RESEARCH IN BIOLOGY.**Conducted by Homer C. Sampson.***Ohio State University, Columbus.*

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to Dr. Homer C. Sampson, Department of Zoology, Ohio State University, Columbus, Ohio.

THE RELATION OF ECOLOGY TO HIGH SCHOOL BIOLOGY.**By MORRIS M. WELLS,***The University of Chicago.*

The problems relating to the teaching of biology in the high school are obvious to those who have attempted the task, and it will not be necessary for me to enumerate them in detail at this time. In general they are problems which may be grouped into two classes, namely, problems pertaining to the organization of the course, and those having to do with the securing of sufficient and suitable material for the class and laboratory work.

These two general groups of problems, which teachers of biology are attempting to solve everywhere are not peculiar to the subject of biology, but are characteristic of all the laboratory sciences. However, I do not believe that the high school curriculum contains any subject, the presentation of which is beset with greater difficulties, than those to be met with in the conducting of a real live course in botany or zoology, and, furthermore, I am inclined to believe that there are few, if any, of the other high school subjects, whose presentation demands as much of the teacher as do these two sciences. It not infrequently happens that the same instructor is called upon to conduct courses in both biology and either physics or chemistry. Those who have had their work thus distributed will, I believe, agree that, given equal training in the two branches of science, the nervous energy expended in their teaching efforts has been largely on the biological side of their program.

The difference in the demands made upon the teacher by the two types of science are due in part to the fact that physics and chemistry are older sciences and are, therefore, more highly organized than are the biological subjects. The textbooks used in either physics or chemistry have reached a high degree of standardization, as have also the materials and apparatus used in

the laboratory. One may choose his textbook of physics, and with practically no effort order from the supply house a complete set of apparatus designed especially for use with the text in question. This apparatus may be left on the storeroom shelves for months without danger of deterioration. With chemistry much the same thing may be done.

The biological sciences have not as yet been reduced to such a comfortable system, and perhaps never will be. It is not impossible that in the future one may order his biological supplies wholesale so to speak, but the very nature of the subject makes it undesirable that one should use biological supplies in the "canned or bottled" form. Biology is the study of life, and it is obvious that we cannot hope to understand or appreciate biological phenomena if we devote all our time to the study of dead organisms. Even though it be possible to purchase living laboratory materials, our knowledge is not broadened to the desired extent by studies made exclusively in the laboratory. Plants and animals cannot be treated in the same manner as chemicals or physical apparatus. Sodium chloride possesses the same chemical properties whether it be one hundred feet below the surface of the earth and mixed with various other salts, or whether it be in a bottle labelled chemically pure. It may be that living organisms are nothing but physico-chemical-colloidal complexes, but life does not consist of salts and physical conditions. Life is a mobile, dynamic force, which, according to our present knowledge of the structure of protoplasm, carries on its activities within a physico-chemical matrix. Life is a type of energy that has so far never been isolated or measured as we measure the energy of heat, light, mechanics, electricity, etc., The biologist has called this energy of life, biotic energy, and is devoting his time to its understanding.

One of the chief characteristics of life is its sensitiveness to change, whether external or internal. It is a familiar fact that protoplasm consists largely of water, the percentage varying from about eighty-five to ninety-five per cent. The organism then in reality is a solution which, so long as life is present, is in a state of equilibrium with its environment. While, as solutions go, the living organism is fairly stable, we know that on the whole it does not require a great change in the surrounding conditions to so disturb the equilibrium that death will result. For aquatic animals and plants, slight alterations in the chemical reaction of the water in which they are living will quickly result in their death if they are unable to escape from the detri-

mental conditions. It cannot be expected that plants and animals that have been collected at some remote point and shipped to a distance will retain much of their normal behavior activities, and in many cases their physiological make-up will be decidedly altered. And this is not all; even though the organisms might be secured in a fairly normal condition, one learns little of their real nature in the laboratory. True, the students may form a clear conception of phylogenetic series as such, but they will derive no real understanding of the forces of evolution from their laboratory work. They may become familiar with the mechanics and anatomy of the organisms, but will have little appreciation of the life which makes use of the structures which they have studied.

In the beginning, I grouped the biology instructor's problems under two heads; those dealing with the organization of the course, and those concerned with the securing of the material. There is a decided tendency upon the part of most teachers to leave the organization of their subject to the writers of textbooks. The value of textbooks requires no emphasis, but it should be the task of every teacher to modify the textbook to meet his own needs. At the present time we have many textbooks in elementary biology, but the fact that others are constantly appearing shows that there is as yet no agreement as to the subject matter that should be incorporated in the ideal biology textbook.

The securing of the proper material at the proper time is, however, usually the most serious problem which confronts the enthusiastic teacher who wishes to conduct a real, successful, live course in biology. Difficulty and delay in securing material may play havoc with the most carefully planned course, and there is no biology teacher who has not experienced such difficulties and delays to a greater or less extent. Furthermore, I am sure there is no teacher of the biological sciences who will not gladly listen to any suggestion which may tend to lessen this handicap.

The suggestions which are contained in the following pages are not put forward as a panacea for the troubles of the biological teacher, but I am convinced that they will bear consideration. Let me say at once that I believe that a training in the science of ecology will remove many of the most serious difficulties relating to the conducting of high school biology courses. In this connection, I wish first to outline the advantages which may be confidently expected to accrue as the result of the introduction of ecological methods into high school biology.

1. The teacher will become thoroughly acquainted with the region in which he is teaching, and will learn where and when to collect his own materials.

2. Ecological methods make it not only easy but essential that the plants and animals be studied together. A course in general biology will automatically result.

3. Ecological methods of analysis necessitate investigations into the texture, composition, etc., of soils. The practical questions relating to agricultural botany and zoology will thus receive attention.

4. The student of ecology must know the animals and plants with which he is working, and the questions of their taxonomy and morphology must be considered.

Ecology has been defined as that branch of physiology which has to do with the relation of the organism to its environment. Ecology is differentiated from the type of physiology with which we are most familiar by the fact that it deals with the organism as a whole and takes little or no account of the physiology of organs. The ecologist is interested in the reactions of the whole organism and is not primarily concerned with the functioning of its liver or the composition of its digestive fluids. In a more general way ecology may be defined as the science of natural history. We do not need to go far back in the history of biology to reach the time, when all biologists were students of natural history. Agassiz, Lubbock, Romanes, Faber, Wallace, Darwin, all were students of nature and did little work in the laboratory. They spent their time studying nature in the field, and we are all familiar with the fact that Darwin and Wallace collected the enormous mass of material upon which they based their individual conceptions of the evolutionary hypothesis, during their excursions into many parts of the world.

With the introduction of the evolutionary idea, backed by so much data, biologists everywhere began a frantic search for more evidence on the subject. It soon became apparent that one of the most fruitful sources of study was to be found in the structure of animals and plants, and as a result, biologists have for the last sixty years devoted a very large proportion of their time to the study of animal and plant anatomy or morphology. A secondary result, of this accumulation of facts concerning the structure of organisms has been, that we have taught in our schools the things which we know best and the high school and college curricula of today reflect this fact in the emphasis laid upon the study of morphology. The botany teacher starts with the blue-green algae and works up through the Proto-coccales, Volvocales, etc., etc. The student may learn of minute structures to be found in *Pleurococcus* which has been secured from a supply house, and will not hear of the acres of

this alga that are growing on the trees, fences, stone walls, etc., all about the school building. The zoology teacher will answer every question concerning the complicated nuclear changes during the conjugation of *Paramoecium* without being able to tell the student where the animal is to be found in nature, or what it does under the varying natural conditions. I do not mean to intimate for an instant that I have struck upon the weak points in the experience of all biological teachers, nor do I mean to condemn any teacher for his weaknesses, whatever they may be. They are teaching what they were taught, and the fault lies with the science of biology and not with the teachers.

However, biology is awakening from this lethargy of extreme specialization; we are beginning to realize that the study of structure was nothing but a stage in which we have already lingered too long. We remember that the man who revolutionized the science of biology in 1859 and set the world by its ears, with a nightmare of being a product of evolution rather than of special creation, was not a product of a man-made laboratory, but was a scientist who secured his information at first hand from the laboratory of nature herself. With this in mind, biologists are no longer going afield, as collectors alone, but as students anxious to learn, at first hand, the working methods of nature's own laboratory.

For many years ecologists were troubled and pestered with the statement that natural history was not and could never be a science. According to these critics, nature was such a complex hodgepodge of unknowns that it could never be organized into a science. While this is without doubt more or less true, those who made such statements failed to remember that the evolutionary theory found its origin in this same hodgepodge, and that every science which we know has originated from the same source. The universe in which we live contains more uncovered sciences than man has ever dreamed of. New sciences are arising on every hand. Bacteriology is less than fifty, and protozoology less than twenty-five years old, not to mention the numerous minor "ologies" that are arising on every hand. The founding of a new science requires merely, the accumulation of a sufficient number of related facts, and we have not even gotten below the surface of the tremendous body of facts that is presented to us in nature.

Ecology is the result of an accumulation of facts that show beyond a doubt, a definite relation between the distribution

and physiology of organisms; in other words, animals and plants select the environments in which they live. The complexity of the relationships involved are bound to be great, which fact but adds to the interest attaching to the science.

All sciences, and especially the laboratory sciences, are readily divisible into descriptive and experimental aspects. In ecology we may make observations and collections which show us that certain animals are characteristic of sandy areas, and others of woods. One species of fish lives in the ripples, and another in the pools of the stream. One insect lives on the ground under the leaves, and another high up in the trees. This analysis may be carried out in great detail and illustrates what is being done in the way of descriptive animal ecology. The descriptive scientist need not necessarily trouble himself with explanations of the facts which he describes, but the experimental worker must determine the why of every fact. Why do certain species of insects live only in sandy regions, and other species in mesophytic woods? Why does one tiger beetle lay its eggs only in clay, and another only in a humus soil? The whys which the experimental ecologist is trying to answer furnish a never-ending list of problems which can be attacked only from the experimental side.

The bearing of all that has gone before upon the teaching of biology in the high school seems to me to be quite clear. Taking it for granted, for there can be no denying the fact, that the place to study nature is in the field, what is there that the high school teacher can do to interest and instruct the student? Let me mention very briefly some of the specific things that may be done. From the descriptive side one of the most interesting phenomena worked out by ecologists is the fact that natural conditions are seldom, if ever, stable. The physiographer finds his science founded upon the fact that the forces of erosion are constantly changing the topography of the earth's surface. The plant ecologist finds that these changes in topography are accompanied by changes in the vegetation of the area, and the animal ecologist finds in turn, that the topographic and vegetational changes are closely followed by changes in the species of animals which inhabit the region. We have then a succession of topographic conditions with an accompanying succession of plant and animal forms. This we call ecological succession. Ecological succession may result from other changes in environment than those related to topography, but the interesting fact at

this time is that these changes are easily recognized and understood by the high school student. Naturally, we cannot wait for a single area to pass through the different stages, but we can readily find the different stages, represented in different parts of any given region.

There are several other types of succession that are also easily studied. When we think of it, we realize that there must be a change in the types of animals and plants that are active at the different seasons of the year. This seasonal succession study works out exceedingly well if begun in the fall, and can be carried through the winter in a study of hibernation, and taken up again in the spring with the beginning of activity of organisms.

There are also daily successions or rhythms that are easily observed in the field.

Another type of descriptive field work that is always of great interest is the observation of the detailed behavior of a single form for a given time. Thus one may select a certain insect and describe its every movement for ten minutes. This is an exercise that appeals to the students more, and more each time it is done, as their powers of observation become sharpened.

One can make various analyses in the field. The temperatures of the different soils, the difference between air and soil temperature, the differences in temperature in different parts and depths of ponds, etc., are readily obtained by the students. Other simple analyses of environmental conditions, such as the measuring of the light intensity inside and outside a dense wood, and the determining of the rate of evaporation, are operations that require neither complicated nor expensive apparatus, and when these analyses are correlated with the actual distribution of the plants and animals as determined at the same time, they furnish a type of work that has been found to appeal to the high school students in places where it has been tried. For the laboratory there are many experiments which may be performed with inexpensive apparatus, but I cannot go into detail as to these at this time.

I do not wish to leave the impression that I am advocating the crowding out of biology as it is now taught in the high schools, in favor of a course in ecology. The point I wish to make and to emphasize strongly, is that the introduction of ecological methods into the teaching of high school biology, will make the instructor more independent of the textbook and of the supply

house than he is at present, and at the same time will make it possible for him to put new life into the subject as he comes into closer contact with nature, the giver of all life.

On the other hand, I am not unaware of the difficulties which the above suggestions will entail. Field trips do not always fit well into the regular high school schedule, yet they are absolutely essential to the study of ecology. Classes in high school biology are frequently large and would probably become larger with the introduction of field trips, while a large class in the field soon becomes unmanageable. These and other objections occur at once. However, I believe that most of the objections can be removed by a proper adjustment of schedules and limiting of the numbers allowed to take the course. Of one thing I am certain; with every school situated within working distance of the great laboratory, which nature has already prepared for us, a laboratory that we could never duplicate indoors, however liberal the appropriation, it is not proper that we should continue to limit our biological instruction to the preserved specimen and the dissecting pan. There are many instructors who are already well on the way toward the transfer of the study of biology from the laboratory to the field, and I believe that within the near future this will be the procedure followed by all enthusiastic teachers. With this return to the study of the real, living environment which surrounds us, we must soon develop a type of observer who will see in nature, not a hodgepodge, but a living, dynamic complex of factors that but awaits analysis, and we can rest assured, I believe, that only from such observers will there arise a new Aristotle or a new Darwin to clear away our ever-increasing impedimenta of miscellaneous biological facts, and set us once more on the straight road to a true understanding of life.

LIBERTY LOAN ACTIVITIES.

A conference was held in Washington during the week beginning December 10, which lasted several days, between Secretary McAdoo and other Treasury officials and representatives from Liberty Loan organizations all over the country, which included officials of the Federal Reserve Banks.

Plans for future Liberty Loan campaigns were perfected and an organization at once wider and closer was arranged for. Rural communities and small towns and small cities particularly will feel the effect of the new campaign plans.