia, containing Dissections of Sheep's Heart and Brain, Rat, Sheep's Head, and Ox's Eye. 8vo, pp. 269. London, 1872.

22. Bucknill and Tuke.—Manual of Psychological Medicine. 1856.

23. Wilder, B. G.—Is Nature Inconsistent? *The Galaxy*, April, 1876, 437–447.

24. Wilder, B. G.—Gar-pikes, Old and Young. *Popular Science Monthly*, May and June, 1877.

25. Wilder, B. G.—Bats and their Young. *Popular Science Monthly*, October, 1875. Pp. 12, 11 figures.