Elementary School Biology

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This is a report of the progress of a curriculum study for elementary pupils. The April, 1967 issue of the journal will include reviews of various curriculum projects in teaching elementary biology.

Of all the science taught in the elementary school, biology should form the largest part, and rightly so, for surely any program of science for children must help them become aware of their place in the world of living things. To give them this awareness, however, the biology taught in the elementary schools must not be the biology taught either in high school or in college, nor should it be merely a simplified version of an advanced course. Rather, it seems to us at the Elementary Science Study (ESS)*, elementary school biology must begin with the child's interest and concern and lead him to a greater understanding of the living world.

For example, children are curious about certain small white dots on carrot or parsley leaves their teacher has given them. When these dots hatch into caterpillars, the children's excitement is intense. The caterpillars grow, eventually pupate, and emerge as butterflies. This is a naturally dramatic series of events which captures the child's interest and leads him to ask a variety of questions: Will the caterpillars eat anything other than carrot or parsley leaves? How fast do they grow? How do they shed their skin? These are questions with meaning for the child who asks them, and, furthermore, they lead to some important conclusions about living things.

One of our fundamental approaches, then, is to start with the child's interest and move from there to the basic ideas of biology, physics, etc. This general approach, once determined, poses a problem for the designer of curricula. The age range of the children—from five to thirteen; the span of ability—from the very slow to the very fast; the location of the school—from Metropolitan New York to the remote areas of Washington—such diversity means that a single curriculum can never serve for all. Is it really necessary for all children to study butterflies, or crayfish, or mealworms? The answer is, obviously, no—some of these topics will be useful in some schools, some in others. Schools near the sea may want to work with marine organisms; a handy pond may lead to work with crayfish; a school in the middle of the city may use mealworms. So much of the choice of what to teach depends upon circumstances—what the teacher feels most at home with, what is available to the school, and, most particularly, what appeals to the children in the class. We suspect that there is no distinct set of study topics which will work in all situations with all children, and this is one reason why we have decided to produce a variety of "units" rather than a single sequential and integrated curriculum.

These units are designed, however, not for

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the purpose of covering all of the areas of biology, but rather to promote exploration of only those areas that are appropriate for elementary school children. Any part of biology must, nonetheless, lean heavily on broader scientific concepts. Even the simplest problem—the rate of growth of a baby gerbil or of a sprouting bean seed—involves measurement, in one case of weight and in the other of length. Indeed, one of the most important functions of elementary school teaching is to use the children's own interest in living things to kindle an exploratory spirit which will lead them to *want* to measure, draw graphs, and make comparisons. Encouraging the children's explorations in this way is important in helping them shape their developing attitudes toward science and toward many other facets of life. A classroom cage of gerbils has become the focus of the whole curriculum in many primary classrooms. The gerbils have found their way into writing, art, poetry, arithmetic, and music.

This diversification is made, however, without diluting the children's interests in biology proper, for the different facets of their experience complement one another. The children raise many questions about the life history of the animals and show great insight into ways of exploring their own questions. The major outcome here is a strong familiarity with the needs and life processes of the animals. For very young children, the central concern of biology is this observation, care, and feeding of classroom plants and animals. Perhaps it can be characterized as the discovery of the requirements for life. What do animals and plants need to survive? Do they all need the same things? This is the basis of the study of ecology brought forth in a second grade classroom. It is clear that for such experiences with animals and plants to be effective, the children have to take personal care of the living forms. If they are the teacher's plants or the teacher's gerbils, not to be touched by the children, few of these questions will arise, and very little will be gained; the children will not become involved. They must have some responsibility; but the teacher must become involved too: she must help the children to look, to pursue their questions, and, on the simplest level, to care for the animals.

With older children, the approach can become somewhat more analytical: children can measure the growth of a corn plant and, with paper strips, make a graph of its growth. Interpolation into and extrapolation from this graph, although tricky, become possible. Again, one can increase the variety of experience by introducing the microscopic world. This raises all sorts of problems about the size and structure of living things. Is an onion plant all-of-a-piece, or are there sub-units? Children find that there are a variety of sub-units, all the way from leaves, bulb, and roots, to tiny box-like cells. Whether the cells, too, contain smaller invisible units, we cannot decide.

Vertebrate animals contain a skeleton, and a bag of bones becomes an intriguing puzzle to assemble. The problem of solving the puzzle may soon lead to some questions about levers and simple mechanics. This can result in an investigation of the structure and movement of animals—the classic case of form and function. About this time children at the fifth-, sixth-, or seventh-grade levels may examine a loaf of moldy bread and wonder what mold is. Some weeks later the children may be repeating Pasteur's famous experiment with the swan-neck flask, using agar growth-tubes fashioned out of plastic toothbrush-containers instead of flasks. This can lead to the equivalent of Fleming's demonstration of the inhibition of bacterial growth by the growth of penicillium mold, and finally to the children's rediscovery of what are essentially Koch's postulates by the isolation of a fungus which kills lentil seedlings. In the older grades, children are concerned with the bending of plants, with the patterns of growth of seedlings, and with the gas exchange of plants and animals, thus arriving at the fundamental idea of photosynthesis.

In summary, then, we see the youngest children beginning their biology with the care and feeding of animals and plants, and, with age, becoming increasingly analytical, until, by the end of junior high school, they have started to investigate some problems of classical biology. We think that this sort of sequence makes sense scientifically and pedagogically. Our units, while not developed with a particular sequence in mind, do

Fig. 1. Out of the dot came this!

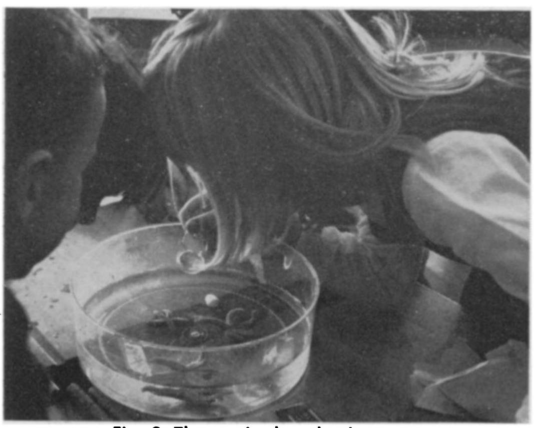

Fig. 2. The sea in the schoolroom.

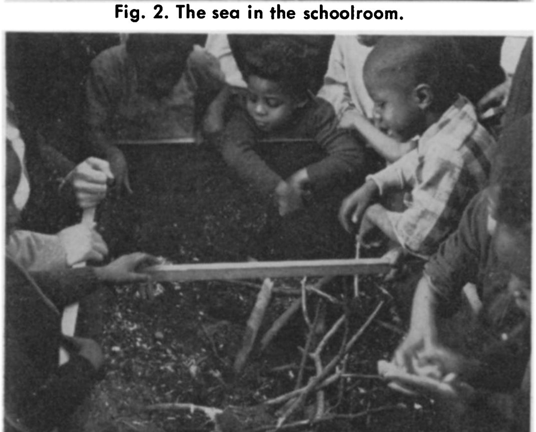

Fig. 3. Elementary ecology.

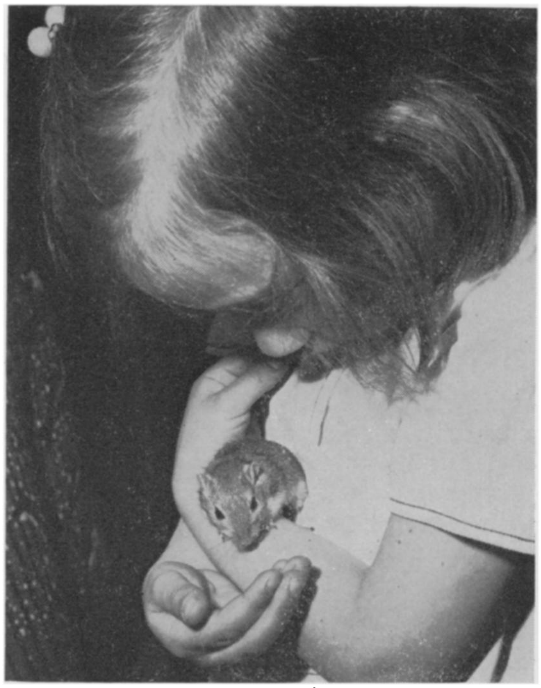

Fig. 4. Responsibility.

Fig. 5. Graphing the growth of a seedling.

Fig. 6. The microscope opens up a whole new world.

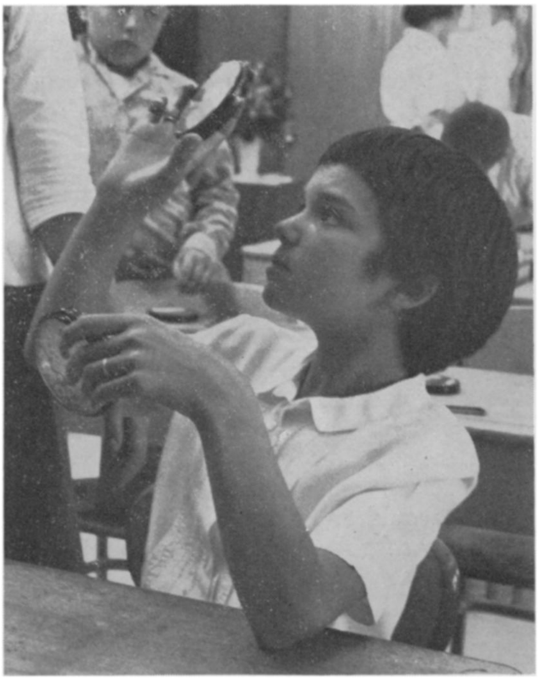

Fig. 7. A young Fleming at work.

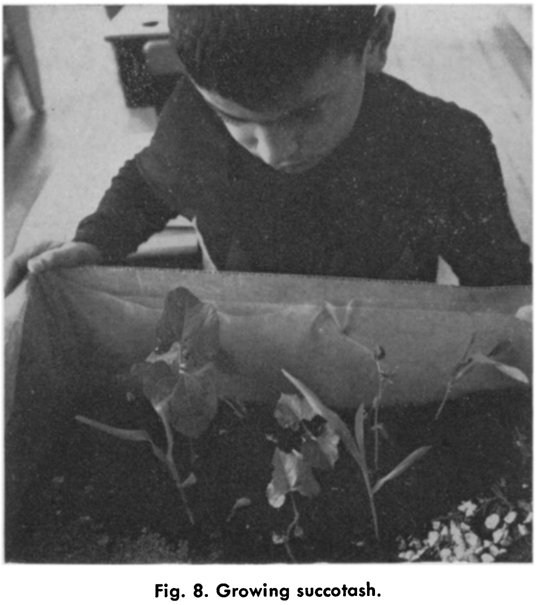

Fig. 8. Growing succotash.

follow this pattern. In the early grades *Growing Seeds* deals with the growth of a seedling. *Plant Bending* is a more analytical study for later grades—and so it goes.

One is tempted to ask the student emerging from a long sequence of units—after he has studied life forms at first hand for perhaps as many as eight to ten years—what

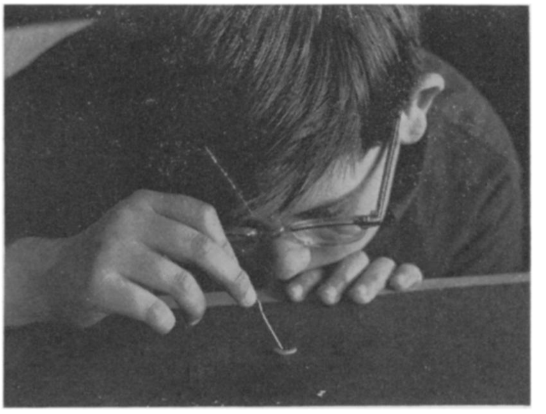

Fig. 9. The behavior of a mealworm.

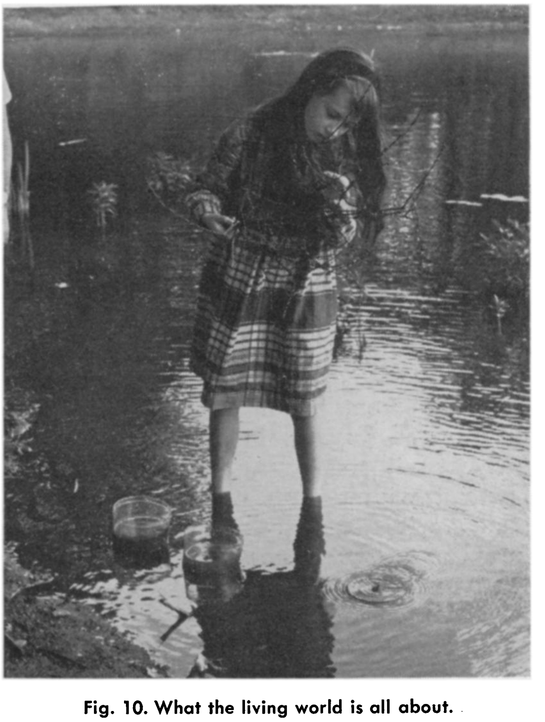

Fig. 10. What the living world is all about.

does he know of biology? What concepts has he learned? What has he gained from it all? Unfortunately, these are very difficult questions to answer, and they are difficult because the things we want the child to learn are hard to define precisely and are, therefore, even harder to measure. On a simple level, we want a child to know something of the needs and the life history of plants and animals. We want him to be aware of the complexity and interrelations of plants and animals. We want him to understand how utterly dependent he is on the living world.

Even more important than any of these, however, we want him to have an attitude about living things—a curiosity, a sympathy, and an appreciation for the living world. We feel very strongly that all these goals can be reached only by exposing children to an environment that is very rich in biological materials and not by feeding them neatly-encapsulated statements about it. Children must work with their own hands and minds; they must become acquainted with nature at first hand. We suspect that such an exposure is a necessary prerequisite to any true appreciation and understanding of the fundamental premises of biological science.

Let us consider one of these major ideas, that of evolution. No single concept is more revealing to a biologist than is the theory of evolution, yet, nowhere is it mentioned by name in any ESS material. Why not? The answer lies in the concept itself. The theory of evolution gains its power from its ability to synthesize a large body of knowledge. After one has marveled at the variety and diversity of species, after one has examined the physiology of plants and animals, in short, after one has examined life, the idea of evolution has great force. To build the other way around—to teach the theory before the facts—seems wrong to us. Such a procedure leads to a familiarity with the words but not with their meaning, with the form but not with the substance. Children are stuffed with words—ask any child if he has heard of energy, atoms, molecules, etc.—but these words are essentially without meaning for them. We are attempting to establish in children a strong and deep root system upon which the great ideas of biology can begin to grow. The major concepts of science are important because they *do* synthesize knowledge. Thus, no matter with what particular animal or plant one works, what he learns will help him understand the general concept of evolution when he comes to study it. It permeates all of biology, so that whether one studies the growth of a seedling, the behavior of a mealworm, the transport of mold spores, or the bending of a plant, one is laying the foundation on which an understanding of evolution can be built.

This very fact has profound implications for later instruction in biology, whether in high school or in college. It means that children who have been exposed to some years of this style of elementary school science can be led to synthesize their knowledge. The first real biology course they take can pull together their experience and show them where it leads in a way that has previously been reserved for specialists in biology. To do this, however, will require that high school biology teachers become familiar with what is being taught in elementary schools, that they become involved in helping elementary school teachers with these new approaches, and that they modify their own teaching to take advantage of what children have already learned.

To return momentarily to the practical side, it would be naive to believe that there are many school systems in this country that could now mount a program such as I have described. For one thing, there are not enough elementary science materials available from ESS or any of the other curriculum research projects or from publishing houses for such a program, nor are schools generally arranged in such a way that there is close contact between high school and elementary biology teachers.

It seems probable that if we are to be successful in teaching children what the living world is all about, we must have a better system of coordination and communication at all levels of instruction from kindergarten to college than we do at present. At ESS we have many teaching materials built around biological ideas. Within the next few years we hope that some of these will find an important place in the curricula of many elementary schools. Working together with curriculum officers, science supervisors, and high school science teachers, we would like to help schools find means of integrating their teaching of science in such a way that a new sort of experience in science learning becomes possible for children—one which will increase their interest and curiosity in, and their knowledge and understanding of the living world.*

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* More detailed information on ESS materials can be obtained by writing the author at the Elementary Science Study, 55 Chapel Street, Newton, Massachusetts, 02160.