DOWNLOAD PDF COURSE OF PRACTICAL INSTRUCTION IN ELEMENTARY BIOLOGY

Chapter 1 : A Course of Practical Instruction in Elementary Biology

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The pyramid of numbers begins with unreckoned millions of elementary school children whose first exposure to things scientific comes from experience with living things. It continues through the approximately 2. The next level comprises the 25, students who, each year, complete baccalaureate training with concentration in one of the life sciences. At the apex of the pyramid are the approximately 3, new Ph. Our present concern rests primarily with education in biology rather than that for the biology-based professions. Eighty percent of Americans who graduate from high school take their only formal science courses in biology. At the college level, the life sciences attract a high proportion of those who enroll in single science courses while majoring in nonscientific disciplines. Thus, biology fulfills a unique role in providing large numbers of our citizens with their only view of science and its impact upon the problems of our society. This opportunity also entails an obligation of professional biologists to provide effective training for the teachers who are entrusted with this task. The heterogeneous academic system that provides training for the research workers and teachers who make up the community of more than 80, professional biologists in the United States is difficult to describe. As we noted earlier, the life sciences are uniquely diverse: Biologists belong to more different professional societies and read more different journals than do other scientists; the life sciences are taught in departments ranging in degree of specialization from biology to forest pathology. While this rich diversity may be useful to society, it adds up to a system that escapes easy characterization. One difficulty is measurement of the extent and efficiency of research training. Almost all the 3, Ph. We cannot be certain of how many of the 25, college majors in the life sciences graduated annually enter upon Ph. Only about half of these complete the highest degree and enter the national pool of potential research workers. The attrition is difficult to measure, but, even among the holders of highly prized Woodrow Wilson fellowships in 10 distinguished graduate schools in the United States, only about half of those who began doctoral studies in the biological sciences between and had earned the Ph. Figures for the other sciences are comparably low. A subsequent, less well-measured and less understood attrition is that which causes fully trained biologists to fail to function as independent investigators. One might conclude from these facts that graduate education is an inefficient process, and, in a sense, this may be true. Inefficiency is inevitable in a system in which even some able students find along the way that they lack the interest or drive to carry through a successful program of independent-research, or that their strongest motivations lie elsewhere. A rigorous selection procedure at the beginning of graduate training, which would guarantee a percent yield of research scientists, would probably also eliminate many of those who later become the most productive creative scientists. Several features of research training in the life sciences present a pattern quite different from that found in other disciplines. Because of the heterogeneity of biology, graduate training is often offered in small, relatively specialized departments. Most departments granting the Ph. The type of training received by doctoral students in such departments is inevitably strikingly different from that provided in coherent departments of biology. The tendency to merge relatively specialized departments into departments of biology has grown during the last decade, as discussed in Chapter 4. The fraction of students trained in these more inclusive departments, however, has not increased, owing to the dramatic increase in Ph. In â€", 5, biologists were postdoctoral fellows in the departments surveyed by this committee. Over three fourths of these were supported by national postdoctoral fellowship programs, primarily from the National Science Foundation and the National Institutes of Health. This pattern contrasts with that in mathematics and the social sciences, in which a much smaller percentage of Ph. The number of persons undertaking and completing advanced training in the life sciences has been increasing dramatically. The number of Ph. Annual output had increased at about 7 percent per year for several decades but rose sharply after ; the increment in over was about 12 percent. To contend with the rise in demand for trained biologists, the fellowship and traineeship programs of the National Science Foundation and the National Institutes of Health supported growing numbers of students until fiscal year These programs should continue to grow as the demands of the educational system as well as those of the pure and applied research establishments grow to keep pace with a growing and increasingly complex society. Moreover, quickening excitement in biological research itselfâ€”occasioned by a decade of especially dramatic progressâ€”produced an unusual shift in the career plans of gifted young people. A recent survey by the American Council on Education showed that whereas, in , 3. Thus the requirements for support of research training in the life sciences are generated not only by the demands of society, but also by the wants of intelligent students who sense that biology is ready for new discoveries and that the life sciences seem both most relevant to human problems and most distant from military use or the furtherance of polluting forms of technology. An important activity of the biological community is neglected if one considers only its contribution to the store of knowledge. It must also provide, directly and through the training of primary and secondary school teachers, for the instruction of large numbers of future citizens who, though not scientists themselves, will be asked to make decisions concerning public issues affecting or affected by science. The overwhelming majority of secondary school students study biology in the tenth grade; a small but increasing fraction are exposed to an advanced-level course later. Two aspects of the secondary school experience are of special interest: The elementary level is nearly terra incognita in understanding of how learning about science occurs. These considerations lead naturally into an experimental approach in which the child is left to reach independent conclusions, not to work toward a set of results that have been given textbook justifications in advance. Some experienced scientists who have worked with elementary school children state that this new approach demands a new philosophy of educating the teacher. Unfortunately, this approach is also expensive. Even the simplest collection of experimental materialsâ€”caterpillars, flowerpots, and aquariaâ€”cost more than books. The secondary school curriculum has been the more frequent target of reform by professional life scientists. As a part of the assault on science education in general, biologists examined the secondary school curriculum and found it wanting. The new insights of molecular biology and genetics were missing; so were up-to-date treatments of the biology of populations, of animal behavior, and of physiology. Secondary school curriculum revision in the life sciences has been principally effected by one group, the Biological Sciences Curriculum Studyâ€” an organization staffed largely by professional biologists, with its policies established by a steering committee drawn from the scientific community. Using writing teams drawn from both secondary school and university faculties, the Study has completed three major secondary-level textbooks. All are comprehensive and reasonably modern in that they have increased emphasis on chemical biology, genetics, and other topics, but they differ in approach. What results has this curriculum reform produced? As with all such efforts, evaluation is difficult. Surveys currently in progress tend to show that colleges receiving students who used this material are pleased with their performance, but this is difficult to separate from the general improvement in secondary education and from increasingly selective admissions policies at most colleges. These judgments notwithstanding, the Study materials represent a major increment in quality over what had gone before. For a substantial percentage of high school students, the biology course is not a foundation for other studies; it is a terminal course. This would include a recounting of the evolution of the physical world and its biological inhabitants in such a way as to give an appreciation of their dimensions in space and in time; attention should be given to the present position of man in the biosphere. Current concern for environmental quality suggests that the approach should be essentially ecological. By historical examples, the future citizen needs to be shown that knowledge is a pre-requisite to intelligent interference in the scheme of nature, and that there are practical limits to what man can do. Problems of food production, pesticides, radiation, pollution, conservation, and population all have their place in secondary school biology courses and will find an appreciative, understanding audience. These considerations are crucial if we want a citizenry equipped to make intelligent decisions about the variety of questions facing society that have biological roots. The nature of our environment is determined in large part by decisions about landscape management that are made at local levelsâ€"by zoning boards, county supervisors, etc. It seems likely that a course so structured could be maximally useful to future citizens, while including a sufficient presentation of cellular and genetic biology to afford a tempting glimpse of the elegance and intellectual attraction of current frontiers of biological progress. Perhaps the greatest problem confronting the adoption of this and other experimental courses in the high schools is the education of a sufficient number of teachers with the training, insight, and enthusiasm to teach them effectively. The difficulties are grounded not so much in intellectual considerations as in the sociology of science. Biology teachers must be trained in colleges, but the curricula of colleges and universities are often structured almost entirely to meet the needs of college teachers, research biologists, or future physicians. With rare exceptions, college biology curricula are neither broad nor humanistic. High school teachers, so trained, tend to structure their high school courses in the same way. The resultant instruction may be well suited to proselytizing students for careers in biological research, but it is ill suited to the education of the citizen. With the best of motives and largely ignorant of what they do, university faculties deflect would-be high school teachers from preparing themselves for educating the citizen. Since the number of high school biology teachers is several times larger than the number of Ph. Various remedial actions can be suggested, depending on local circumstances. One general proposalâ€"that universities create curricula in human biologyâ€"should be seriously considered. Such a program could well include instruction in the specialties of human physiology, physical anthropology, human engineering, human genetics, ecology both general and human , and population studies. Whatever the specialties of its members, the faculty should be recruited on the basis of interest in the scientific aspects of the relation of man to man and man to his environment. The education of teachers of biology in high schools and junior colleges would be a central concern of a program of this kind. Many secondary school teachers are simply unprepared for new curricular materials. In some areas of the United States, only three semester units of college biology is considered adequate preparation to teach on the secondary level. Clearly, retraining and updating of teachers, as well as methods of recruiting better trained ones, are a large part of the secondary education problem; such methods are discussed in a later section. New curricula developed by the professionals in a particular discipline often carry the taint of paternalism; occasionally, they have been resented by local officials or teachers. An additional pressure confronts biology: The programs of the Biological Sciences Curriculum Study have been attacked because their treatment of evolution offended some fundamentalist religious groups, or because their rather restrained treatment of sexual reproduction was held to be lascivious. Such irrational pressures prejudice the acceptance of new curricula and can rob thousands of students of educational advantages that ought to be theirs. One part of the process of curriculum improvement is the development of an intellectual climate appropriate for its acceptance. In some universities, the elements of biology are drawn together under a department bearing that name; in others, there are separate departments of botany and zoology; and, in perhaps the largest number, an even greater array of separate structures exist. The traditional departmental fragmentation that prevails in the biological sciences at many American universities, and at the land-grant institutions in particular, is the consequence of a peculiar historical development. Zoology departments, charged with the responsibility of training premedical students, become incorporated into colleges of arts and sciences. Botany, as a rule developed independently of zoology, often derives a major part of its support from schools of agriculture. As various other subdisciplines achieved strength of their own, separate administrative units were erected to accommodate their interests. This trend to fragmentation, once initiated, has been reversed only with difficulty; individual departments tend to persist unchanged, even when the disciplines they represent can no longer flourish in isolation. Biology and the training of biologists have suffered as a result. For example, many departments, even those dealing with the more specialized biological disciplines, offer undergraduate as well as graduate degrees. The requirements for the major are frequently an overdose of specialized courses, taken at the expense of more fundamental subjects of a broadly encompassing nature. The outlook of the student is restricted, and he may be ill prepared for subsequent graduate work. The tendency is to train disciples rather than pioneers.

Chapter 2 : Full text of "A course of elementary instruction in practical biology"

Moreover, it was obvious that the road to a sound and thorough knowledge of Zoology and Botany lay through Morphology and Physiology; and that, as in the case of all other physical sciences, so in these, sound and thorough knowledge was only to be obtained by practical work in the laboratory.

Elementary Instruction in Practical Biology by E. Extended and Edited by G. With a Preface by Prof. The appearance of the first edition of "A Course of Elementary Instruction in Practical Biology" in marked an epoch in biological education. The great effects which the doctrine of evolution had been gradually producing in the general system of biological education were then set forth, and widely extended, by means of a clearly written volume containing an account of thirteen types of the organic kingdom. On the appearance of a greatly extended edition of the work, it may not be out of place to say a few words upon the "type-system" of biological education for which the book in its earlier form has done so much. The immense educational success of the work may perhaps be best judged by the fact that, since its publication, an ever-increasing demand has rendered necessary the production of quite a number of new books following the "type-system," and constructed on an identical plan, but dealing with other forms of life. The important changes in teaching which have followed these publications are seen in the far smaller amount of systematic and classificatory work which is now imposed upon beginners, and its replacement by the acquisition of a thorough knowledge of well-selected types. Remembering that classifications are no more than a condensed abstract of the opinion of the day upon the relative affinities of organic forms, it is clear that no one of the suggested schemes of arrangement can be regarded as real, except as perhaps expressing in the best way the results of a limited state of knowledge. We know that opinion on the subject of affinity has greatly changed in the past, and as long as new facts are revealed by biological research, so long will opinion continue to change in the future. From its necessarily shifting character, and from the fact that the teacher cannot fairly insist upon the accuracy of its conclusions, classificatory biology is eminently unsuited to the needs of a beginner. And there is also another reason, in that classification, if properly taught, is far too advanced a subject to be made an element in early education. If classification is the concise expression of biological opinion, it should nevertheless represent an opinion arrived at after the consideration of all the facts and arguments which bear upon the question. The true and only vindication for any suggested modification of existing schemes of affinity must lie in the decided proofs of a better accordance with existing facts. Whoever suggests a modification is under a great responsibility, for, if the alteration is not an improvement, it will certainly be pernicious in adding to our present state of confusion. It is to be hoped that the whole subject will be treated in a more serious spirit in the future than has been accorded to it in the past. If, then, classification must be dethroned from the high educational position it has held for so long, and which it still maintains to a considerable extent in botanical teaching, what is to be put in its place? Under the type-system a beginner is set to acquire a thorough knowledge of certain central forms of life, each of which is an example of, and a key to, the understanding of an important organic group. At first the types only represent the very largest groups, such as the sub-kingdoms, so that the amount of implied classification is extremely small. As the student progresses, the number of types increases, and the less important organic groups are represented, so that at the end of his course the advanced student finds himself a master of the solid framework of classification, and then the filling in of the details can be carried on in an intelligent and satisfactory manner. It is at this advanced stage of education that advantage can be gained by means of the celebrated "Hunterian system. But just as the type system prepares the way for, and in fact culminates in, all that is educationally important in classification, so, when a large number of types has been thoroughly learnt, and the varied relations of organ to organ, and of isolated structure to the whole organism, have been grasped in very many instances, then, and not till then, can great advantage be gained by the Hunterian method. And the extensive use of this system will be wisely postponed to a very late period; in fact, until the student is beginning to make use of the training which he has received in the wide fields of biological research. The Hunterian system must always form the backbone of a large part of biological research, although it would be most unwise to make it a fundamental part of biological education. It must, however, be conceded that there are certain systems of structures such as the osteological and dental systems which especially lend themselves to this mode of teaching, but on account of this very facility such subjects are liable to assume too great a relative importance in biological training. One incidental, but by no means necessary or even natural, result of the prevalence of the type-system is to be greatly deplored. This result, which is especially found among students of botany, follows from the habit of rejecting the good as well as the bad points in a disused system. Just as the introduction of section-cutting has led to a too great neglect of dissection and the examination of solid structures, so the prevalence of the type-system seems to threaten the existence of the field naturalist and botanist. Those who follow the old, and, upon the whole, the very foolish system of botanical education which a few years ago was the only system taught, have at least one great advantage: But it is not at all uncommon for the successful student of the newer [] system to speak of field botany with utter contempt, as a subject unworthy of notice. This is a very unfortunate thing, for there are many most interesting questions which can only be settled by field-observation; and field-observation is in itself a most important, and at the same time a most enjoyable, side of biological training. The same contrast also holds, although to a less extent, on the zoological side. It is much to be hoped that we may be able to correct this great error which has unfortunately attended a healthy, and, upon the whole, highly beneficial educational reaction. It is to be observed that the excellent general descriptions of the types which form so important a feature of the work are in every way calculated to avert this error. The most striking thing in the revised form of "Practical Biology" is the reversal of the old arrangement, so that the student is now led to begin with a Vertebrate type, and from this to work his way down to the lowest forms of life, and from these, again, upwards to a type of the flowering-plants. There is little doubt that such a change will be met by conflicting criticisms. The process by which a student first learns to see with the microscope is almost like the education of a new sense-organ suddenly conferred upon a mature organism. We know that under such circumstances it would be a very long time before the impressions conveyed by the new organ could be harmonized with the well-known experiences resulting from the stimulation of other organs. Accustomed to judge of the shapes of objects by their appearance in three dimensions, the student is suddenly provided with a field of vision in which shapes have to be nearly always inferred from the appearance of solid three-dimensional objects when seen under conditions which prevent them from being examined in more than two dimensions at any one time. For it is a long time before the student can accustom himself, by focussing at successive depths, and by making the most of the limited third dimension of depth which the high powers of the microscope provide, to judge accurately of the forms of objects. And the novel conditions under which a student sees with the microscope effectually prevent him from making the best of the impressions he receives. Thus, if the section of a solid object presented the appearance of a circle 1 inch in diameter, and if two other sections at right angles to each other and to the first section presented the appearance of a rectangular figure 3 feet by 1 inch, nearly everyone would readily infer that the shape was that of a cylinder 3 feet long by 1 inch in diameter. But precisely similar data, when presented in the field of the microscope, do not readily lead the student to any definite conclusions as to the forms of objects, and in reality a long course of discipline is necessary in order to make him form any clear conception of the actual shape of the object at which he is looking. Thus the gradual training in the use of the microscope will proceed parallel with its gradually increasing necessity. The addition of the earthworm, the snail, and of Spirogyra is a great improvement upon the former edition of the work. If a choice were necessary, the snail is in many respects a more suitable type than the Anodon. In spite of the greater structural simplicity of the latter form, the anatomical details are more difficult to demonstrate by dissection and more difficult to see when dissected than those of the snail. This objection to the Anodon of course only applies to its selection in preference to the snail in the earlier edition; it is in every way desirable that the Lamellibranchs, as well as the Gastropods, should be represented by a well-known type. These newly added types and the additions to the descriptions of those in the previous edition, and to the practical directions, so increase the size of the volume that it contains almost exactly twice the number of pages present in the earlier form of the work. The practical directions given in the appendix appear to be excellent, and to contain in a very small compass an immense amount of information upon the most recent and approved methods. There are a few slips and indefinite statements which should be modified in succeeding editions, which will doubtless be called for at no distant date. They are in reality hypogeal.. Such slight errors can easily be put right, and they would in most cases be detected by the student in reading the book for the first time. They cannot be considered as seriously detracting from so excellent a book, and one which, in the extreme clearness of its style.

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Chapter 4 : Full text of "A course of practical instruction in elementary biology"

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