THE CHIEF AIMS IN ZOOLOGY WORK IN HIGH SCHOOLS.*

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The determination of what constitutes the best zoology work in the high school is a difficult problem, and for its most successful solution demands co-operation among those representing the different interests involved.

I shall make no attempt to discuss an ideal arrangement of high school courses and programs, but recognize existing conditions. In the majority of Illinois high schools, zoology is taught for one semester in the second year to pupils averaging 15 or 16 years of age.

Without personal experience with high school zoology either as pupil or teacher, I have felt keenly my lack of definite knowledge of the characteristics and possibilities of the human mind at the stage of development attained by the average second-year high school pupil. For my conception of their capacities I am dependent on the testimony of others who have had teaching relations with such minds. On the other hand, my association with the instruction work in the department of zoology in this institution for the past dozen years has afforded abundant opportunity for studying the output of Illinois high schools of all grades, from best to poorest, and also of studying a very considerable number of the zoology teachers found in those schools. In fact, I am in part responsible for defects in the preparation and ideals that are displayed by the considerable number of such high school teachers that have had their preparation at this institution during the past dozen years.

At the outset, before stating what I think the main object of the secondary course in zoology should be, I wish to state clearly that I think it should not be planned with reference to subsequent work in zoology at college or university. Since but a very small percentage of the high school pupils in zoology are to continue a study of the subject beyond the high school, it seems clearly wrong to have any pressure brought to bear to bring about any modification of the high school zoology course for the purpose of better adapting it to serve as an introduction to college courses,

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if such modification in any considerable degree diminishes its usefulness for those students who are to take no further work in the subject. I am convinced that there is so much difference between the course that serves best as a complete course and the one that is best as an introduction to college courses that it is unwise to make the one serve the purpose of the other or to attempt a compromise between them, I shall, accordingly, favor the attempt to arrange a course best adapted to meet the needs of a majority and let the college and university get along as best they can with the relatively small minority. This eliminates any possible conflicting interests and leaves us with the same object, viz.: to elaborate the best course in zoology for the second year high school pupil who is to have no subsequent work in that subject.

So much has been written and said within recent years concerning zoology courses in secondary schools, their objects and methods, and the ground has been so thoroughly gone over that we have abundant material from which to choose those ideas that promise to be most useful and improve on them if opportunity offers.

Perhaps the most important advantage within reach of the student of zoology in the secondary schools is a cultural one as shown by the attitude of mind which it may give him toward the facts and problems which he must face in after life. If his work has been properly directed it should help him to gain the power of independent thinking, should increase his ability to accurately judge the value of evidence and so make him better able to reach safe conclusions. Such results are highly desirable if attainable and amply repay one for the time and energy involved. That they are obtainable is firmly believed by some of our prominent educators.

I think that it is quite commonly agreed now-a-days that the number and kind of facts gained are of less consequence to the student than are the mental processes involved in their acquisition, and practically all agree that the method should be that commonly known as the scientific method, which, in its complete form, involves a series of observations, their classification and generalization, the invention of hypotheses or explanations followed by deductions and experiments for the purpose of testing the correctness of the hypotheses or explanations.

It is, of course, not to be expected that the student will go through all of these steps from observations to verified generalizations any considerable number of times, but that he may do it a few times in cases which are comparatively simple and that, in general, he will be expected to bring the facts gained from his own observation into relation to each other and also to facts obtained from other sources. Furthermore, it is not to be expected that the student is to get all of his facts by any such method, but that a goodly part of his time, at least four forty-minute periods per week, is to be spent in the laboratory or field, getting facts first hand from his own observations and experiments, and that with these as a foundation he is to gain other facts from his teacher and from books, and under such guidance as necessary he is to organize these facts into a useful body of knowledge which may be available in after life. This body of knowledge should, at the least, contain some of the more important generalizations of biology, as well as some of the more useful facts of physiology and economic zoology.

At the end of his course in high school zoology the pupil should realize that his human physiology is simply one province of a more general animal physiology and that there is a much closer relation between plants and animals than he had previously supposed. After his high school course in botany he should no longer think of plants, animals and man as widely distinct, unrelated objects, but rather as different forms of living matter adapted to different modes of life.

In educational work as in other fields of human effort it is often much easier to state in a general way what objects and aims are desirable than it is to give directions for their accomplishment, but our discussions cannot be helpful to those teachers most needing help unless they lead to the formulation of quite definite detailed outlines of the course of procedure necessary for them to follow in order that they may improve as teachers of zoology.

Some well-known educators and writers consider that facts of structure are the most available and most useful material for the pupil, and that his time and energy should be chiefly employed in accumulating such facts and classifying them, so that he may be able to frame definitions of the different groups of animals. To such persons the chief value of zoology and botany to the

pupil lies in the fact that they are classificatory sciences. There can be little doubt that work of that sort consistently carried out is better than the aimless hit and miss kind of work which is so common in our schools and which leads to but little in the way of mental training or useful knowledge, but I am heartily in sympathy with the idea held by some that function and structure rather than structure alone furnish much more useful material for the development of the pupil's reasoning powers as well as more useful material for his stock of general information.

There are two recent contributions to the literature of secondary school zoology with which teachers should be familiar. One of these is the new book by Lloyd and Bigelow entitled, "The Teaching of Biology" and published by Longmans, Green and Co. Chapter VIII of the part devoted to zoology gives suggested outlines of work on which can be based excellent courses of study for either a half year or a whole year.

The other contribution to which reference is made is found in "Science" for December 16, 1904, and is a report of a committee of the Eastern Branch of the American Society of Zoologists, appointed to outline a course in zoology for secondary schools, which should best meet the needs of such schools and should also be worthy of acceptance for entrance credit by colleges and universities. The report outlines work for half year and whole year courses, and was adopted by the society at its annual meeting in the latter part of December.

I will now attempt to give the general features of a good course in zoology as judged from my point of view.

If there has been no nature study work in the grades, the first few weeks might perhaps be spent most profitably in laboratory and field work on the external characters, habits and life histories of several types of insects and of a few other common groups of animals, not forgetting the birds, but a considerable part of the course should consist of work from other than the natural history point of view. Let a few desirable forms be chosen, such as the crayfish and frog, also Hydra, Amoeba and Paramoecium if equipment permits, and let them be studied with reference to internal and external anatomy, and especially to their physiology and environment. Either coincident with the work on the first type form studied in this way or just preceding it there should be a few exercises and simpler experiments which

should make as clear as possible the simple chemical phenomena of animal life. A sufficient knowledge of carbon, hydrogen, oxygen and nitrogen and their relation to water, carbon dioxide and in a general way to proteids, fats and carbohydrates is just as much within the reach of a fifteen or sixteen year old pupil in zoology as of the same pupil in chemistry. That water, carbon dioxide and comparatively simple nitrogenous materials arise from oxidation of the organic substances of the body can certainly be made intelligible. The significance of the terms acid, alkaline and salt and the use of an indicator like litmus paper should present no difficulty.

If the pupil has not already had an opportunity to see the results of simple experiments dealing with dialysis and with the digestion of proteids and starch, it would be advantageous to give them in connection with the preliminary work in chemistry.

With these necessary facts of physics and chemistry as a foundation the pupil can be made to realize something of the conditions essential to the maintenance of living matter while in a state of activity. The necessity for food, together with the real purpose of digestion, can be made clear. A more adequate notion of respiration can be given than the one implied in the too frequent answer, "to purify the blood" with its implication that animals with no blood have no respiration. Still further, the significance of excretion becomes apparent. The pupil is now prepared to understand why the very small animals living in water or in very moist situations may be much more simple in structure than those living in comparatively dry air or than large animals in any situation. He is also prepared to understand something of the relation between the real assimilation, respiration and excretion of the living matter throughout the tissues of the complex body in which the circulating fluids act as a surrounding medium, and the corresponding activities of smaller animals living in water, also the somewhat different nature of the activities of special organs of respiration, excretion and the like in the complex animals. One compound microscope, to be used in helping the pupils of a class to gain a conception of the multicellular nature of Metazoa and for exhibiting the activities of Amoeba and a few Protozoa, seems to me to be an indispensable adjunct for a successful course in zoology. Additional microscopes, although highly desirable, are not so essential.

Laboratory work on the structure of animals must still constitute an essential and relatively large part of high school work in zoology, but it becomes much more interesting and profitable when the organs are studied as structures for the performance of necessary functions under the conditions fixed by the environment.

For the greater part, the directions for the pupil's work should be so planned that they continually assign problems for him to work out rather than make extensive use of the verification method of work, and especial effort should be made to plan some experiments which involve all the steps of the scientific method.

More general features of development, such as the origin of animals from single-celled ova and the subsequent cell division and differentiation should receive attention, but the details of mitosis and maturation would probably better be omitted.

As to the matter of evolution the tact of the teacher and local conditions will determine whether it should receive much attention. It would doubtless be better for the teacher not to assume the part of a special advocate for the theory, but it seems that so important a body of ideas should not remain entirely unnoticed. A general statement of the theory and that it is believed by many scientists to be true, although not absolutely demonstrated, ought not to do harm, and certainly a general notion of evolution seems to be an essential part of the equipment of any well educated person.

I think that in many of the better high schools of the state excellent work is now being done in zoology. There is sometimes a tendency to give too much attention to anatomical details of which no especial use is made subsequently and to give too little attention to physiological and environmental aspects of the animal, and especially is there a deficiency in those phases of the work which exercise the pupil's ingenuity in testing the accuracy of his generalizations, which are often made on very scanty data. Too large a part of the work is mechanical and observational, while too small a part is calculated to aid the development of the reasoning powers.

A very obvious deficiency in the students from the average high schools and from those below the average is their lack of knowledge of even the elementary notions of physiology. We usually find the explanation readily enough when we get the teachers from such schools into our classes.

I know full well that the life of the science teachers in our average high schools is a strenuous one, and that the number of classes that they are obliged to teach and the variety of subjects with which they must be familiar is so great that it must often seem to them that the easiest mode possible for laboratory management is the only mode possible. I also realize that the management of the laboratory work of large zoology classes is more easily accomplished when the work is chiefly anatomical. It may often times happen that from sheer necessity the teacher seems driven to a course of procedure that his own best judgment condemns, but, on the other hand, there are teachers who are able and willing to modify the character of their instruction work when convinced that a modification is desirable.

What relation has the high school zoology to the subsequent zoology work of college and university? I fancy that many teachers of college classes would prefer that the students coming to them should have had chiefly natural history work and have a general interest in animals, but not have much knowledge of type forms. I should certainly advocate such a course for the high schools if ninety-five per cent instead of five per cent of the pupils taking zoology were to follow it with more zoology at college. The pupil who has had Hydra and Amoeba and other such forms in one of our large high schools naturally feels that his time is being wasted if he is asked to study them again at the university, and too frequently is really at a disadvantage because of an unwise attitude of mind toward his work. This might in many cases be obviated if the teachers in such schools would take care to set their pupils right in the matter and not leave them with the impression that they have learned all that there is to be known about the forms they have studied.

We often hear the college graduate berated for requiring his high school pupils to study the "college frog" instead of the "high school frog." I have no doubt that there is often ground for complaint in this matter, but I do not value very highly the high school frogs that have no internal organs nor functions.

I can see no sufficient reason why there should be any differences between the course in general zoology for the college man and the one for the high school man other than those made necessary by the differences in mental characteristics and the time and equipment available.