Ecology and Children

By CHESTER A. LAWSON

Though man became a distinct species more than 300,000 years ago, his position as the dominant population in the world biotic community has developed only within the last 10,000 years. Early Stone Age man was dependent on all the organisms in the community for food and shelter; he lived by hunting, fishing, and collecting berries, fruits, and nuts. Man was simply one of the many predators who at times were prey for other predators. His numbers were limited by the availability of food, by disease and predation, and by other factors that operate to balance the various populations in a community. Man was a part of nature.

Then came agriculture and the domestication of animals. Man learned to plant seeds and harvest crops. He cut down the trees of the forest to extend his pastures and croplands. He learned to manipulate and change the biotic community to his advantage: plants that grew in the way of his crops were destroyed, and animals that preyed on his flock became his enemies. Food became more plentiful and man's numbers increased.

Protecting himself from heat or cold with buildings and clothing, man moved into environments to which he was not originally suited. He built villages, then towns, then cities. Cities became larger and roadways were built to connect them. Slowly man changed the face of the earth.

Throughout these events man has acted as though he were independent of nature and could manipulate it with impunity. Today he is learning that he cannot in truth physically separate himself. Pollution of air, water, and soil, the devastation of the landscape, the extermination of numerous wildlife species, and the threat of human overpopulation—all have proved the fallacy of man's belief that he can do what he wants and suffer no consequences. Whether he likes it or not, man is inseparably a part of nature.

Most of us have now come to accept ecologic problems as real and urgent. We are reminded of their existence almost daily in television reports, newspapers, and magazines. Campaigns have begun throughout the country to set up legislative pressure groups, and already many large corporations have made public concessions and implemented corrective measures. But all of these efforts will have little long-term effect unless there is general public understanding of the relationships among plants, animals, and the environment.

A Six-Year Program

The Science Curriculum Improvement Study makes a contribution to children's understanding of the ecosystem through its six-year elementary-school life-science program. In the SCIS classroom and outside, the children work directly with plants and animals. They build aquaria and terraria and observe the interactions of plants and animals. They experiment to find answers to questions about changes they

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According to the project's newsletter, SCIS is engaged in "developing ungraded, sequential physical and life-science programs for the elementary school—programs that in essence turn the classroom into a laboratory. . . . Central to these programs are current ideas of intellectual development." SCIS is supported by a grant from the National Science Foundation.

observe. Through these experiences children are introduced to the program's unifying theme—the ecosystem.

Thinking about a forest may help in understanding the ecosystem concept. A forest contains trees, of course, but it is more than just trees. Living in the shade of the trees may be many kinds of shrubs, vines, herbs, ferns, mosses, and toadstools. In addition, the forest swarms with insects, birds, mammals, reptiles, and amphibians. All of these plants and animals are tied to each other by mutual dependencies that involve food and living conditions. This multitude of plants and animals does not merely live in the forest—it *is* the forest.

But the forest is not a self-contained system: it could not persist without sunlight, water, air, and soil. The green plants need sunlight, carbon dioxide, water, and minerals in order to make food; this food helps sustain not only the plants but all the other organisms in the forest as well. The plants and animals take materials from their environment, but they also return materials to it; there is a continuous exchange between organisms and their environment. The interrelated plants, animals, sunlight, air, water, and soil constitute an ecosystem.

Although the word ecosystem is not used until the sixth year, the children in the first-year unit, "Organisms," begin their study of the life sciences with a look at a model ecosystem: an aquarium. The aquaria in the classroom provide artificial habitats within which guppies, water plants, and snails are born, reproduce, and die. As the children watch these changes occur, they begin asking questions about them. At the age of six or seven, most children are not yet able to hypothesize, predict, and design experiments on their own; but in a group—sparked by other children's ideas and led by the teacher—they can experiment and find answers to their questions. Thus, much of the first year is spent testing children's ideas: they learn that careful observation leads to ideas, and that ideas can be tested. The concepts introduced in "Organisms"—birth, death, detritus, habitat, and food web—are investigated in greater depth in later years.

"Life Cycles," the second-year unit, provides the theme around which an investigation of individual organisms is developed. Whether the children remember, years later, that the mealworm begins as an egg, develops into a wormlike larva, pupates, and emerges as an adult mealworm beetle is not as important as their realization that each individual begins his life as an egg (or seed) produced by a parent, that this egg undergoes a series of developmental changes and grows, and that the mature individual in turn produces offspring, thus beginning a new generation. By observing carefully the life-cycle stages of mealworms, fruit flies, frogs, and bean and pea plants, the children can discover some of the basic properties that distinguish between the living and the nonliving and between plants and animals.

Third Year: Populations

In the third year the children observe organisms living together. In a real ecosystem organisms are always found living with others of their own kind, in groups called populations: one never finds a

In springtime, a field trip relates classroom experiments to the real world.

single blade of grass. Nor would one find a population of grass alone: if there is a population of grass, there will be a population of grass-eaters living in the same place, as well as a population of animal-eaters preying on them.

Usually the births and deaths in any population roughly balance each other, so the size of the population remains relatively constant. If all the offspring produced each year in a population survived, the population would increase in size to the point where there would not be enough food to support it. Population explosions of this kind are prevented by predators or parasites.

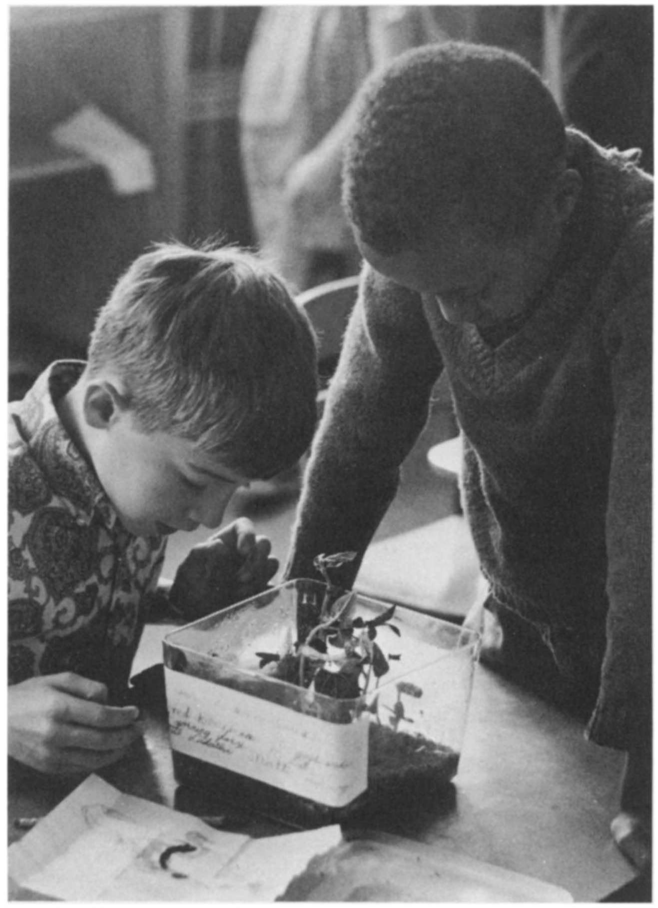
An example of what can happen when natural controls are removed comes from the story of the mule deer in the Kaibab forest, in northern Arizona. A population of 4,000 mule deer lived in the forest, feeding on small trees, shrubs, and saplings. Mountain lions, coyotes, and timber wolves, also a part of the forest community, fed on the deer. In 1906 the forest was declared a national game preserve; deer hunting was prohibited and the systematic elimination of the deer's predators was begun. The plans to increase the deer population worked all too well: in 18 years the deer population increased from 4,000 to 100,000. The forest could not support this many deer; after stripping the forest of every plant and tree within reach, the population began to decline. In two winters 60% of the deer died of starvation and disease. By 1930 the population had decreased to 20,000; by 1942 it was down to 8,000.

In the third-year unit, "Populations," the children observe dramatic increases and decreases in populations in their classroom systems and speculate about the causes. They discover the cause of decreases when they observe animals eating plants and other animals capturing and eating animals. On the basis of these observations, the terms plant-eater and animal-eater are introduced. The children picture the food relationships among the populations with diagrams called food chains and food webs.

By isolating populations of organisms and counting them periodically, the children relate population increase to reproduction. They learn that populations of plants and animals living in the same place and depending on one another for food constitute a community. (This term is more fully developed in the fifth year.)

Communities differ because of differences in the amounts of light, heat, and water—factors in an environment. Plants and animals in the desert differ from those in the forest primarily because of the amount of water available; ocean communities differ from lake communities because of the relative content of salt; and arctic communities differ from tropical communities mainly because of temperature.

Most organisms are able to grow and reproduce within a fairly wide range of any environmental factor. Thus we might find a particular kind of plant living anywhere the summer temperature ranges from 10° to 35° C. However, there is an optimum range of any environmental factor for every



Observing what happens in their terrarium.

kind of organism. Thus the largest and healthiest population of our sample plant might be found in an area where the summer temperature rarely drops below 20° C and seldom exceeds 30° C. This would be the optimum temperature range for that kind of organism. In addition, there are optimum ranges of light, water, and other factors, combining to produce the environment in which the population grows and reproduces best.

Communities in Terraria

In the fourth-year unit, "Environments," children are presented with several organisms and asked to construct terraria for them. The children observe that in some terraria certain populations increase, while in others their numbers decline. They discover that, in addition to predation and reproduction, these differences in growth and survival of organisms may be caused by too much or too little of an environmental factor.

The children experiment with isopods, mealworms, beans, clover, and other organisms to determine their responses to different intensities of several environmental factors. To conclude the unit the children again construct terraria, using their data on optimum ranges to plan a favorable environment for the organisms.

The children have now been introduced to the two major components of the ecosystem: the community and the environment. But before they investigate the interrelations of these two components they need a fuller picture of the community. A community is not made up simply of plants, plant-eaters, and animal-eaters—categories the children learned in the third year. Not all of the plants in a community are eaten, nor are all the animals captured and consumed. There are many plants and animals that simply die and fall to the earth. What happens to these organisms? They are attacked by microorganisms: bacteria, molds, and yeasts. These organisms, called decomposers, use the dead bodies for food and in the process decompose the bodies until only raw materials, such as minerals, certain gases, and water, remain. Thus a phenomenon that offends many people—a decomposing carcass or decaying heap of vegetation—is a necessary and orderly part of the process of food transfer. Were it not for these simple microorganisms the remains of dead plants and animals would cover the earth and there would be no means of returning necessary raw materials to the soil and atmosphere to be used by plants.

The children begin the study of food transfer—the major concept investigated in the "Communities" unit—by experimenting with seeds. By separating parts of seeds they learn that it is the embryo in the seed that grows, and that it does so only when attached to its food source, the cotyledon. Finding that green plants grow in the dark and in the light, as long as they have cotyledons, but that they die if kept in the dark after the cotyledons are gone—these findings introduce the concept of photosynthesis: plants manufacture food in the light. Because green plants are the only organisms in the community that can manufacture food, they are called producers.

Consumers make up the next level in the food-transfer cycle. The children observe a population of crickets eating plants in the terraria; then they add frogs, which eat the crickets. Thus the food stored in the plant is transferred to the cricket and then to the frog. But, as we stated earlier, the transfer of food does not stop here. Organisms in the terraria that die during the course of the unit are not discarded. Instead, children place them in vials of moist sand and observe them over a period of weeks. Slowly the dead plant or animal is broken down. As this happens, the children observe a fuzzy material in the vials (mold) and an unpleasant odor when the vial caps are removed (evidence of bacteria). In this way the third level of food transfer—decomposers—is introduced.

In addition to attacking dead plant and animal bodies, decomposers also feed on the wastes from these organisms. In a balanced community nothing accumulates, because waste materials produced by one kind of organism are required by some other kind of organism. This process of production and utilization of waste is a part of the balance that keeps the ecosystem going. Investigations of some aspects of this process are carried out in the sixth year.

Understanding Their Own Role

The children begin the "Ecosystems" unit by assembling aquarium–terrarium systems. As they observe these water and land communities interacting with one another, the major concepts of the previous five units are reviewed, and this sets the stage for the introduction of the ecosystem concept.

The children cannot see an entire ecosystem. What they can see is evidence of interaction between organisms and their environment. In their investigations children observe evidence of organisms interacting with water and with oxygen and carbon dioxide. The appearance of moisture on the terrarium walls initiates an investigation into the water cycle, which involves all organisms in a community. Where did the water come from? Through experiments the children discover that moisture is released from aquarium water, soil, plants, and animals. These experiences are related to the worldwide evaporation and condensation of water that make up the natural water-cycle.

Using a simple test for the presence of carbon dioxide, the children discover that their own breath contains this gas; by testing snails they learn that other animals also produce carbon dioxide. This gas production is seen as a cycle when the children discover that plants in the light use the carbon dioxide present in samples of water. Thus they have new examples of the interdependence of plants and animals: these are tied together not only by food relations but by the production and utilization of gases and the cycling of water as well.

As the children become more aware of the dependence of organisms on each other and on their environment, they can realize that any major change in the physical environment could be fatal for some organisms, and that this could lead to the destruction of an entire community. They experiment by changing the conditions of certain systems. They increase the amount of carbon dioxide in water and observe the reactions of the contained fish. They observe the effect on algae of different concentrations of fertilizer. They add large amounts of food to aquaria and observe the effect on the organisms due to the increase in the bacterial population.

These and other experiments represent some change man has made or is making in the ecosystem. They serve to introduce the concept of pollution. After the classroom experiments the children identify particular examples of pollution caused by man and discuss possible consequences.

From "Organisms" to "Ecosystems" the SCIS life-science program provides a conceptual background that enables children to appreciate the complexity and interrelatedness of the ecosystem. On this foundation they can later seek answers to environmental problems with an awareness of their own role in the ecosystem and their responsibility as the custodians of its future.