GENERAL AIMS AND METHODS OF THE HIGH SCHOOL COURSE IN ZOOLOGY.*

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Before the organization of a course in zoology for the high school, it is necessary to determine just what it is to do for the pupil—to discover wherein the chief gain to the pupil lies. Is it in information, mental training or interest in animals?

It is my duty to propose an answer to this question. Were I able to do this satisfactorily to all persons concerned, I should be able to harmonize conflicting claims made by men who are authorities in the field of zoology. However, I shall reply to this question, as well as to others which may be considered in this paper, from the standpoint of the high-school teacher, whose duty it is to give to the multitude of high-school pupils the best possible instruction to fit them for entrance into higher schools or for entrance into the world of industry without further preparation.

The emphasis placed upon each of the three possible ends of the work as mentioned above can not be determined by the teacher arbitrarily, but it is determined by the relation of the pupil to the great mass of zoological facts, and the relation of this group to other similar groups of facts.

The ideal position of the individual, so far as zoology is concerned, is at the center of gravity of zoological matter. My meaning will be plain if all zoological facts are thought of as being distributed over a plane surface, in which surface the individual occupies a point. He should be so located that the relative distance of the various facts from him varies inversely as their relative importance to him. This arrangement would place him near the important facts around which the science is organized and far away from the facts which are relatively of little importance. This is as it should be, and such a condition may be realized if the proper emphasis is placed upon each fact as it is presented to the pupil. The amount of emphasis should vary directly as the importance of the fact to the pupil.

I think that I am safe in saying that all instruction in the high school should have in view two things, viz., to give the pupil

* Read before the Conference of English and Science Teachers in the High Schools of Illinois, at the University of Illinois, February 16, 1905.

information and to give him mental training so that he may have the power of obtaining further information. It should give the pupil tools and the power to use them—the one without the other being practically useless. These two things may be accomplished in presenting the subject of zoology to high-school pupils. Certainly the information gained by the pupil in performing the work prescribed in the course is of great value to him as a factor in the biological world, and there is no course given in the high school which offers better opportunities for mental training. It is necessary that the work be adapted to the needs of those pupils who leave school when high-school work is finished, as well as to those who pursue the subject further in college or university. This may be accomplished by choosing for presentation the fundamental zoological facts and eliminating a large number of minor importance. The aim is to fix in mind these landmarks so that the individual may be able to orient himself in a general way, at least, in the zoological field at any time, for the actual number of facts which he learns in a year's work in zoology is very small when compared with the number which will present themselves in the years to come.

With these fundamental facts well grounded in the mind of the individual, it is necessary that he should have the power to use them and thus be able to master new facts which present themselves to him. Here arises the need of a special mental training which will enable him to proceed scientifically. Further, since zoology may be considered a typical science, the method employed in studying it will apply in the study of all other sciences, and, most important of all, this same method is employed wherever facts are to be classified.

The work in zoology should so train the mind of the pupil that he is able to trace the same principle through a variety of forms in which, perhaps, a development into more highly differentiated forms occurs. This, I believe, is one of the great accomplishments of an educated mind. Interest in animals will come with interest in the subject, and appears as a means, not as an end.

In other sciences and in other fields the pupil must discover an organizing principle when it manifests itself in a variety of forms, and, having performed this process, he may go further and create in his own mind a fact in which the manifestation of a

principle is partly or entirely new. This is the constructive imagination of the inventor and of the man of affairs who sees the end of a great enterprise from the beginning. It is the power of analysis reversed, resulting in that synthetic process which makes growth and development possible. From this point of view it is clear that ultimately the greatest gain to the pupil is in mental training.

It may be said that this is beyond the reach of the high school, yet I know that the beginnings may be made in the high-school classes and that they may serve as a basis for further work in the university without alteration, or that they may serve as a basis for the mental activities of the individual who goes out into the business world without further preparation.

How may this be accomplished? How is the high-school teacher to proceed in order that he may give to the individuals in his charge valuable information and at the same time give them that scientific training which is so fundamental? Permit me to introduce an example from another field. The principle involved in a simple machine is not difficult of understanding even to the uneducated mind, but to understand the principle involved in a complicated machine like one of the improved printing presses used in printing our large daily papers is quite another proposition. Yet the same principle is involved in the complex machine which is involved in the simple machine, though it requires the mind of a trained mechanic to understand it fully. To those who saw the exhibit at St. Louis illustrating the evolution of the locomotive from the primitive form to the latest improved giant of iron and steel it is clear that there has been a growth, a development, from the simple to the more complex, and there must be a growth in the mind of the observer who sees in the complex machine the same principle which is involved in the simple one. This growth is similar to the growth in the minds of the inventors who applied the principle and improved upon the application until we have the product to-day. This power to discover the organizing principle of any group of facts is all important in this complex life of the twentieth century.

Examine one of the simpler forms of animal life and find there embodied certain principles or fundamental characteristics—irritability, contractility, growth, variation, reproduction. Compare this animal with a highly differentiated animal and these

first principles are obscured by the complexity of the organism. Yet the same principles are involved in the higher organism that are involved in the lower form, and the mind with the proper training will comprehend them just as fully as it does in the simpler organism.

This power may be acquired by tracing the development through a number of forms ranging from the lower to the higher in the order of their complexity. To do this it is necessary to study carefully and in detail at least a few representative forms selected from a small number of important groups. The following are suggested, though they may be varied both as to number and kind as circumstances may warrant: Amoeba, Paramoecium, Fresh-water Sponge, Hydra, Starfish, Sea Urchin, Earth Worm, Crayfish, Locust, Moth, Spider, Clam, Fish, Frog, Snake, Pigeon and Rat.

If the pupil's work covers a large number of forms, but only in a superficial way, it is doubtful if those deeper principles, the manifestation of which gives rise to the animal world, will be discovered. The pupil in this way will have a little information concerning a large number of animals, but will not have fixed in mind those important facts around which the science of zoology is organized.

The science of zoology has been divided in three parts, viz., morphology, physiology and ecology. It is difficult to say at this point which should receive most attention, and especially since men of high standing have written text-books for high schools in which varying degrees of importance are given to these divisions. To teach one without the other two would be to teach the triangle with two sides absent. However, one side must be drawn before the other two can be constructed. In a similar way we may consider one division of the science of zoology as a base, a foundation for the other two. Structure appeals to the pupil as something tangible, something permanent. This makes structure a good starting point. A study of structure without regard to function or adaptation to environment is of little value. In every case the pupil should endeavor to discover the function as well as the relation to the environment. Often special adaptations are present and these emphasize development. The real significance of the structures will not be fully understood until they are seen as parts of a living animal engaged in the struggle for existence.

I believe this work in morphology to be of the greatest importance in the study of zoology.

The pupil should study internal anatomy, for it is in the various systems of the body that the fundamental modifications are most evident. These can be studied only by studying the internal anatomy. At this point I wish to say that as much attention as possible should be given to the manner of reproduction and to the fundamental facts of embryology along with the life history of the forms under consideration. I do not mean that a pupil should go into minute details, for this is impossible; but there are certain facts which may be presented which will serve as a basis for future work.

The instructor should teach the pupils to make dissections. The fact that the pupil separates the parts with his own hands gives him the opportunity of gaining information through another sense, thus giving added content to his idea. Demonstrations by the instructor before the class, as well as work with the individual pupil in the laboratory, will beget the careful and thoughtful examination and investigation which are all important in the study of zoology as well as of other subjects.

A permanent record of all work done in the laboratory and the field should be kept, so that any fact observed may be brought up for consideration or comparison at any time. This record consists of notes and drawings which should be completed while the animal is before the pupil, lest the truth should be perverted by a vivid imagination. The drawings should be made from the animal and not from drawings contained in texts, though these latter are often helpful in making clear the more obscure points.

The drawings should be simple and unimportant details should be omitted, thus emphasizing the important parts of the structure. Often the development of an organ may be traced through a number of forms and drawings should show this development. Drawings of the various systems of some of the forms should be made separately. They should not be dismissed from mind until by drawing or diagram the relation of the various systems to each other in the body has been shown. I believe that diagrams are helpful, because they emphasize the important relations of a set of structures and exclude all the unimportant.

All drawings should be accompanied by the proper labels. These are more satisfactory if they appear on a separate sheet

and reference is made by figures or letters. This method leaves the drawing free from writing, an advantage which does not require any comment.

The aim of the course should determine the kind of drawings to be made, and I think that it is clear from the foregoing statements just what the pupil should do in the way of drawings and how he should do it. Clearness and strict adherence to the fact are indispensable. Every line should mean something. In Agassiz's laboratory, which stood on Penekese Island, a class of students, a number of whom have become noted as biologists, worked with this great naturalist. On the walls were a few mottoes, for Agassiz believed in mottoes. One of these now hangs in the Marine Biological Laboratory at Wood's Hole, Mass. Agassiz realized the value of drawing to the scientist when he placed this motto before his students: "The pencil is the best of eyes."

TO WHAT EXTENT IS A CLOSER CORRELATION OF
THE DIFFERENT BRANCHES OF COLLEGE
MATHEMATICS DESIRABLE FROM THE
TEACHER'S STANDPOINT.*

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Considering the vital point at issue as brought out in recent papers suggested by the Perry movement, I feel justified in making the term "college mathematics" include both pure and applied mathematics. The teacher's desire is, of course, what he believes will best equip the student for the kind of mental activity in which he will be engaged.

Most of the students of the present day who study college mathematics do not do so primarily for its own peculiar mental discipline. It is becoming more and more evident that a majority of those who are now electing courses of pure mathematics, do so because they desire equipment for specific kinds of work in departments where higher mathematics is indispensable.

The condition was different, at least in the middle West, a

* Read before the Association of Ohio Teachers of Mathematics and Science, Columbus, Ohio, December 30, 1904.