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ZOÖLOGY IN THE HIGH-SCHOOL CURRICULUM.

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A long time has elapsed since Bacon gave to the world the sound advice that "we should accustom ourselves to things themselves." Little by little this idea has gained ground, until now it is recognized as a general principle in every grade of educational work and in widely separated departments of study that contact with concrete objects is far more inspiring and thought-producing than the mere scanning of black marks on a white page. So far as natural science is concerned, the varied training which it affords has been abundantly discussed before this association and elsewhere. To be sure, its practical value was for many years, unfortunately, the chief, or even the only, reason advanced for its importance from the educational standpoint. But of late attention has been directed to more fundamental considerations, prominent among which may be mentioned the interest always aroused and, consequently, developed by it along a "line of least resistance." It was reserved for the work of this Natural Science Department last year to furnish through the papers of two able educators specific demonstration of what many of us have felt for years, that natural science possesses a culture value in education as well as practical worth, and that, furthermore, its culture value is not a whit less important or less necessary than that of certain educational shibboleths. In fact, the educational world is just coming to believe what Louis Agassiz maintained more than twenty-five years ago: "A few weeks' training in natural science is the best preparation a man can have for work in any department of life."

The right of natural science to a place in the curriculum of our schools is still less open to question, since its introduction in various places has been productive of such favorable results. These have been attained in spite of many adverse circumstances: lack of knowledge on the part of the teachers of both the subject-matter and of the method of teaching it; lack of facilities in schools, and not only lack of sympathy, but even active and violent opposition in many cases, from the public. All this is rapidly passing away; natural science has won its place. But there still exist differences of opinion with reference to the time and, especially, with regard to the manner in which it shall be studied. It is my purpose to discuss these questions briefly, as far as they concern the

relations of one branch of natural science to the curriculum of the high school.

The study of life represents, undoubtedly, the culmination of natural science, taken in its widest sense, and yet the preliminary consideration of this subject may well come, if need be, in the first year of the high-school course. As the nature study of the grades has made the pupil familiar with the external form and habits of animals, particularly of those with which he is most frequently brought in contact, he is fitted to take up the study of their internal anatomy and the general discussion of their structure. Moreover, the subject does not necessarily involve previous training in other scientific branches. To be sure, no one of us would doubt that a preliminary study of chemistry and physics, to say nothing of other less closely related branches, would enable the student to appreciate better and more fully the facts which are presented to him in the world of life. But specific preparatory work is not essential to biological study, however advantageous it may be, and, on the other hand, the phenomena of life appeal to the opening mind in its untrained condition much more powerfully than do the more formal processes of reasoning involved in the physical and chemical sciences. In my opinion, while biological study should open the high-school course, it should also close it, and its highest aspect, the study of man himself, should be taken up in the senior year in the light of the studies already made in general biology, chemistry, and physics.

The phenomena of life are so similar, whether presented by plants or animals, and the work on the one subject is so clearly the complement of that on the other, that the really advantageous programme will either alternate the two or provide that the work in the one follows closely upon the completion of that in the other subject. If this be the case, the botanical work, on account of the somewhat greater simplicity and decidedly less mobility of plant structure, should precede the work in zoölogy.

The character of the work itself may now be subject to more careful analysis, and, while I shall consider simply work in zoölogy, yet, on account of the essential similarity among living things, there is much that, *mutatis mutandis*, may be applied equally to botanical work. There are a number of elements to be considered in planning a high-school course in zoölogy: the laboratory work, the field excursions, the text-book or lecture work; these should be supplemented by the formation of collections and by collateral reading. As laboratory work is the keystone of the modern scientific method, it naturally demands the major portion of the time; from three-fifths to four-fifths of the time at the disposal of the course should be spent in laboratory study. But it is not enough to

devote to it this time; the work must be carefully planned and conducted along logical lines, if the results are to be obtained of the processes involved in the work. The first is observation of the object under consideration, the animal itself. This must needs be careful and critical, and every effort should be made to lead the pupil to the analytical habit of thought. He must distinguish between what is actually observed and what is only an inference from the facts observed.

But the observation thus made does not become a possession of the student—is not available for further use—until it can be reproduced with accuracy. To this end a careful drawing constitutes a necessary part of the process. So-called "approximately correct" drawing is the usual result of a generally inaccurate observation. While the drawing of the object shows whether the observation has been correct, a further step is needed to fix that observation in the mind. It should be recorded in note form. This description will show at once what the student has judged to be important and what has been estimated of little value. These notes should be criticised more closely than any other part of the process. Here is a frequent cause of failure, I am sure, in the work of certain teachers; instead of cultivating the accuracy which they appreciate as necessary in mathematical training, they permit the description—which is merely a specific statement of the observation—to be made in such a loose and inexact fashion that the effect is really the reverse of that sought.

The fourth step in laboratory work is a comparison of the observation just made with other cases. Exercise of the analytical powers, merely, does not bring full development; through the comparison of the facts obtained from various sources the power of allowable scientific induction and generalization is also to be developed. This is a real point of danger in our emphasis of the laboratory method. It tends, perhaps, to teach destructive rather than constructive reasoning, and here I think that those who urge the introduction of a certain amount of systematic work into the laboratory training have strong grounds for their position. Entomology and conchology have already attained to a sufficient stage of development as sciences to furnish satisfactory material for comparative study, and, since they treat of objects easily preserved and plentifully obtained, their practical introduction is attended with little difficulty. They deal, moreover, with hard parts, capable of exact measurement and of description in precise terms, and not subject to great individual variation. This work is peculiarly fitted to attain the desired results as regards care, accuracy, and discrimination between essential and non-essential factors. Similar work forms an important factor in the natural-science study of the German *gymnasia*, and, so far as one

can judge from its bearing on higher education, the results are most desirable.

There are two conflicting methods in vogue as regards the scope of laboratory work in zoölogy. On the one hand, the student is to observe a little about a great many objects, a point here and a point there, until a large amount of ground has been covered, but the hard places have been necessarily skipped, while accuracy and thoroughness have been sacrificed to "breadth" of training. Some one has very aptly said that it is the office of biology to educate rather than instruct. And the rapid method, which, to my mind, has much of the butterfly habit in it, fails to emphasize some very important results which may be obtained through laboratory work.

On the other hand, a more accurate study is made of a limited number of forms. Personally I am convinced that a series of typical forms, if studied thoroughly, carefully, and analytically, will yield those results in accuracy, in power of thought, and in independence of judgment which are the greatest pride of every successful science teacher. It is not necessary to study many forms, to cover a large amount of ground, even to take up a representative of every branch of the animal kingdom. The best of laboratory manuals attempt too much for the time ordinarily devoted to such a course. It is the quality of the work, not the quantity, that will yield the results sought after.

The choice of a laboratory guide needs to be made with great care, if a spirit of independence in the work is to be cultivated. Many teachers prefer to write outlines themselves, but the majority will no doubt be compelled to depend on the published manuals. The method employed in such a book is of vital importance, and there is grave danger lest the laboratory guide chosen be of such a character that the process of observation degenerates to a mere superficial verification of the facts worked out by the author of the manual. No matter how considerable the variations from the truth may actually be, I have rarely found a student who has failed to "verify" the "facts" as stated to him. The truly valuable laboratory guide employs the interrogation point more frequently than the period.

It is undoubtedly the pressure of overwork and lack of familiarity, on the part of the teachers themselves, with this side of the topic that have resulted in such limited use of the laboratory of nature. We walk through life with our eyes shut, and even students of biological problems are, with a measure of justice, charged with having become mere laboratory manipulators. The study of living things in their natural environment has been neglected, and here we may take another lesson from the German schools, in which field work constitutes a regular and prominent

part of every course in natural science. As a matter of fact, field excursions are actually one of the most valuable and stimulating factors in biological training. Not that they may not easily degenerate into nothing more than a picnic and entirely fail of their desired end; but, if systematically carried out as a part of the regular work, recurring at specific intervals (with due regard to the weather), and so planned as to cover each time but a limited area of ground, and that thoroughly, they become a powerful element in training the observation, and also furnish a never-failing source of interest for all who participate in them. To be successful, they must be carefully planned in advance, and should be aimed to give the pupils as thorough a survey as possible of the life of that region. How few there are who have any idea of their biological environment! All teachers will find in the Agassiz Association a source of assistance and inspiration for this work. From a hygienic point of view the introduction of field excursions should be strongly urged, and the æsthetic value of acquaintance with nature needs no emphasis. If the child is not brought into communion with nature, she will woo the heart of the man in vain.

As a text-book the old-time "natural history" had its undoubted advantages; its encyclopedic character, the large amount of information that could be acquired within a limited time — and forgotten even sooner, as some of us could bear witness — put it, in this respect, far ahead of any other means of instruction. But this advantage is more than outweighed by the fatal dependence upon authority and the study of that rather than the object. Of course, no one could hope to have a pupil acquire a satisfactory idea of general zoölogy by laboratory processes alone. Some information, especially concerning those inductions which we call biological principles, must be furnished second-hand. The great trouble is that most of the text-books at present available are merely books of reference, much like our old natural histories, and void of any mention of the biological side of the subject. Until there shall be greater emphasis placed upon the general biological aspect, many teachers will prefer to instruct by the lecture method, with its undoubted advantages, in spite of the difficulties which will always be met in dealing with younger pupils. The personal element imparted through a lecture is a constant source of inspiration to the classes.

In connection with the systematic work of the laboratory and with the field excursions, it will be natural for the student to gather a collection, and, if the tendency be well directed, it becomes a valuable factor in the education of the individual. Of course, a heterogeneous mass of stuff does neither the accumulator nor anyone else any good; but the same energy devoted to a limited group would yield valuable

results and perhaps lay the foundation for a lifelong study of incalculable value to the student. Among other nations educated men have regularly each his scientific or literary diversion; here the tendency is rather towards more ephemeral amusements.

It is a single step from the individual collection of the student to that of the school itself. The school museum should be a working collection only, not merely a receptacle for curiosities. It is the comparative laboratory, and should contain nothing except what can be used and is used. If properly arranged, and cared for, it will be an object of pride to the school; it will also excite a large fund of interest and be an inspiration to a much larger body than those directly connected with the work in natural science. The gradual contributions of successive classes will serve to build up a complete representation of the local fauna and to make it of value as a record of life in that region.

Finally, among these elements of a well-rounded course may be mentioned collateral reading. The acquirement of information in this way comes normally last of all. Taken at the right time, its value in broadening the horizon is not easily overestimated. It should be varied and, if possible, spontaneous on the part of the pupils, at least to the extent of their exercising a choice in the selection of reading from the works listed. I believe that a most valuable source of such reading is to be found in the travels of famous naturalists and in the records of those close students of nature whose works have attracted literary as well as scientific attention. No one can cross the ocean with Yacht Sunbeam, explore tropical forests with Agassiz or Wallace, or walk amid the quiet scenes of New England with Thoreau, without acquiring some of the power of observation which characterized these men, and cultivating at the same time a taste for good reading, which will tend to counteract the unhealthful appetite for trash so prevalent in the younger generation at present.

I cannot close without a word on one point. The ultimate results of any study depend very largely upon the teacher. All of us know that it was the teacher frequently more than the subject which yielded the best in our school life, and, necessary as mere knowledge may be, it can never compensate for lack of inspiration. What was it that made Louis Agassiz the greatest biological teacher of our country and our time? Not that he was a close observer — others have equaled him in this respect; nor yet that the fund of information at his command, that his wide training and personal contact with the great minds of the century in natural science, had given him intellectual resources beyond those of his associates. It was, rather, his boundless enthusiasm that recognized no obstacles, that knew the end secure before the beginning was made; it was the divine inspiration which has not only reflected itself in his own

work, but has also been transmitted to scores and hundreds of those who have been his scholars and his scholars' scholars. I care not how well you know how to teach, how thoroughly you have at command all methods and theories, your success will be measured by your devotion, by the inspiration you can impart to others. As Faust says:

Grau, lieber Freund, ist alle Theorie,
Und grün des Lebens goldner Baum.