at any stage. I understand also that botanists are by no means agreed to accept the Myxomycetes as veritable plants. One cannot but ask, Have we not here organisms which connect the two kingdoms? Certainly, in using the above definitions in teaching, it will always be easy to specify the one exception offered by the Myxomycetes and still leave a clear and available conception in the student's mind.

Other facts, which stand in the way of strictly upholding the two definitions, are encountered among animal parasites. For example, a tape-worm in the intestine does not apparently take up any solid food, but is nourished by absorption through the surface of its body of food material in solution. But in these cases we have evidently secondary modifications due to the parasitic life, and in the near relatives of the tape-worms, the trematods and planarians, solid food is taken up. It is to be remarked, too, that it is possible, though perhaps not probable, that even tape-worms will be found on more careful study to take up solid food.

The extent to which it has now been demonstrated that animals take up food in the form of discrete solid particles is not realized generally. The process has been observed with varying degrees of accuracy in the entodermal cells of the digestive tract of hydroids, ctenophores, planarians, trematods, annelids, crustacea, insects, amphibia and mammals, and probably in other forms, which have not come to my notice in this regard. There is here offered a rare opportunity for a valuable research, by making a comparative study of the absorption of solid food. That the protozoa take up particles by means of their pseudopodia is certainly one of the most familiar and most be-taught facts of elementary biology.

I believe that we can also safely teach that the absorption of solid particles of food is to be considered one of the most essential factors in determining the evolution of the animal kingdom. The plant receives its food passively by absorption, and the evolution of the plant world has been dominated by the tendency to increase the external surfaces—to make leaves and roots. The animal, on the contrary, has to obtain at least the solid part of its food by its own active exertions, and to the effects—through natural selection—of the active struggle to secure food we may, I think, safely attribute a large part of the evolution of locomotor nervous and sensory systems of animals. That it has been the only factor cannot be asserted of course for a moment, but it is presumably not going too far in speculative conclusions to look upon it as the most important single factor. An equally important rôle must be attributed to the taking of solid food in connection with the evolution of digestive organs, which are cavities which hold food material until it is absorbed by the cellular walls of the cavities. Indeed, we may expect to find that the entodermal cavity had originally no digestive function whatsoever, but was merely a receptacle to retain the food while the surrounding entodermal cells swallowed it at leisure.

With these speculations I will close, adding only that the speculations have in themselves little value, their only value being to suggest lines of research, which appear promising. The sober naturalist avoids the infernal dipsomania for sheer speculation, and in this article I have already yielded sufficiently to the temptation.

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## *THE BEST ORDER OF TOPICS IN A TWO-YEARS' COURSE OF ANATOMY IN A MEDICAL SCHOOL.**

Teachers of anatomy differ so widely in their views as to the most useful arrangement of the various branches of the subject

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that it is desirable to clear the field as far as possible at the very beginning of our discussion by the elimination of those points upon which there is substantial agreement. I assume that there is no diversity of opinion on the places which should be occupied by histology and topography. It is to my mind perfectly manifest that the student cannot profitably or comfortably receive instruction in gross anatomy until he has learned the elements of histology: has become familiar with the characters of the various textures which make up the parts and organs of the body, and to which, of necessity, references are constantly made in macroscopic anatomy. By identically the same method of reasoning the conclusion is reached that topography should be taken up latest of all; for it cannot be in a high degree useful to the pupil to work at the relations in space which different organs sustain to each other, until he has acquainted himself with the facts of their shape, size and consistency. To attempt descriptive anatomy without histological knowledge is comparable to studying architectural structures in perfect ignorance of the qualities of building materials, such as stone, brick, wood, iron and mortar; and to undertake regional, before being well grounded in systematic, anatomy is about as possible as reading sentences before acquiring words, or studying the relations of any other things without knowing something about the things themselves. Besides, there is a marked advantage in the incidental, but searching, review of every preceding portion of gross anatomy involved in the pursuit of typographical; and all teachers recognize the vast importance of such repetitions for the student, even if they do not admit that they themselves retain their familiarity with this science of innumerable details only by virtue of incessant review in one way or another.

There is certainly room for difference of opinion concerning the most advantageous marshaling of the remainder of the topics with which we have to deal; but our decision should probably be in largest measure determined by the circumstances in which it is necessary to pursue the study. If the pupil is to devote himself to anatomy only, no great objection is to be raised to the order of subjects adopted in the text-books in most common use—the order which, I think, the majority of teachers employ—beginning with osteology, and following in regular succession with arthrology, myology, angiology, neurology and splanchnology. Much can be said in support of this arrangement. The knowledge of vessels, their origins and terminations, can be of little avail, if there is not a precedent acquaintance with the muscles and other structures which they flush with nourishing blood, or drain of unneeded and effete material; and so, before undertaking angiology, we need especially to study muscles, which constitute so large a part of the human bulk outside of the great cavities, and in which are found so considerable a proportion of the tubes of supply and waste with which we have to deal in the practice of medicine and surgery. The nerves, too, cannot be studied to advantage without antecedent familiarity with the muscles, which are the objective point of their motorial function. In their turn, also, the active organs of locomotion are never learned unless there is a well-laid foundation of skeletal knowledge, upon which to build them; for, in absence of this basis, they are but impotent, flabby, almost shapeless masses of flesh, but little amenable to description, and quite elusive of comprehension. Arthrology is plainly out of the question without osteology, which should immediately precede it. The study of the viscera and organs of special sense concludes the series.

This arrangement is not altogether free from objections. For instance, even after

one knows the skeleton and the muscles clothing it, he finds in his study of the arteries much that he cannot fully comprehend from lack of acquaintance with the viscera. But no method can be absolutely perfect: one needs to know all of his anatomy—the whole of everything—in order to understand any one organ perfectly. The problem, therefore, for us, as teachers, is to discover that plan which reduces to the minimum this necessity of knowing a good deal of every department of our great science before entering upon the study of any one of them; and particularly the scheme which makes this need least conspicuous in the earlier portion of the course, when everything is new; for, since the growth of one's anatomical knowledge makes further acquisition in the same line progressively easier day by day, because he is all the time getting nearer to the goal of knowledge of the whole, the last part of the course is naturally that in which there is the least occasion for such help as can be derived from a wise order of topics. After all, however, the arrangement in question is useful, perhaps as good as any other, provided that there is an observance of the condition which I have attached to my commendation of it; but without this provision it seems to me to be clumsy, obstructive, wasteful and irrational.

The condition is that the student is attempting nothing else than anatomy. Practically this is a state of affairs which never obtains in the schools, and is not in the least likely to occur; always physiology is studied synchronously, and usually, also, general chemistry—the latter a branch with no more claim to be regarded as a legitimate topic of medical study than have botany and zoölogy, and, in all fairness to student, school and community, should be required as a preliminary to the medical course. We may confidently count upon finding the first-year student occupied equally with physiology and anatomy. Now, it is so obvious as to require no argument that the action of an organ can never be studied with complete satisfaction until its structure is well understood. Consequently, the anatomy of each part should be learned before its function is presented, in order that the pupil may work intelligently and be spared much difficult and unproductive effort. If the professor of anatomy does not aid him in this matter, the physiologist is driven to perform the task, although it is outside of the proper sphere of his work, and involves the expenditure of much time which he needs for affairs in his own peculiar field. The physiology which we most require is a knowledge of the offices of the viscera, and the teachers of this branch necessarily devote the greater part of their instruction to the consideration of the action of these organs, which, according to the conventional order of topics in the anatomical course, are not touched until all other portions of systematic anatomy have been disposed of. As a result of this, in the early part of the course the anatomist is teaching a vast number of things which are of the smallest possible help to the student of physiology; and, in almost the last part, he goes over ground which has been traversed long before by a suffering colleague, who has been forced into this unwilling usurpation by the unhappy arrangement of the anatomical schedule. In other words, a large and important (to my thinking, the most important) section of anatomy is not taught by the professor of this branch at a period when it is most urgently required by the student, and is presented by him long after it has been already learned.

Surely this state of affairs is, to say the best of it, deplorable, and should not be permitted to continue, if it can be abolished without injustice to the interests of the science to which we dedicate so much of our lives. Each one of us should bear con-

stantly in mind that he is not merely an instructor in a special branch, but is, besides this, a member of a faculty, the purpose of which is to give to medical students the most complete, well-rounded, professional education possible with the available means. On the old lines, which schools have followed far too long, and which are not yet abandoned by all institutions, every professor discoursed to the entire class—a higgledy-piggledy arrangement (perhaps derangement would be the more appropriate designation for so lunatic a scheme) which would not be tolerated for a week in a common school of the lowest grade. Gradually faculties are becoming converted to the idea that a grading of the course is essential to the best results; and those branches which are natural stepping stones to others are completed before advanced studies are undertaken. But much still remains to be done before the most useful system is formulated, and the part of this work which most concerns us is the proper adjustment of our topics to the needs of our colleagues who teach physiology. The plan which I am about to propose is designed especially to attain this end, and will be seen, I trust, to be the most advantageous in other respects, also. It is devised in the spirit which should actuate every individual in a body which is formed to accomplish a given purpose; each one is bound not simply to do these things which will make his department a success, but to do them in such a way as to promote the interests of every other chair. There should be perfect coördination in teaching—the faculty should work always as a 'team,' if a popular expression may be used. In no other way can the highest results be achieved.

In the first place I would have the anatomist ascertain the exact order of topics in the course of his physiological colleague. Let us suppose that the latter purposes, after a little time spent in necessary preliminary considerations, to conduct his class into the realm of the circulation. The anatomist will precede him by a day or two with the study of the organs by means of which circulation is performed. The structure of the heart will be presented with as much of detail as is requisite for the ready comprehension of its action, and this will be followed by the physiological anatomy of the blood vessels: the materials of which they are composed, the arrangement of these, and the variations in their proportions in the large, medium, and small vessels respectively; the physical qualities of the walls; the style of division and union: how the great arterial trunks branch and divide until the most diminutive twigs terminate in capillaries, and how the venous radicles begin in the midst of the tissues and by successive and innumerable conjunctions form larger tubes until the great tap-roots of the system are reached; in short, all those points which aid in the understanding of the function of these organs. He makes no attempt at this stage of the course to present the systematic anatomy of the arteries and veins; perhaps not a single vessel of the great multitude is called by name, except those which, being attached to the heart, must be specifically designated in order to make the description of that organ intelligible. He does not undertake to describe the relations in space which the heart and principal vessels sustain to the parts by which they are surrounded; for he knows that these relations might be very different without essential modification of their action, and that therefore they need not be introduced at this period of the curriculum. Thus, the students are well equipped to receive instruction on the circulation from the professor of physiology, and the latter is free to devote his energies entirely to the work which alone he should be expected to undertake.

This example is no more striking than any other; but it serves well to illustrate

on the physiological side the benefits coming from the adoption of the order which I advocate. In this manner the course proceeds; and no portion of the field is entered upon by the physiologist which has not been explored and surveyed as far as structure is concerned by the anatomist in company with the same set of pupils. After the study of the viscera, including the cerebro-spinal centres and the organs of special sense, comes the consideration of the remaining branches of systematic anatomy, beginning with the skeleton and proceeding in the conventional order.

That much advantage accrues to the class in physiology by the execution of this plan seems to me to be perfectly clear. That any anatomical sacrifice is made by it I do not believe. On the contrary, a distinct benefit is gained even in anatomy; for the learning of the function of an organ immediately after the study of its structure serves to emphasize and deepen the impression made by the earlier lesson, and quickens with a living interest what otherwise might remain in the mind only as dry and arbitrary fact, if, indeed, it did not lapse altogether from memory because of its lack of significance.

Incidentally, too, there results great profit of a practical kind, which is lost in following the common order. Students usually know less about visceral anatomy than about any other section of the science. This comparative ignorance depends upon three causes. The first is the fact that the ordinary text-books are far less accurate in the description of the viscera than in that of other parts—a statement which it is unnecessary to substantiate in this learned presence. Second, the study of the viscera is much more difficult than that of other parts. In their best estate they present appearances which are liable to be misleading even to the most careful and experienced observers, as witness the conspicuous errors which for generations passed muster regarding the form of the liver and the position of the stomach—points still misstated in some of the text-books of the day. But another obstacle is often more serious than this. If the organs are fresh, much that is valuable can be learned from them; but when they are the seat of advanced putrefactive changes, as often happens when the muscles and associated parts are still useful for somewhat prolonged examination, they must be removed speedily, without affording the slightest opportunity for careful observation. Third, as the subject of the viscera is usually placed last in the study of systematic anatomy, it is more likely than anything else to be slighted. We all doubtless know from observation, and some of us probably from personal experience, that the enthusiasm of a novice in a study rarely is sustained to the end. In fact, it may be said without incurring the imputation of exaggeration that a large majority of students in any class flag very noticeably towards the close of the term, however eagerly they may have started out. Unquestionably most medical men, young or old, know more about osteology than about any other branch of anatomy. The reasons of this are not far to seek. The skeleton is less perishable than the soft parts and hence the opportunities for the study of it are vastly greater; and, what seems to me to be of quite as deep significance, it is generally the first branch of our science which the student attacks. It is his memorable, first step inside the mighty and mysterious domain of medicine, and, consequently, every detail makes a powerful impression on his plastic mind. Although he sees that his book contains much besides osteology, this is the first and, by inference, the most important of its contents. The common people sometimes speak of a skeleton as an anatomy; and the young student almost deludes himself with the

notion that he knows the bulk of anatomy, when he has acquired a very general conception of the bones. Of course, his ideas are silly and childish, and have to be corrected; but we must take human nature as we find it, and, if possible, turn its very weaknesses into useful channels. Now, without having the smallest disposition to belittle the advantage of an accurate knowledge of the skeleton, it has long been a conviction with me that visceral anatomy should be ranked first in the list of topics, considered from the purely utilitarian point of view: that the subject of which our students generally know least is precisely that of which they ought to know most. They come to us in order to be equipped as practitioners. Whatever may be their callow aspirations, however much they may be dazzled and charmed by the brilliant performances of surgery, we and all of our colleagues know that the enormous majority of them must be general practitioners, doing almost no surgical operations, except the strictly minor; having a great many obstetric cases; seeing a multitude of sick infants, a good many ailing women, and not a few acutely ill adults of both sexes. What is the greatest anatomical need of such men? Is it not undeniable that, for one case demanding in them a knowledge of bones, muscles, blood vessels or nerves, they have at least a score in which they must know something definitely about the structure of lungs, heart, stomach, bowels, liver, kidneys, uterus or brain? If, then, visceral anatomy far surpasses all other portions of the field in importance to the enormous majority of practitioners of the healing art, it should be placed first chronologically in the course of systematic anatomy, so that it shall be taught at the time when the learner's mind is most eagerly receptive and most faithfully retentive—provided, of course, that this assignment of position does not conflict with the rights of other things. Unless my argument has utterly miscarried, it is established that the proposed order not only does not sacrifice anything on the physiological side, but is even of conspicuous advantage to it; and I have been unable to discover any way in which it can affect unfavorably the welfare of any department whatsoever. There is no occasion for anxiety lest the postponement of osteology will result in its being ignored or slighted. The facilities for its study are so comparatively abundant, the conventional conception of its importance is so deeply rooted, and the natural and inevitable attraction which it exercises on the student is so strong as to insure the bestowal upon it of a sufficient share of his attention.*

With me the order advocated is not merely a theory: it is a long accomplished fact. For about fifteen years I have had the plan in practical operation, and have not yet observed a single thing which has caused me to regret the change from the ancient system. It appears to me now, as in the beginning, to be the most rational, economical, facile, attractive and useful succession of topics. During this prolonged trial of the order I have had as fellow-members of the Bowdoin faculty in the chair of physiology three gentlemen, of whom two, Drs. B. G. Wilder and C. D. Smith, are members of this Association, and can testify as to the usefulness of the plan.

*It would be foolish to disparage the cultivation of any portion of the field of human anatomy; the more thoroughly the physician knows every part of it, the better equipped will he be as a practitioner. Vastly more blunders than are ever recognized depend upon ignorance of easily known facts of structure. But the tremendous insistence upon the supreme value of osteology, which characterizes the method of some teachers of anatomy, seems to me to demonstrate a lack of sense of proportion, which, while easily enough accounted for by the student of medical history, who appreciates also the dominating (sometimes almost domineering) influence of habit and suggestion upon the mind, is none the less peculiarly unfortunate in its effect.

The third, Dr. Henry Hastings Hunt, has within a month ceased from his labors, and been borne to his honored grave; but I feel justified in giving his testimony emphatically in its favor.

My plan, slightly detailed, is as follows: Beginning with some explanations of a general character, and the definition of certain terms which are so technical that the novice cannot be expected to know them, I give the names, both English and Latin, and the limits of extension of all of the superficial parts; for I have learned that it is not safe to count on anybody's knowing what an anatomist or surgeon means by various terms applied to parts which are visible without dissection, and have vernacular appellations. Histology is then presented in an elementary way, and the student is taught the essential truths about the simple tissues. The different kinds of membranes are discussed, and the structure of glands in general is naturally given the next place. The student is now fairly equipped for the study of the viscera, and these are taken up in whatever order the physiologist of the institution prefers. In one important particular my course at this period differs from visceral anatomy as presented in most of our books; the brain and spinal cord, the noblest and most interesting of all entrails, are included in the company of the viscera, and not, as ordinarily in the text-books, with the nerves. After this come in regular, conventional style the bones, ligaments, muscles, arteries, veins, lymphatics and nerves; and, last of all, topographical, or, as I prefer to call it, relational anatomy.

In this scheme no separate place is assigned to embryology, a subject usually treated in obstetrical and physiological works, as well as in anatomical. By agreement with my colleague in physiology, its systematic presentation is made by him; but all through my course the facts of development are introduced, not only to inform the student upon points of practical moment, but also to illustrate and enforce many features of adult structure.

At the end of his first year in the school the student is required to pass a satisfactory examination in histology, splanchnology, and osteology, and he is not permitted to enter upon second-year studies until he has so passed. At the end of his second year he is examined on the remainder of systematic and all of relational anatomy, failure excluding him from his third year.

It will be observed that I have confined my remarks strictly to the subject announced, and have refrained from discussing the relative merits of various methods of imparting instruction, as by lectures, recitations, demonstrations, and so forth. I wish it to be understood, however, that, if any expression of mine has seemed to imply that the old-time method of teaching by lectures holds the first place in my esteem, I have unwittingly done an injustice to a cherished conviction; for the lecture system, as an exclusive, or even principal, method of instruction, has long seemed to me to be the worst which has been devised.

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*CURRENT NOTES ON PHYSIOGRAPHY (IV).*

MERRIAM ON THE DISTRIBUTION OF ANIMALS AND PLANTS.

A study that is admirable, alike in its quality and its results, has been presented by Dr. C. Hart Merriam in a vice-presidential address to the National Geographical Society of Washington, under the title, 'Laws of temperature control of the geographical distribution of terrestrial animals and plants' (Nat. Geogr. Mag., VI., 1894, 228–238). The life zones of the United States, as mapped two years ago (Ann. Rep. Sec'y Agriculture, 1893), are now shown to be limited northward by the total quantity of heat during the season of growth and re-