Role of the Biological Station

It can bring field problems into the laboratory and test laboratory problems in the field.

Stanley A. Cain

To simplify the question I have posed for myself—What is the role of the biological station?—I would exclude from present consideration agricultural, forestry, medical, and other experiment stations that are concerned largely with problems of immediate practical importance in restricted fields and have a permanent staff of investigators. Such experiment stations are also largely governmental institutions. I would exclude, as special cases, Brookhaven, Oak Ridge, and other installations of the Atomic Energy Commission, the Navy's Point Barrow station, and similar installations. The private research stations of pharmaceutical firms and other business enterprises form another special category, as do Audubon and other natural history field schools. Finally, I would omit from present consideration college wild-land preserves and similar reservations that are without attached laboratory and related physical facilities.

All such institutions may be the sites of fundamental biological research, and many of them carry on some of the functions of biological stations. These omissions still leave us with a great number and variety of institutions and operations that generally are recognized as biological stations even though the distinction between them and those omitted may not be sharp.

What can one say of the role of biological stations when they are so varied? Many are marine or fresh-water stations, while others are largely terrestrial in activity and may be located in mountains or on continental plains. Some are large and wealthy, but others are small, ill-equipped, and struggling. A few oceanographic stations have ocean-going yachts that cost $1000 a day to operate, while others are limited in range by having only rowboats or, at best, a small diesel launch. Some biological stations are specialized, dealing, for example, only with problems of fisheries or with seaweeds, but most have a range of activity as broad as the field of biology itself. Many are local or regional in interest while others, such as the Woods Hole Oceanographic Institute, are concerned with the wide sweep of the oceans.

Common Characteristics

Biological stations have certain characteristics in common. Although closely tied in most cases to higher education, they are physically separate from the campuses of the universities and colleges which sponsor or utilize them and are usually located where the biota is rich and varied and where nature is comparatively unspoiled.

A second characteristic of biological stations results from the kinds of research usually carried out there and the kinds of teaching they offer. Although studies made at biological stations may be in morphology and anatomy, physiology, biochemistry, biophysics, and genetics, such studies might as well be carried out at the usual campus and urban laboratory (except for the more pleasant environment of the station) unless they exploit the abundance of living material close at hand and the natural terrestrial and aquatic habitats. One thinks of the biological station as traditionally and predominantly a center for taxonomic and ecological studies.

All biological stations, I believe, are involved in research. Some have a fairly large research staff, but this is augmented, as are the staffs of the seasonal stations, by professors on leave from other institutions, investigators assigned from government or industry on special projects, and others taking advantage of summer vacations to make studies without the distractions of students and administrative duties. A most important characteristic of biological stations, it seems to me, is the large extent to which the investigator is free to follow his own bent and to choose from among many opportunities. If the station has well-equipped laboratories and is well situated for field work, the array of possibilities for study and research greatly surpasses that of the campus laboratory.

Most biological stations are involved in teaching, at least in the sense of supervised research, and some of them offer regular classes in upper-division and graduate-level subjects. However, I do not know of any large biological station that is devoted solely to teaching (although the Wyoming Science Field School approaches it in geology and biology), and I know of none that is managed principally for the teaching of beginning subjects in biology.

I think that one prime virtue of the biological station is that it is the natural meeting place of the general and the specific, the qualitative and the quantitative, the descriptive and the experimental. It is the place where field problems can be brought into the laboratory for refinement and where laboratory problems can be tested in the field. The door of the biological laboratory swings both ways. A further important feature of biological stations, in contrast to the usual campus situation where inter- and intradepartmental fences are high, is the close commingling of specialists of different breed under conditions in which they are likely to interact. The easily acquired knowledge of another's problems and results is stimulating and broadening and often leads to cooperation and joint research.

Qualitative and Quantitative Approach

In order further to examine the role of the biological station, I wish to make some remarks about the roles of qualitative and quantitative science. All branches of science tend to change from a qualitative to a quantitative approach as they undergo development.

The quantitative approach was attained earlier in the physical than in the biological sciences. Among the biological

The author is professor of conservation and chairman of the department of conservation of the School of Natural Resources, University of Michigan, Ann Arbor. This article is adapted from an address delivered 27 June 1958 at the dedication of the Highlands Biological Station, Highlands, N.C.

sciences a quantitative approach developed earliest in physiology and has been carried farthest, perhaps, in biochemistry and biophysics. Genetics was early forced into mathematics and soon developed its Sewall Wrights, whose mathematics is sometimes too esoteric for most biologists. Taxonomy, of course, long has counted and measured organs of plants and animals in its descriptive morphology and has only recently turned to refined biometric analysis of populations and the statistical separation of races, subspecies, and species. Ecology and biogeography started as broadly descriptive sciences with a large intuitive element, especially as to communities for which biotic composition was emphasized over structure. To a considerable extent ecology is still largely nonquantitative. More lately, concern with the nature and causes of physiognomic similarities and differences among communities is leading to quantitative plant ecology, with emphasis on the number, arrangement, and form of constituent organisms as aspects of structure. Appropriate new methodologies, largely statistical, are only partly developed and occasionally applied by ecologists. Both in systematics and in ecology the recent concern for quantification, coupled with the size and complexity of many populations and communities, is leading investigators to consideration of the statistical requirements of sampling.

Grieg-Smith, in his new *Quantitative Plant Ecology* (*1*), points out a basic difference between the physical and the biological sciences. In the physical sciences it is generally possible to isolate for study one variable at a time, but in the biological sciences this is rarely possible. The quantitative approach, as a consequence, is usually much more difficult in biology than in the physical sciences. In the physical sciences differences among replicated measurements often are due to methodology; hence, with refinements in instrumentation and methods, sets of measurements can be obtained that have very slight variability. In biology differences among replicated measurements are due not only to deficiencies in techniques, as in the physical sciences, but also to fluctuations in variables not being studied that are thought or assumed to be constant.

Biologists may use clonal materials or pure lines in control chambers or phytotrons, or in field tests, and assume that variability has been eliminated for hereditary and some environmental factors when, in reality, it has not been eliminated and its effects remain to confuse the biological characteristic being examined; this sometimes results in wide differences among measurements or replicated material. For example, recent studies on peas by Frits Went and his associates, made in the phytotron at the California Institute of Technology, indicate that the past environmental history of certain plants influences their responses to various environments. Both the growth characteristics and the temperature optimum of a given strain of peas are dependent not only on the conditions during growth but on the past history of that strain through several generations. This is similar to the findings by Sonneborn that within a single genetic strain of *Paramecium aurelia* there can exist a number of distinct nongenetic forms dependent on the environment of culture. Whether or not this is a sort of mid-20th-century Lamarckianism, these "enduring modifications" represent at least a temporary inheritance of a nongenetic nature. They suggest also one of the reasons why biological replications may result in considerable variability among measurements.

The familiar difficulty in biology of obtaining truly replicate samples led one biologist—more frank and verbal than most—to what he called a new law: No matter how rigorously you control your experiments, organisms do as they damned well please.

Education and Training

However important biological stations are for the pursuit of research by mature and experienced investigators, I believe one of their most important roles—perhaps I should say opportunities—is in education and training.

Biological education might well start where biology did—with an interest in the recognition and classification of species and in their local and general places of occurrence, together with an interest in their usefulness to man. This would be followed by an interest in their relationships and development—their development as individual organisms and their evolution. This is natural history—a knowledge of life in nature. It presupposes a love of nature as well as a love of knowledge. From such a base of intimate but general experience one can move on to whatever refined techniques, precise measurements, and specialization interest demands and the correlative advances of other sciences permit.

There is a reciprocal dependency here. The field biologist will encounter problems he can't solve without recourse to quantification and, in many cases, to the laboratory and the methodologies of physiology or genetics. Contrariwise, the laboratory man may be working not with the realities of nature but with the artifacts of the control chamber, the decimated organism, and the dying cell.

We can all think of examples of the incomplete biologist. I know of a doctoral thesis on the anatomy of the apical meristems of three members of a fern genus common throughout the eastern United States done on pickled material drawn from bottles on the shelf by a man who was said never to have seen these beautiful plants growing naturally. A widely known mistake that has caused many smiles was made by an investigator of seed dormancy at a well-known research institute. He found out a lot about the physiology of the seeds of the tropical American papaw, *Carica papaya,* and published it. Unfortunately, in view of his later embarrassment, he looked up *papaw* in Gray's *Manual* and attributed his work to the temperate American *Asimina triloba,* a very different plant.

To be fair about this telling of anecdotes, I should mention the field ecologist, intrigued by a new gadget permitting rapid, accurate field measurements of soil acidity, who averaged *p*H numbers arithmetically, although a beginner in chemistry would have known that the numbers are powers of the hydrogen ion concentration and can't be added and averaged directly. And, of course, many ecologists have embarrassed themselves by assuming a correlation between structure and function when no epharmonic relationship existed. Schimper's hypothesis of physiological drought of bog plants stood unchallenged for decades and spawned some ingenious hypotheses in explanation of "xerophytes" growing in water until Walter, Stocker, and others finally experimented with these plants and showed that, although they looked like xerophytes, they were only xeromorphic and actually used water as freely as mesophytes and in some cases were profligate with it.

You probably have anticipated my reason for making such remarks. I believe in the marriage of field and laboratory approaches, and in the existence of at least two roads to biological truth: the observations of the astute naturalist in uncontrolled field conditions and the measurements—as precise as possible under conditions as controlled as possible

—made by the laboratory investigator.

Where better can a student learn the value of, and respect for, the two sides of the biological coin than at a biological station? Where better can the investigator move his field problem into the laboratory or his laboratory problem into the field than at a biological station? At a biological station the physiologist may stick to his test tubes and the ecologist to his quadrats, but in the close camaraderie of the biological station both are likely to get contaminated or (perhaps a better biological figure of speech) cross-fertilized, with resultant intellectual heterosis.

I would suggest, then, that the training and experience of a biologist should repeat in essential outline the history of the development of biology as a general science, and that his specialized education should repeat the history of the specialty. I will restate that by paraphrasing a familiar biological principle: The intellectual ontogeny of the biologist should recapitulate the intellectual phylogeny of biology. I am not sure that my pedagogical principle would be acceptable to the professional educators, but I believe that it is in line with the human being's natural course of development. I feel certain that many promising young biologists, who started perhaps as collectors of insects, shells, or bird lists, have been discouraged from following their inclinations by the stultifying effects of their early experience with general zoology and, later, anatomy designed for premedical students. And many potential botanists, who were taught with the heavy hand of Germanic ordination about a world of organisms unknown to the student and long embalmed in formaldehyde and strapped to herbarium sheets, have turned their backs forever on plant science.

Starting with a broad base in natural history, the future biologist can develop in whatever direction his maturing interests dictate without ever losing either his perspective or his enthusiasm.

My only general criticism of the situation with respect to biological stations is that nearly all of them are designed to meet the needs of the trained investigator and, at most, of the advanced student. It is not that these are unimportant or dispensable functions, but that there should also be some biological stations for senior high-school and lower-division college students where they can be as scientific as they will but where it is also respectable to behave like Carolus Linnaeus, Thomas Say, or any other "father of biology."

I have completed my brief for the biological station, and it is, of course, a familiar one. But as Seneca long ago said, "A thing is never too often repeated which is never sufficiently learned."

Balanced Program in Science

These considerations of the characteristics of biological stations and the opportunities they offer for the progress of biology, together with my belief that biologists develop naturally very much along the general lines of the development of biological science, lead me to the conclusion that we do not have in this country the full array of biological stations that we need. Most stations are designed, equipped, and managed to promote advanced investigation, and most teaching at them is correlative with the spirit of research in the areas that lend themselves to control and quantification. Many old stations have, through the years, dropped or minimized field-based taxonomic and ecological work. I would not call for any reduction in the programs of such stations but would, on the contrary, welcome increased support for them, especially where the costs are large relative to traditional biology. The need for large expenditures in astronomy, geophysics, physics, chemistry, and geology has been better sold than has the need in biology, except, perhaps, in medicine and some applied fields. In comparison we have, I believe, far too few biological stations that devote themselves mainly and without apology to such fields as taxonomy and ecology.

Yet I would strongly express my belief that we very much need at least some biological stations devoted to beginning experiences in biology for young people, perhaps in the range of the last two years of high school and the first two years of college. It seems to me that at present our talent searches, systems of recognition and award, and facilities—in fact, our national concern—for young people in science is too much directed toward the physical sciences and mathematics. Without reduction in such worthy efforts, let us urge the development of the life sciences and their application so that we may have a more healthy, rational, and balanced program in science and in the popular appreciation of science.

Reference

1. P. Greig-Smith, *Quantitative Plant Ecology* (Academic Press, New York, and Butterworths, London, 1957).