SCIENCE

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*ADVANCES IN METHODS OF TEACHING.**

ZOOLOGY.

BY *advances in teaching* I understand the use of desirable methods not now generally employed, for while the common methods of this generation are advances over those of a preceding one a discussion of this fact could have no possible value and only an historical interest to us.

I take it that the common method of teaching zoology is by means of laboratory work supplemented by lectures or recitations, and, further, that both teacher and institution are well equipped for this work; these are prerequisites, the need of which need not be emphasized here. Beyond and in addition to these common provisions what advances in teaching zoology are both possible and desirable? Many minor features might be considered, such as certain improvements in laboratory and museum methods, the best sequence of subjects, the relations of lectures to laboratory work, etc.; but I prefer to emphasize two, and only two, main features, viz.: (1) the relations of research to teaching, and (2) the study of the whole of zoology.

I. One of the greatest possible advances in teaching zoology would be the promotion of research work in all institutions of college or university grade and the establishment of the closest possible relations be-

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tween teaching and research. Advances in teaching must be, in the main, founded upon advances in research. Objects which every beginner in zoology sees and studies to-day were known to only a few investigators ten years ago. Methods which are common property now were then being worked out for the first time. The interest and value of teaching is directly proportional to the teacher's acquaintance with original sources of knowledge. The all too common method of leaning—or rather riding—upon a text-book violates the whole laboratory idea, and the more advanced custom of relying upon original papers without making any attempt to see the things described is but little better. Every teacher should endeavor to see and know for himself, and to give his students opportunity to see and know the classical objects upon which important doctrines of zoology rest.

But the relation of the teacher to research should not be merely that of a *hearer* of the word, but of a *doer* also. Research work on the part of the teacher and, if possible, by at least a few advanced students should be a part of the *teaching equipment* of every college and university. Too frequently and indiscriminately has it been maintained that the qualities which make a man a good investigator ruin him as a teacher. The examples of Agassiz, Huxley, Leuckart and many others, both here and abroad, show how erroneous is such a view. Great ability as an investigator may be united with qualities which are ruinous to the teacher, but these are not qualities essential to research. On the other hand, a good teacher must be, at least to a certain extent, an investigator also. The ability to make a subject plain is not the first nor, indeed, the most important function of a college or university teacher; his first duty is to arouse interest in his subject, to direct students to reliable sources of information and to encourage them in independent work. For all of these purposes research is of the utmost value. A new fact discovered in a laboratory is a stimulus to faithful and independent work, such as nothing else in the world can be; whatever other requirements colleges and universities may make upon their teachers, they might safely require that they be contributors to knowledge. The greatest mistake which a college or university teacher can make is to talk and act as if his science were a closed and finished one. A subject which seems old and stale to the teacher will seem uninteresting and unimportant to the learner. To the teacher who has only a text-book knowledge of things all subjects soon seem finished, fixed, bottled and labelled; once a year, perhaps, he wearily exhibits these dead and changeless things before his suffering class. But the teacher who realizes how little we know about any subject and how much remains to be learned—who, while accurately presenting what is known, can by both precept and example help to extend the bounds of knowledge—will never find his subject stale nor his class uninterested.

It will be objected that in many subjects and in most institutions such a course is impossible. Undoubtedly it is more difficult to make discoveries in some fields than in others, but it is one of the particular charms of the biological sciences that the opportunities for research here are greater than in most other subjects. The great amount of teaching and of administrative work which is required of many teachers is the greatest obstacle to this plan; and yet I know persons who teach from twenty-five to thirty hours a week and who yet find time to do research work, if in no other way, at least by keeping their eyes open for new points in the material used in their classes.

It is sometimes maintained that there is a fundamental difference in kind between graduate and undergraduate teaching, and

that the former alone can have any relations to independent work or research, while the latter must consist of information courses merely. But whatever may be true of other subjects, it is certain that biological studies encourage and develop independence in observations and reflections from the beginning. I maintain, even at the risk of being charged with holding low ideals of graduate work, that the distinction between graduate and undergraduade work in biology is one of degree and not of kind. Of course, elementary students cannot do research work of any great value, and yet they may catch the spirit of research and assist in carrying out work of importance. Some valuable work of the last few years has grown out of the careful and independent study, in undergraduate classes, of the structure, development and variations of well-known animals. The knowledge that new facts may be discovered even in elementary work is an inspiration to both student and teacher. I pity the man who has to teach a finished science; I wonder how either he or his students stand it. The zoologist has here an advantage which he cannot afford to throw away. If it is further objected that this method would induce students to neglect well-known facts in ridiculous attempts to find new ones, or that it would assist an ignorant or lazy teacher to fill up gaps in his information by ingenious speculations, I can only reply that such an abuse should be credited to the teacher and not to the system. The thesis which I defend is simply and comprehensively this: The spirit of zoological teaching should be the inquiring, independent, alert spirit of research.

II. Another advance not less important than the one just emphasized would be found in increased facilities for studying the whole of zoology. The time was when zoology meant merely classification; at present it means little more than morphology; a great advance will have been made we all realize, and succeed in getting our institutions to realize, that these subjects, however important, are but a part of zoology and that a large and important field is still almost unoccupied. The usual laboratory work in zoology, viz.: the anatomy of a few alcoholic specimens, is less than one-half of the science and in all respects the least interesting and important half. Research to-day is tending more and more to the study of *living* things, and in this respect, as in so many others, research points out the way for advances in teaching. The study of living animals; of their actual development under normal and experimentally altered conditions; of their food and the manner of getting it; their enemies and friends, parasites and messmates; their mating, breeding and care of young; the effects of isolation, crossing and close breeding on structure and habits; the effects of varying light, color, temperature, density of medium, etc., on color, size and structure of every part; the daily and nightly activities of animals; the origin and nature of peculiar habits and instincts—in short, the study of all the varied ways in which animals live and adapt themselves to their environment is an integral part of zoology; and who can doubt that together these things form its most important part, and yet there are few if any places where any systematic attempt is made to give instruction in these subjects.

Practically the only attempt which is made in most institutions to meet these needs is by means of field work. The value of such work cannot be overestimated and it must always remain an indispensable part of any broad zoological training, but it is not in itself sufficient. In large cities and during the colder part of the year it is especially difficult to carry on field work, and in no case is it possible to have animals under observation for considerable periods

of time or to carry on experiments with them in the field. Field work must consist largely of collection, classification and scattered observations; more serious work must be transferred to the laboratory.

A most useful and important adjunct to zoological teaching is an animal house, or vivarium, in which may be found fresh and salt-water aquaria; terraria for small land forms; hives for bees, ants and other insects; rooms for various amphibia, reptiles, birds and small mammals; hatcheries for the eggs of various vertebrates and invertebrates, and various appliances for the experimental study of living animals. Such a vivarium might contain a synoptic collection of living animals, worth vastly more for teaching purposes than the ordinary museum or laboratory. Botanists have long recognized the necessity of greenhouses for teaching purposes, and the need of having living material for study is quite as great in zoology as in botany. Some such vivarium is a necessity if zoology is to be studied in any broad way. It is usual in building laboratories to provide an animal room in some small, dark corner of the cellar, while the whole of the building proper is devoted to lecture rooms, laboratories and museums. It is sad to think that such a disposition of space represents the popular view of the importance of the study of living animals. In a very important sense a vivarium is the most essential part of any laboratory of zoology, representing that for which all the rest exists. In cases where it is not possible to have a separate building or large, well-lighted rooms for this purpose a greenhouse and animal house could be combined; and in all cases a few well-stocked ponds in the immediate vicinity of the laboratory can usually be provided without trouble or expense, which will furnish a never-failing supply of living material.

But under the most favorable circumstances the number of living animals which can be kept in or near the laboratory is not large; for making extensive studies on large numbers of animals, recourse must be had to experimental farms and to marine and fresh-water stations. Little has yet been done in the way of establishing experimental farms for purposes of pure science, though I believe they are destined to play a very important part in the development of our science in the future, but the establishment of biological stations has done more to advance the study of zoology than any other one thing in this generation. While the laboratory, the vivarium and perhaps also the experimental farm are things which each university must provide for itself, the marine and fresh-water stations can reach their greatest usefulness through the cooperation of many institutions. Without in any way disparaging the work done by other stations of a similar kind, I think it may truthfully and modestly be said that the Woods Holl Station, in the measure of cooperation which it represents; in the close relations which there exist between teaching and research, and in the fullness with which the whole of zoology is represented, has done more to advance the teaching of zoology in this country than has any other institution or factor. The professor of anatomy in one of our best medical schools said to me a few days ago: "In all my teaching I try to follow the general methods employed in the classes at the Woods Holl Laboratory; those methods are models of good teaching." If this can be said for the teaching of human anatomy how much more is it true of the studies which are there directly represented. Some of the greatest possible advances in teaching zoology will be found in realizing in every college and university the Woods Holl ideal.

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