

your minds eye the keen struggle for existence. * * *

* * * Here you have before you the methods and present aims of paleontology; it is the history of the world in the period which is mistakenly called prehistoric; it is your history and mine when our ancestors were struggling upwards in the long ascent of man. Every broad, serious, honest contribution to paleontology will constitute a word, a line, a chapter in the final history which our descendants will complete.

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*BIOLOGY AS AN ELEMENT IN COLLEGE
TRAINING.**

COURSES in natural science under the head of biology are a comparatively recent feature in our college programs. They may be described in general terms as consisting of a comparative study of certain types of animal and vegetable life with reference to their functions as well as their structures. Strictly speaking biology is in no essential respect a new subject. Nevertheless the term is a useful one, and courses in general biology differ in several important, if not essential respects, from those usually given under the title of zoology or botany or natural history. In the first place, these courses, as given in our colleges, endeavor to present the salient facts with regard to the properties of living things from a common or general standpoint. They attempt to bring into the foreground the resemblances as well as the differences in structure and function among varied forms of life belonging to both the plant and the animal kingdom. The intention is to give a bird's-eye view in which the general plan shall be made evident, and fundamental relationships shall be emphasized. A student

who has acquired this point of view is prepared to appreciate discussions of the great general laws of biology, or, if need be, to enter more carefully upon a closer study of details.

But, in addition to this feature, courses in general biology are characterized by the emphasis laid upon the functional manifestations of living matter, by a presentation and discussion of the great questions of nutrition, heredity and reaction to environment.

In other words, the physiological point of view is brought out more prominently, if I mistake not, than is the case in the customary courses in botany or zoology. For these reasons a course in elementary biology has a special value, which has been recognized and has led to its very general introduction into our colleges. In a proper sequence of biological studies its place falls naturally in the college period. It should be preceded, preferably in the secondary schools, by an out-door study of the forms and life-histories of familiar plants and animals, and, on the other hand, should itself precede courses in botany or zoology or special professional training.

It is in this last respect that the importance of collegiate training in biology has been most widely recognized, that is, as a preparation for a future professional career, particularly the profession of medicine. Medicine on its scientific side falls into the group of biological studies, but as taught in the professional schools it concerns itself almost exclusively with a single, and that the most highly developed, form of life. The intelligent members of the medical profession have recognized freely that a general survey of the whole series of living types forms an excellent basis for the more special work of medical schools and medical practice, in that it gives a wholesome breadth of view and an educational training that may save its possessor from many

* Address delivered at Trinity College, Hartford, Connecticut, on the occasion of the opening of the Hall of Natural History.

a crude theory or foolish notion. It contributes, in other words, to that sound scientific foundation which is a characteristic of the well-educated physician. We find, therefore, in many or indeed in most of our colleges that courses in biology are arranged with special reference to the needs of those who expect to go into medicine. The value of this preparation is emphasized by the fact that in Great Britain all medical students are required to show evidence that they have had courses in elementary biology before entering upon their medical studies, and in this country one at least of our better schools makes a similar requirement. This intimate and recognized relationship to one of the most important professions is in itself a strong practical reason for the encouragement of undergraduate courses in biology in our colleges, for it is evident, I think, that the rapid increase in preliminary requirements now taking place in our medical schools will result in a corresponding increase in the number of those who, intending to enter medicine, will first prepare themselves by a college training. There will be in the future a greater demand from this source for biological instruction.

This relationship of biology to medicine is not, perhaps, wholly beneficial to biology, in that it tends in the minds of some to give to the subject a technical aspect which is inconsistent with pedagogical ideas of what should constitute the proper material for undergraduate study. On the contrary, it has always seemed to me that biological courses, of the kind I have in mind, are singularly well adapted to the purposes of a liberal training, that they possess both a culture and a training value entirely apart from their especial importance as a preparation for professional life. The educational value of biological work has been pointed out by many eminent writers. Huxley has summarized the arguments upon this point by showing that the work involved leads

necessarily to training in observation, in comparison and classification of facts, in deduction and verification, that is in those processes of thought which enter into the intellectual life of every man. The special feature of biological training, perhaps, is the exercise it gives to the power of observation; in this respect at least it possesses a distinct advantage over other means employed to develop the mind, and I fancy that few will dispute its supremacy in this regard.

But another important influence, from the standpoint of liberal training, which may be expected from a college course in biology is frequently overlooked. I refer to the culture value of biological studies in bringing one into an intelligent relation with life on its physical as well as its psychical side. To my mind this feature is emphasized by the frequent instances one meets of crass ignorance regarding the simpler processes of bodily life. By way of example, a friend of mine, a gentleman and a scholar, a linguist of international reputation, once remarked to me that he was suffering from a headache, and he thought it probable that the fumes from his liver had gotten into his head. Evidently my friend, like some other classical scholars, had imbibed his physiological information quite incidentally from very ancient sources. With respect to modern biological knowledge his position was not more advanced than that of Brother Jasper regarding the planetary system. So, too, I am informed upon good authority that an eminent divine in this country based a certain mystical theory of his own regarding spiritual phenomena upon the fact that after amputation an individual may experience sensations in his lost fingers or toes, a fact perfectly understood by any one possessing an elementary knowledge of physiology without recourse to far-reaching mystical views.

Curiously enough, deplorable ignorance of

this kind is frequently displayed by educated men without the least sign of compunction. In fact it is usually treated in a jocund way much as when one confesses his ignorance of the latest mode in garments or of other trivial affairs of life. One may infer from this attitude that a knowledge of biology is not widespread or highly esteemed among the educated people of our time, otherwise it would not be deemed expedient to treat this knowledge with the contempt of levity. The condition that actually exists recalls the state of affairs that prevailed some two or three hundred years ago, when "Many a pretty fellow, who was a wit, too, ready of repartee, and possessed of a thousand graces would be puzzled if he had to write more than his own name." The ability to write with moderate ease is widespread now, and not even the possession of a thousand graces, would save one from a sense of humiliation if he were deficient in the elements of an English education. It would really seem desirable that our colleges should provide against the possibility of their graduates entering life a thousand years or more in arrears in all that concerns vital phenomena. So far as I am aware it is possible for a man to go through college and be instructed in the wisdom of the ancients and the history of mankind, and yet be left in a condition of child-like ignorance concerning what is known of the most striking and important phenomenon of the universe, namely, living matter and its properties.

Next to living itself there is nothing, it would seem, that should so interest mortal man as that physical basis of life through which his living is effected and in such large part influenced and controlled. Biology seeks to discover what it may concerning this substance, its structure, the laws controlling its activity, its origin, its growth, its death. These are matters concerning which every intelligent man has a natural curiosity, and concerning which every educated

man ought to have some reliable information, so much at least as would enable him to appreciate the modern point of view and follow the trend of contemporaneous thought. A brief course in elementary biology meets this requirement where a course in natural history, so-called, would probably prove insufficient. The latter gives the large but external view of living nature, the former brings us into close contact with the inner structure of living matter, the medium of all the manifestations of life. On the other hand, those who have not had the advantage of some elementary instruction in biology will find that a large and important chapter in the revelations of modern science and the progress of modern civilization is written in a language which it will be difficult for them to comprehend.

When one considers the interest and importance of biology and its peculiarly intimate relations with the act of living, it becomes a fair question whether or not this side of knowledge should be represented in the course of study of every college student. It would seem to me that inasmuch as we are creatures of the senses, and must seek the foundations of our knowledge in the deliverances of the senses concerning the world without, the education of every individual should include some instruction concerning the animate as well as the inanimate world in which we find ourselves placed. He should possess some information about the means and method by which knowledge is acquired, and the external phenomena that are the occasion of this knowledge.

Moreover, the culture inculcated by natural science, both physical and biological, is a world culture that takes us back beyond the history of mankind and looks hopefully forward into the future expectant of greater and greater development. It is a culture too that we can share in common with all the sons of men, whether their classical tra-

ditions, the sources of their laws and customs and languages, are the same as ours or not. We must assume that it will become more and more important to educated men as the varied nations of the earth are brought into closer intercourse and a greater community of life.

Among the specific advantages that may be hoped from a spread of biological knowledge among the educated classes is an abatement of the surprising credulity that they often exhibit regarding natural phenomena. This credulity finds its most common manifestation in relation to diseases, their causes and their cure, and springs without doubt from ignorance of the elementary facts of biology. Men of ability and discrimination, of wide acquaintance with the affairs of life, or versed in the classical learning of the schools, are oftentimes as prone as a child or an untutored savage to be misled by the utterly irresponsible views of ignorant persons concerning the human body and its functions. From time to time in the history of medicine sects arise which propose to treat disease upon *a priori* theories that are as devoid of a rational basis as are the incantations of the Indian medicine-man. The dupes of these theories are not alone the ignorant and untrained, but frequently the well-educated. They are deceived by the shallow sophistries of quacks and charlatans, because, I fancy, the living body is to them what it was to the ancients, the seat of mysterious forces. About these mysteries they know nothing and, therefore, they are ready to believe almost anything, especially from the mouths of charlatans or self-deceived fanatics, because in the nature of things it is the latter classes that speak most positively and in the loudest tones of conviction, and such mannerisms carry much weight with most of us when we are upon unfamiliar grounds.

I am entirely willing to admit, of course,

that there are more things in heaven and earth than are dreamed of in our philosophy, but this is a very vague and unsatisfactory premise upon which to erect a working hypothesis of life. I am sure that in the practical and serious affairs of life it is much better to be guided by the knowledge that we have, incomplete though it may be, rather than by wild speculations about the knowledge that we have not. The wrecks of many fantastic beliefs scattered through the history of mankind bear witness to the wisdom of this rule of conduct. It would seem that the primitive mysticism that enveloped the healer's art still clings more or less to the profession of medicine. Those who practice the art to-day, whether legitimately or illegitimately, are supposed by many who should know better, to have acquired in some way the power to lift the veil that enshrouds the mysteries of life. It would be well for the profession as well as the public if this remnant of ancient superstition could be forever effaced, and practitioners of the art of medicine could be measured by the standards of knowledge and skill that apply to less occult callings of life. For naturally this factor is used chiefly by those who are least deserving of confidence, and to the undoing of a credulous public.

We may infer that the establishment of a rational theory and practice of medicine depends nearly as much upon an education of the public as upon the training of the physician. Education in the traditional humanities does not seem to be sufficient for it is well known that those who are provided with this culture may fall easy victims to the vagaries of quacks. One might suppose that instruction in the elements of human physiology such as prevails in many colleges and secondary schools would meet the need that I am describing. But seemingly this is not the case, and the reasons for the inefficiency of this kind of

instruction are very apparent to my mind. It has none of the virtues of first-hand knowledge. Human physiology as taught in our schools is good enough in its way, but it gives no real information of the nature and properties of living matter. Outside the fact that the instruction is usually authoritative and based upon book-work, it fails to develop an acquaintance with fundamental conceptions of the nature of the living processes, and these must be comprehended in some measure if one wishes to look at the living side of nature from the proper standpoint. It may very well happen that an individual has a fair idea of his internal topography, and yet believes firmly in mad-stones as a cure for hydrophobia, or the occult influence of horse-chestnuts in the coat pocket upon rheumatic conditions, or in some similar superstition that has come down from the age of witchcraft and sorcery. These last illustrations are perhaps extreme and not generally applicable to the college graduate, but if it were desirable it would be easy to give quite specific instances of fads and theories just as unscientific and irrational which do find lodgment among the educated classes.

As an antidote to this unworthy credulity I can imagine no more certain remedy than a course in biology, including some laboratory exercises. Not a great deal is required if the instruction is real and first hand. Any one who has examined into the minute structure of living forms and gained some conception of the nature of vital processes is effectively armed against the grosser fallacies that at present find some acceptance among even the educated classes. I do not mean to say that training of this kind is indispensable for an appreciation of the nature of biological conceptions, but only that by its means the whole subject is illumined and given a reality that otherwise could scarcely be hoped for. One sees the difference fully illustrated by

the attitude of the general public toward modern ideas of germ diseases and bacteria in general. How many absurdities and false notions are entertained by educated people regarding these latter forms of life!

The point that I wish to make is that in this day and generation the man or woman who goes out from college entirely uninformed on the biological side is ignorant of a very important phase of the world's history, is out of adjustment with his times, and is deprived of a most helpful means of controlling rationally his own health and that of others committed to his care. If this kind of knowledge is desirable at all as part of the armamentarium of an educated man, it is hopeless to seek for it elsewhere than in the college period. Much of the education necessary to put us into intelligent adjustment with modern life can be obtained in the secondary schools, but laboratory courses in biology can scarcely find a place so early in the scheme of instruction; they require some degree of maturity and previous training on the part of students, to say nothing of the paraphernalia requisite for actual instruction. Our college courses are crowded as it is, and perhaps it is not possible to include biology as a compulsory subject in the polymathic curriculum that is forced upon the student at present, but the opportunity at least should be freely offered. And indeed it is offered in a way in all good colleges. I only wonder that its general value is not more widely appreciated. Instead of being restricted practically to those expecting to enter the medical profession or looking forward to careers as specialists, it should be utilized by all who hope to keep abreast of the intellectual life of their times.

From a pedagogical standpoint biology is one of the most attractive subjects offered in the college programs. Outside any question of training value there are few if any subjects that lend themselves more

readily to good teaching. This peculiarity arises from the inherent human interest of the material it deals with, and by virtue of which it is easily possible to arouse the student to voluntary effort. The more I see of practical teaching the more I am convinced of the great influence that can be exerted by a teacher in this matter of stimulating the interest of students in his subject. Interest in one's work is like a brilliant light; it brings out numerous details that would be overlooked in the obscurer illumination that comes from an effort under compulsion or from a mere sense of duty, and by the same token the mental impressions produced under its influence are of a more enduring character. Real interest in one's work leads to voluntary exertion and to a concentration of attention, both of which factors produce excellent results, as regards the subject under study as well as in the matter of exercising and developing the potential capacities of the brain. I should be willing to defend this thesis purely on physiological grounds, although it is scarcely necessary, perhaps, since it seems to be fully appreciated in modern methods of teaching, particularly in the instruction of the young.

I am sure that those of us who are watching the education of our children must be struck with this fact. In former times the teacher, from the beginning, was often a task master, driving us to unwelcome labor, and when interest on the part of the pupil flagged he stirred up the circulation in the organs of thought by external applications of the rod. Learning and the rod, to use an often-quoted simile, were nail and hammer. The method was effective; temporarily, at least, it served as a means of concentrating the mind on the work in hand, but from the physiological standpoint the rod is a crude instrument, ill-adapted to mental culture. In these happier days the teacher is more frequently a friend endeavoring

by gentler means to arouse in his pupils a vivid personal interest in the subjects studied, and successful in his work in proportion to his ability to effect this result. In fact, I am inclined to believe that the power to interest his students in their work is the test of a good teacher. It makes no difference how well a teacher may know his subject, nor how skilled he may be in the technical side of his calling, if he has not sufficient enthusiasm and ingenuity to put life and attractiveness into his instruction he is not doing justice to his opportunities. No student is getting the full measure of information or mental discipline out of his course unless by the interest he takes in the subject, or by some other means, he has been led to exert himself voluntarily. I feel that this consideration is quite as important in university instruction as in kindergarten teaching. I am convinced that every teacher should exert himself to devise legitimate means of arousing the interest of his student, upon the theory that they will thereby be led to think and meditate for themselves. It is for this reason, mainly, that in the natural sciences we make such extensive use of ocular demonstrations. It is not often that these demonstrations are really necessary to the comprehension of facts; their value, so it seems to me at least, lies mainly in this, that they stir the sluggish mind, they bring the brain into a condition of receptivity and activity in which it is at its best as a physiological mechanism.

That this last statement is a matter of fact and not a mere figure of speech is indicated pretty clearly by laboratory experiments. It is well known to physiologists that mental exertion is accompanied by a greater flow of blood through the brain, and that, roughly speaking, the effectiveness and intensity of the brain work is proportional to the increase in the flow of blood. We have instruments in the laboratories by

means of which we can measure these changes in blood flow, and thus approximately determine the intensity of mental activity under different conditions. I need not here describe the instrument any further than to say that it consists of an apparatus for measuring the volume of the hand or arm. When the brain is working actively the arm shrinks in size, the shrinkage being due to a shunting, so to speak, of some of its blood to the brain. I have had occasion to use this apparatus repeatedly in my laboratory, and the results seem to indicate quite clearly that an important factor in bringing about increased circulation through the brain, and therefore probably an accompanying intensity of brain activity, is that of a high degree of interest in the subject of thought or discussion.

I may be permitted to describe one or two incidents which, though trivial in themselves, illustrate the point I am making. It happened on one occasion that a graduate student in my laboratory, a Catholic priest, was using this apparatus in the course of some investigations upon the physiological effects of pleasant and unpleasant sensations. In connection with his problem he made a number of tests of the effect of strong mental activity upon the circulation. In one of these experiments he had a young theological student in the apparatus and was putting him through an examination, with the result that the record showed some indication of increased mental activity. He had arranged, however, that while the experiment was in progress one of the young man's regular teachers should appear suddenly upon the scene and pretend to give him his final examination which was due at about that time. The ruse succeeded admirably; the student took the examination seriously and the effect upon his arm was so great that the apparatus was unable to record the full extent of its shrinkage. It was a capi-

tal illustration of the effect on the circulatory system of intense mental activity when accompanied by some degree of emotional excitement; or as a Methodist Bishop, to whom I was showing the record, expressed himself, it showed the serious effect that dogmatic theology may have on the extremities.

On another occasion, a colleague of the priest, who was himself an instructor in a theological seminary, was placed in the apparatus and subjected to an examination. The result upon his extremities was very slight. The truth was that he was on familiar grounds, he was as well acquainted with the subject as his interlocutor, and perhaps was a little weary of it. The experimenter, however, recalled that his friend was from Kentucky and began to ask some questions concerning the blue-grass region, the breeds of race-horses and horses in general. He was delighted to find that he not only got an enthusiastic and minute description of the region and its famous racers, but, that his apparatus gave most satisfactory indications that the sluggish brain had been fully aroused, and was working in its best form as regards the subject under discussion.

Many similar results obtained by other observers bear witness to the general truth that the element of interest is an important factor in stimulating brain activity, and so acting upon the vaso-motor centers as to put this organ under its most favorable physiological conditions for work. The brain that is but half aroused and interested is in fact partly unconscious. Much that it sees or hears fails utterly to awaken that chain of associations, that synthesis and comparison of memory records which forms the physical basis of mental growth and training.

It is possible, I believe, that this factor is not entirely appreciated in our college teaching. Some weight, indeed consider-

able weight should be given to it, not only in the individual work of the teacher, but in the construction of courses. I do not mean, of course, that in making the curriculum this consideration should have a predominating influence, but it should certainly be borne in mind. Other things being equal the subject that has the most intrinsic interest is likely to have the highest degree of training and developing value, and I feel safe in asserting that this virtue is possessed to an uncommon degree by the subject of biology. Its importance in illustrating the methods of scientific thought, and the practical utility in life of its subject matter are combined with an attractiveness that appeals to every intelligent person.

To have under the eye the primitive forms of life in all their strange and suggestive variations, to follow the development of an apparently simple and structureless ovum into a complicated and exquisitely constructed organism and to see these various stages in the individual history paralleled in nature by the slow phylogenetic growth of animal forms, to realize for one's self the community of structure and function that binds together all living beings, these things are of a nature to awaken interest in the minds of the most careless. Such at least was my personal experience as a student, and such has been my observation upon many classes composed of men with varied training and widely different purposes in life. Just as an elementary study of astronomy lifts one out of his self-sufficient narrowness and brings him face to face with great thoughts and problems, so an acquaintance with the teeming existence of the microscopic world leads us to a thoughtful, intelligent and humble consideration of the great mysteries of the universe.

The desirability of having some form of biological work represented in our college courses commends itself to my mind for

still another reason which has, I believe, some practical basis. I refer to the fact that during a man's college life it is necessary as a rule that some decision shall be reached concerning the character of his future career. There are some, doubtless, among our college students upon whose conscience the necessity of making this decision rests but lightly, by reason of the exuberant hopefulness and confidence of youth, yet upon the whole I fancy that few students in their senior year fail to give this serious subject much careful and anxious consideration. Motives of expediency or the advice of parents or friends frequently furnish the controlling factor in the decision to which he finally comes, but individually he must desire and seek for some light, from his own experience, regarding his personal fitness and adaptability for the various possible careers that lie before him. It is a sad business when the search is fruitless, and he stands at the parting of the ways, undecided, not knowing which path offers to him the greatest chances of happiness, usefulness and success. It seems to me that a student's college course should be of direct assistance to him in this matter of his life's work, not only in giving him a general training that shall send him forth equipped for competition with his fellows, and prepared to enjoy the usufruct of the world's intellectual inheritance, but specifically in throwing light upon the nature of his own talents. In some way this period of preparation and training should be adapted to enable the individual to find himself, to discover wherein lie his greatest interests and greatest possibility of success and happiness. For this reason it would seem to be a mistake if a department of knowledge so important and peculiar as biology is not brought in some way to the student's attention. It forms the gateway to at least one great profession which though overcrowded at present is in

reality suffering from the lack of men with college training.

If our colleges could turn into the profession of medicine those of their students who find within themselves a peculiar adaptability to its work, to take the place of the thousands of uneducated men who at present are attracted to it by commercial motives alone, they would accomplish a most useful work for humanity at large.

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THE OPENING OF THE HALL OF NATURAL HISTORY, TRINITY COLLEGE.

ON December 7th the new Hall of Natural History of Trinity College was formally opened.

The Rev. George Williamson Smith, D.D., President of the College, delivered the address of welcome, as follows:

"It gives me great pleasure to welcome

of chemistry and mineralogy, of agriculture and political economy, and of botany. A professor of natural philosophy was to be appointed at an early day. It was a radical departure from the college curriculum accepted at that time to give such a large place to scientific study, and the difference was increased by a provision that students could be admitted to 'pursue such *particular studies* as might be suited to their circumstances,' 'or as the inclination of their parents or guardians might require.' The additional announcement that 'if, in the end' of their association with the college, 'the amount of the attainments' of special students 'should be judged by the faculty to be equal to the knowledge acquired in the regular course, they might be candidates for the Degrees in Arts, which would be conferred on the students in that course,' is still regarded as revolutionary in most of our colleges.

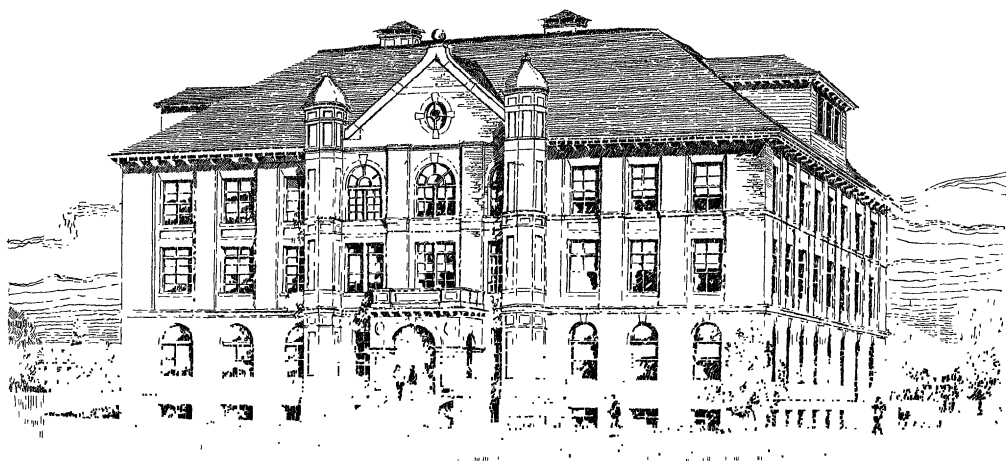


FIG. 1. The Hall of Natural History.

you to Trinity College on this occasion. It is the realization of what was undertaken by the trustees of Washington College when they issued their prospectus in 1824. In that prospectus we find that professors had been appointed for departments

"The position and importance given to scientific studies attracted a large number of students who wished to prepare for the study of medicine or for scientific pursuits, and among the early students a large proportion became distinguished physicians.