

Objectives and Content of An Introductory Course In Zoology

PAUL R. DAVID and HARLEY P. BROWN, University of Oklahoma, Norman

Introductory Zoology at the University of Oklahoma is a one-semester course conducted on the practicum-discussion plan, in which from three to five hundred students per semester have been enrolled. The class is divided into sections each of which (in full charge of a single instructor) contains twenty-four to thirty students and meets for one fifty-minute period five times a week. The mechanics of administering the course, the distribution and sharing of responsibility among the instructional and assisting staff, and methods of examination and grading have been described elsewhere (Brown and David 1949) and will not be reviewed here.

Only one course in introductory zoology is offered; this is required of departmental majors and of pre-medical students, and may be taken by non-majors to satisfy their requirements in biologic science. The syllabus is not, however, intended to represent a compromise between the needs of the different categories of student enrolled. On the contrary, the material and method of treatment have been chosen with a view to providing information and concepts which we think should be of fundamental value to all classes of students. This implies, first, our conviction that as zoologists we do have something of real worth to offer to the student majoring in other fields; and second (an immediate corollary), that any materials in zoology that are of sufficiently fundamental significance to be important to students in other areas must be important also for prospective zoologists. The young zoologist, we believe, should be introduced to the fundamentally significant aspects of his science as early as possible in his career; he should not have to wait until he is a graduate student to find out about them.

The viewpoint reflected in the preceding paragraph virtually demands that a primary objective of the introductory course must be to train students in habits of scientific reasoning. The students must learn that the value of accurate observation and of critical thinking is not restricted to the scientist in the laboratory; that objectivity and logical rigor are indispensable aids in every area of human activity. We do not undertake to teach habits of critical thinking by presenting rules of logic or formalized schemes of scientific procedure; but we do try in every phase of the course to impress on the student that the validity of any statement rests wholly on the strength of the evidence which supports it. On every possible occasion we try to raise, in one form or another, such questions as "What is the evidence?" "Is the conclusion reached consistent with the evidence?" "Are there alternative conclusions which would also be consistent with the evidence?" "If so, what kind of observations or experiments would be needed to decide among the alternatives?"

A second major objective of the course is to stress the interrelations of biology with other sciences; more accurately, perhaps, to stress the essential unity and consistency of all knowledge concerning natural phenomena, and therefore the interrelatedness of the phenomena themselves. We insist that organisms must be studied as *biologic* entities; that physiology, for example, cannot be understood merely in terms of the physical and chemical processes occurring within an animal, but demands recognition of the structural organization of the animal as a living and integrated organism. At the same time, we emphasize that the characteristics of an organism are ultimately dependent on the physical and chemical properties of its constituent materials, and we try to make full use of elementary principles of physics and chemistry throughout our treatment of organ-system physiology. Equally important, we think, is our attempt to show that biologic phenomena, in the narrower sense, are intimately relevant to and inter-

connected with phenomena that are commonly thought of as properly belonging to the fields of psychology and sociology.

A third objective is to present all of the materials of the course, under whatever topics they are introduced, within the framework of general orienting concepts and principles which cut across, and therefore serve to integrate, the various conventional sub-divisions within the general field of zoology. Throughout our teaching we have tried to keep constantly in focus the concept of evolution, the principle of homeostasis, the integrity of the organism as a whole, and the inescapable interrelation between structure and function.

Obviously, the objectives outlined (or any alternative set of objectives) must profoundly affect both the choice of topics and materials for the course and the sequence in which they are presented, as well as the treatment of the subject matter. In our case, no effort is made to offer a balanced survey of all aspects of zoology; we are convinced, in fact, that in the seventy-odd contact hours at our disposal such a survey, except at the price of utter superficiality, would be impossible even if there were serious reasons for regarding it as intrinsically desirable.

A relatively large part of our course is devoted to physiologic mechanisms, because it seems to us that reasonably cogent evidence comprehensible to an elementary student can be presented for the ascribed functions and functional interrelations of various organ systems rather more readily than for many other biologic phenomena. Moreover, we allocate much more time to nervous-system function, inclusive of behavior, than to the function of any other organ system. This stems logically from our intention to stress the unity of the organism, because nervous-system function obviously affords illustration *par excellence* of integrated activity in the organism as a whole. At the same time, a relatively extended consideration of nervous-system function permits us to call attention to psycho-physiologic interactions, and to indicate the dependence of behavioral response both upon the neurologic organization of the individual organism and upon inter-individual or sociologic relations among organisms.

Our effort to orient all of the course materials around general unifying principles leads us to introduce the concept of evolution, and the related notion of adaptive significance, almost at the beginning of the course. This is an unorthodox position, but it seems to us a convincingly logical one. The idea of evolution assists in clarifying so many phenomena in all areas of zoology that it seems a shame not to introduce the student to it at the earliest possible moment. The evolutionary concept, introduced at the outset, is utilized throughout our treatment of organ-systems, where we direct attention whenever possible to the adaptive significance—patent or presumptive, as the case may be—of the physiologic mechanisms we examine. The general idea of natural selection, in more or less classical terms, is presented in the introductory treatment of evolution near the beginning of the course; an attempt is made to refine the concept somewhat, in terms of gene-frequency change, in our treatment of genetics, which is the last topic studied. An idea of homeostasis is also presented very early in the course, in terms of buffering and osmoregulation. The principle is developed along these and other lines in the subsequent consideration of organ systems, where special emphasis is placed on self-regulatory mechanisms. The interdependence of form and function is emphasized from the earliest part of the course in the introductory material on cells and tissues, and the concept is reinforced in the treatment of organ systems:—in general, no physiologic function is discussed without explicit consideration of its structural basis, and conversely, we try not to make the student learn any morphologic facts or terms for the sake of the facts or terms alone; as a rule we demand knowledge of anatomic structure only when we intend to develop the functional (or other, e. g., phylogenetic) significance of the structures.

Many additional features in the arrangement of the course also tend to break down compartmentalization and at the same time, we think, contribute to didactic efficiency. Such taxonomy as we include, for example, is not presented as a unit in itself. On the contrary, we introduce some of the broader principles of taxonomy in our initial discussion of evolution, which is illustrated chiefly by vertebrate phylogeny, adaptive radiation as seen in mammalian teeth and jaws, and the paleontology of the horse. Here we have opportunity to indicate what is meant by a number of the taxonomic categories. The meaning of phylum receives some clarification when we come to a very brief sequence on several invertebrate types; concepts of species and speciation which are touched upon in the early material on evolution, receive a little further elaboration in our terminal discussion of gene-frequency and its relation to subspecific variation. We try also to tie together the various phases of the course by considering, in our selection of material for any given topic, how serviceable it will be for back reference in later class discussions. Thus, in our material on vision, we include demonstration of the retinal blind spot. When subsequently we come to a consideration of prejudice and rationalization, we call attention to our (presumably acquired) obliviousness of the blind spot even in monocular vision, and we use this to suggest—by analogy, and not as proof—that the social conditioning of prejudice need not involve any consciousness that the process has occurred. In the minimal time that we are able to give to embryogeny, our emphasis is on developmental mechanics, and we later use some of the concepts developed here to serve as background for the treatment of gene action.

In view of the fact that we make extensive use of man as an illustrative organism, we should perhaps emphasize that we do not at all regard the course as one in *human biology*, which we would take to mean a course primarily focused on man rather than one centered about zoologic principles, as we think ours is. In selecting particular types for chief or exclusive consideration under the various topics, we have tried in each case to choose the animal or group which seems to afford the most practicable demonstration of the principles we are trying to make clear. When man or another species might be equally usable (e. g., for illustrating most of the mechanisms of vertebrate physiology) we confess to a pardonable predilection for centering the discussion on *Homo sapiens*, and giving other vertebrate types subsidiary attention in respect to features for which comparative treatment is indicated. In other instances, man is sometimes clearly more satisfactory and sometimes clearly less satisfactory than another form. We would hardly consider using the Hominidae to illustrate phylogeny, for example, in preference to the Equidae or Camelidae; for discussion of stereotyped behavior at a complex level, illustration must inevitably be drawn from arthropodan materials; in presenting developmental mechanics, amphibian experiments are drawn upon; and so on. On the other hand, man is about as favorable a subject as any animal for the actual demonstration of tropistic response; he is superior to almost every other species for the illustration of taxonomic principles at subspecific levels—because there are few if any other forms for which as extensive data exist on both morphologic and gene-frequency variation, and because the morphologic criteria which are used to classify human races are certainly easier for the elementary student to visualize than the race-differentiating characteristics of such animals as *Lymantria* or *Drosophila*. And for illustrating psychophysiological interaction and bio-sociologic interrelations, man must necessarily provide the chief or exclusive material.

In conclusion, we should like to comment on the overall content and approach of the type of elementary course we are trying to develop, in relation to general problems of science curricula in colleges. There is certainly nothing either revolutionary or original in the three major objectives we have chosen to guide us in the selection and organization of

our materials. We feel sure that virtually every instructor who ever plans the syllabus of a basic science course intends to emphasize scientific habits of thought, the interrelations of the branch of science he is teaching with other areas of knowledge, and the unifying concepts which are fundamental in his particular field. Nevertheless, we suspect that in many cases the exploitation of these objectives is in large degree subordinated to other considerations,—e. g., to attempts at encyclopedic coverage, at technical vocabulary building, at training in techniques peculiar to the branch of science in question.

Some acquaintance with all areas of a given branch of science, extensive knowledge of its technical vocabulary, and facility in its specific techniques are all desirable, indeed essential, for future specialists; but they are of relatively little value to those whose careers will be in other fields, and it seems to us that their achievement may properly be regarded as the responsibility of courses beyond the introductory level. On the other hand, few would deny that accomplishment of the more general objectives we have indicated, and especially of the first two, would be of supreme value to specialists and non-specialists alike. The offering of a single elementary course in a given science department, sharply focused on these objectives, would seem a more likely way of maximizing their attainment than an attempt to provide different introductory courses for majors and non-majors. The latter expedient (aside from the dissipation of energy inherent in the division of teaching effort) often implies superficial treatment of students in the non-major course, and the equally grave danger of training science majors as technicians rather than as scientists—i. e., of failing to develop in them critical scientific attitudes toward materials outside their immediate fields. We suspect it is in large part a consequence of this type of training that many professional scientists who are irreproachably analytic and critical in dealing with problems related to their own work are frequently not at all alert to the demands of scientific rigor in fields other than those in which they have been specifically trained.

We cannot pretend to be competent judges of the special problems of elementary instruction in fields other than zoology. But we strongly suspect that our arguments for a single introductory course are at least approximately valid in other branches of science, and it seems very unlikely that a student will develop a proclivity for applying principles of critical thinking over broad areas if his education in their applicability has been limited to illustration within a single field. We should like, therefore, ultimately to see the development of introductory courses in every department of science, each consciously designed to accustom the student to scientific thinking in terms of its own materials and to stress interrelations with other branches of science, as well as to establish a framework of unified knowledge in the science itself as a foundation for possible future study in the same field. A curriculum which included a semester's (or better, a full year's) elementary course of this type in a physical, a biologic, and a social science would provide practice in the scientific analysis of a sufficiently varied assortment of problems to justify a reasonable expectation that there would be some carry-over into the everyday thinking of students who completed it. Introductory courses from the three areas named should also provide a broad and substantial orientation in science as a whole, not by presenting a panoramic view of the problems and accomplishments of all branches of science, but by exposing and emphasizing the intimate interconnections of major areas of scientific activity from the several viewpoints of the separate sciences involved.

It should be evident that a curriculum of the type we have suggested would offer fair promise of accomplishing some of the major aims of what in recent years has come to be called *general education* (see McGrath et al. 1948; Hawley 1950). At the same time, it would not be subject to several of the difficulties and disadvantages of alternative procedures which have

been proposed to achieve these aims. For one thing, it would not involve a multiplication of courses. For another, the syllabi of the individual courses would be independently planned by separate departments, in conformity with the requirements of their respective disciplines and the interests of their staffs; interdepartmental consultation would undeniably be desirable, but the necessity for the kind of cooperative planning which is in theory ideal, but which in practice often involves frustrating complications, would be obliterated.

The degree to which the several courses taken collectively might provide an integrated program of "general education" would of course vary according to circumstances; in general it would perhaps be less than might be expected under an alternative program of overall planning in which a unified presentation of the materials from several fields was deliberately attempted. It would seem inevitable, nevertheless, that insofar as the general objectives common to all of the courses were kept in mind, a substantial degree of integration would emerge; and we think that integration achieved in this way would very probably have a foundation both more logical and more durable than any degree of unity reached by compromise or imposed by fiat. We fully realize that our thoughts regarding undergraduate science curricula are to some extent utopian. In particular we recognize that the kind of education in science (or for that matter in the humanities) which we should like to see accomplished in colleges is scarcely possible within the customary four-year span until there is a fairly extensive overhauling of curricula in secondary and perhaps even in elementary schools. In the meanwhile, however, it would seem to be a responsibility of those who are concerned with undergraduate teaching to ponder carefully the *direction* in which it is most desirable to move. We think the direction we have suggested is one which may be worthy of serious consideration.

LITERATURE CITED

- Brown, H. P., and P. R. David 1949. Use of democratic methods in the organization of a zoology course. *Proc. Okla. Acad. Sci.* 50: 193-194.
- Hawley, C. E. 1950. Curriculum problems in general education. Extension Study Center, University of Oklahoma.
- McGrath, E. J. and others 1948. *Toward general education.* The Macmillan Company, New York.
-