Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Biosphere II

Curriculum Unit 92.05.05
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The purpose of this unit on Biosphere 2 is to contribute to our understanding of life on Planet Earth and the potential for life beyond it. This unit will look at Earth "Our Water Planet" and see what roles the water cycle and biogeochemical cycles play in maintaining balance on the planet. It will also examine a closed system, such as Biosphere 2, to facilitate our understanding of how these cycles work.

The unit is designed to be taught to students in grades 5-8. It will contain subject content, lesson plans, resource list, field trips, teacher and student reading lists and a bibliography.

After studying this unit, it is my desire that teachers and students will have a better understanding of the planet and our roles as caretakers and as inhabitants of the planet Earth.

The study of Biosphere 2 will help students understand the integration of many disciplines, such as science, engineering, business, art, agriculture and much more.

Students will also get the opportunity to observe and do several hands-on activities. Some of these activities will be bottle biology projects. This will give students new insights about the planet and their relationship to it.

Biosphere 2 will be used as a tie-in to the curriculum to help students, as well as teachers, understand more about life on Earth and to better manage Earth's resources. Students will learn how human, plant and animal life is affected by environmental problems. They will discover that the formation of the Earth is a unique suitable home for life compared to other planets.

The unit will raise the level of awareness to recognize that natural and human events will impact on the health of the planet and that various remedies are available.

The students will become aware of environmental impacts of technology and technological aids to environmental clean up. They will explore the relationship between technology and cultural change; the impact of people working in groups to effect change and that interdependence of economic growth and environment preservation is a natural phenomenon.

BIOSPHERE

The biosphere is the relatively thin stratum of the Earth's surface and upper water layer that contains the total mass of living organisms, which process and recycle the energy and nutrients available from the environment. The whole Earth is an ecosystem, a system of give and take among plants, animals and their surroundings. As in any system, whatever happens to one part of an ecosystem affects its other parts. Materials are cycled from soil, water and air through the plants and animals and then back to the soil, water and air.

The energy that operates the ecosystem originates in the sun. This solar energy is trapped by green plants in the food they manufacture during the process of photosynthesis. The energy is needed to hold atoms of carbon, hydrogen, oxygen, nitrogen and other elements together in the compounds we call food. As the food is used by the plants, by animals that eat the plants and by animals that eat other animals, energy is released and used. As carbon and other elements are cycled through the plants and animals and back into the soil, water and air, energy dissipates.

An understanding of the biosphere involves the study not only of its constituent organisms but also the cycles by which energy and essential substances are transferred among species and between the biotic and abiotic segments of the environment. Photosynthesis, for example, the first stage in the conversion of solar energy into usable nutrients, operates at maximum efficiency of three (3) per cent. At each stage in the transfer of this energy through the consumption of plants by animals, efficiency declines. In order for an organism to make the most efficient use of the energy it consumes, it must regulate its activity within an environment that supplies the temperature and the amounts of sunlight, water, and essential elements optimal for its species.

As energy flows in a single direction from solar radiation through plants and animals to humans and is dissipated at each successive stage, the chemical elements essential for life cycle through the biotic community. Gaseous elements are generally transferred through the atmosphere or hydrosphere, and the mineral elements such as magnesium, boron, sulfur, calcium, potassium, and phosphorus are absorbed through the soil and transmitted by water to plants and animals. Oxygen, for example, is cycled as an element of water and of mineral compounds, and it is released into the atmosphere in its free form by photosynthesis.

Most important of all, perhaps, is the cycle of water, a substance necessary for all life forms and a principal determinant of the climatic conditions suitable for each species. Water is circulated primarily through evaporation and precipitation and distributed chiefly as a liquid over much of the Earth's surface, or as atmospheric water vapour. It is absorbed directly by plants and animals in both liquid and gaseous states and is released through respiration, perspiration, elimination, and, in plants, transpiration. Besides its importance as a component of all organisms, it also serves as a medium for the transference of nutrients and assists in the regulation of internal conditions such as body temperature.

WATER CYCLE

Much of our planet Earth is covered with water. Almost eighty (80) percent of the Earth is covered with water. Most of the water on Earth, about ninety-seven (97) percent, is in the salty oceans and seas. Another two (2) percent is frozen in glaciers and ice around the North and South Poles. The remaining one (1) percent of the fresh water is found in rivers, lakes, streams and in aquifers under the ground. Water is continuously recycling

in a process called the hydrologic or water cycle.

Sometimes we call water by its chemical name, H2O, which means each water molecule is made up of two (2) atoms of hydrogen (H) and one atom of oxygen (O). Heat energy from the sun causes the liquid water to change into its gaseous form, water vapor, through evaporation happens constantly from lakes, rivers, oceans, etc. Water vapor enters the atmosphere in other ways. Water evaporates from the surface of leaves in a process called transpiration. The amount of water moving from the ground through the leaves of plants and into the air depends on factors such as: temperature, light, wind, and the amount of water in the soil.

When water vapor enters the atmosphere and rises, the water vapor cools because the air is cooler. Particles of dust and salt attract the water molecules. The water gathers together in larger and larger droplets and forms clouds. This change from vapor back into liquid form is called condensation. Condensation is the opposite of evaporation. Condensation will occur whenever warm air comes in contact with a cold surface.

When enough water droplets collect, the cloud turns grey. When conditions are right, water will fall from the clouds back to Earth is some form of precipitation such as rain, sleet, hail or snow.

Air currents carry air pollutants. Sulfurdioxide and nitrogen oxides cling to water molecules in the air producing sulfuric and nitric acids. The acids, mixed with water vapor, fall from the sky as acid rain. This type of pollution can kill fish and plants, erode buildings and may seriously affect drinking water. Scientist are working on finding a solution to this problem. The movement of water from the Earth to the atmosphere and back to the Earth is the hydrologic cycle. Evaporation, condensation, and precipitation are the three major parts of this cycle. See figure 1.

THE CARBON CYCLE

All living things can be found on or near the surface of the Earth. Accept for the sun's energy, all their needs are supplied by the small proportion of the Earth's resources contained in thin layers on the Earth. If the water, oxygen and other elements vital for life were only used once, they would soon run out. This is why many of nature's processes work in cycles. There is a constant exchange of the elements between air, earth, water, plants and animals. These recycling processes ensure that all living things are able to live and grow. [1] Carbon is constantly circulating in many different forms through living things, the soil and the atmosphere.

The sun provides light, warmth, food and oxygen. Green plants use solar energy to make food from carbon dioxide and water. As the plants do this, they release oxygen to the environment.

The green plants use the food themselves and, in turn, nourish many other living organisms, including man. The energy from food is really chemical energy produced from solar energy by plants.

Carbon dioxide in the atmosphere plays an important role in warming the Earth by trapping the sun's heat, in what is called the greenhouse effect. The burning of fossil fuels has greatly increased the amount of carbon dioxide in the atmosphere. [2]

The future effects of this buildup on global temperatures can only be guessed at. Nature's cycles are relatively stable. Any changes that do occur take place within certain limits. Although there may be minor variations, the

cycles continue and life goes on. Man's activities are fundamentally changing the environment and disturbing cycles in nature. See figure 2.

(figure available in print form)

Figure 1: Reprinted by permission from *Exploring The Water World* , 1991: Regional Water Authority Education Programs.

(figure available in print form)

Figure 2: Carbon is constantly circulating in many different forms through living things, the soil and the atmosphere.

BIOSPHERE 2

The self-contained sealed environment known as Biosphere 2 is located in the Sonoran desert in Arizona. The four men and four women inside it at the beginning of 1991 are committed to a two year experiment in life and living. This project is designed to be a hundred-year experiment. The future is unknown and in science it is not certain as to what might happen. There is no way of predicting exactly which and how many of the thirty-eight hundred species Biosphere 2 contains will survive. What Biosphere 2 will mean, will reveal and will prove in the end we can only guess at. The story of Biosphere 2 begins ten thousand years ago with the origins of agriculture, when man first began making human-controlled ecosystems and exploited the surplus energy thus made available to create cities and develop technology. People's impact on the natural world has increased since that time at what seems to be an ever accelerating rate. [3]

Biosphere 1, Earth, solar powered, 3.8 billion years old, two trillion living tons networked through thirty million species contains our past, present and destiny. Biosphere 2, scientific model and symbol, helps us understand life and, therefore, ourselves. [4]

Biosphere 2 is open to energy inputs: sunlight provides the basic energy for ecological systems and electrical energy for technical systems. Heating and cooling would be generated outside the Biosphere and delivered to the inside. Just as Earth sends and receives radio waves, light beams, and communications to and from vehicles in space, the Biosphere would also be open to information exchange.

A significant purpose of the experiment is to create a dialogue between the biosphere and Earth and another biosphere and make comparisons which had never before been possible. [5]

The rules of the house of Biosphere 2 are much the same as those for ecosystems of the Earth. People living in Biosphere 2 must earn their keep, performing some useful functions in the ecosystem. All the work of the ecosystem has to get done and all the functional niches must be filled. [6]

MANAGING THE WATER CYCLE ON BIOSPHERE 2

Earth's biosphere depends on a natural water cycle. Energy from the sun evaporates water from lakes, oceans, and other bodies of water. Water vapor builds up in the atmosphere, clouds form and become saturated, rain falls, which feeds streams and rivers that eventually return the water to lakes and oceans. Biosphere 2 is too small to ensure the complete natural water cycle. The job of managing the water cycle was made more difficult by the demands of controlling levels of acidity and alkalinity; acidic water flowing from the rainforest would affect the neighboring Savannah, whose plant life depends on less acidic water. Fresh water also would flow into the ocean, making necessary a method for recovering fresh water again or else all the fresh water in the wilderness would eventually mix with the sea water, leaving brackish brew. A design was settled on to wed mechanical systems with natural forces, supplementing the natural evaporation from the ocean with a system to desalinate the amount of water needed to maintain the fresh water reservoir.

The closest thing to rainfall expected in the Biosphere 2 was an artificial cloud in the top of the rainforest biome generated by pumps misting nozzles, a necessity to maintain the health of rainforest species accustomed to high humidity, and the condensation on the glass and glazing that would drip. The drip and fog will modestly feed a pool atop the rainforest mountain, whose major inflow will come from water pumped out of the reservoirs in the basement. The pool feeds the rainforest stream, which meanders toward the Savannah. Before reaching the Savannah, most of the water in the rainforest stream will be diverted to pipes leading it back to the basement reservoirs, recycling it within the rainforest. [7]

THE QUALITY OF BIOSPHERE 2 ATMOSPHERE

There were two scenarios posed about the quality of Biosphere 2 atmosphere. The first scenario hypothesized that if there were too many plants in relation to animals, the vegetation might drastically reduce all the carbon dioxide. Then, when the concentration of carbon dioxide had dropped to fifty to one hundred parts per million, many plants except for some survivalist species that evolved genetic capacities to process lower levels would stop growing. So comparatively few animals could live there. [8] The other scenario would happen if there were too many animals. When carbon dioxide levels increase, plants respond to that richer diet by photosynthesizing at an increased rate. But the response is slow. In small closed areas animals could deplete all of the oxygen and die before plants had a chance to replenish the supply. Long before this could occur humans might start suffering the effects of too much carbon dioxide in the air, which may become unhealthy for humans at levels of ten to twenty thousand parts per million. [9]

BREATHING ON BIOSPHERE

The build up of trace gases could kill the inhabitants of Biosphere 2. Even in nonlethal doses, carbon monoxide, nitrogen oxides, and other such gases affect health; gases such as methane are flammable. A structure the size of Biosphere 2 will have numerous sources of trace gases. Plastics, paints, sealers, and other materials used to build the structure of Biosphere 2 will slowly release various hydrocarbons. Hot lubricants will produce carbon monoxide. Electrical sparks will generate nitrogen oxide and ozone. Livestock produces methane and other gases. Plants will produce ethylene, a hormone affecting flowering, fruit

maturation, senescence, and wound response. If ethylene were not cleaned from the air, it would prematurely stimulate plants into life cycle changes. Composting of cabbage, turnips, kale, and other crucifer vegetables will also produce sulfur dioxide. This might give rise to actual acid rain. Some trace gases, such as methane, break down naturally, high in Earth's atmosphere but this is not expected on Biosphere 2.

The principle that was worked out on Biosphere 2 is simple. Soil properly aerated, contains vast surface area coverted by a living carpet of bacteria and fungi. By pumping air through the soil beds microbes would consume trace gases quicker, digest them, and release carbon dioxide and water. In Biosphere 2, this could be accomplished by pulling air with fans and blowing it through it. By using the soil in the agricultural area, that is giving it a dual purpose, the Biosphere 2 wouldn't have to increase in size. The air would pass up through the soil, rejoining the Biosphere 2 atmosphere among the potatoes, beans greens, and cucumbers. As the air passed through the soil, the microbes' insatiable appetites would ensure clean air. [10]

ENERGY

The Energy Center for Biosphere 2 is a two story building made up of a series of opaque vault structures similar to those glassed vaults that enclose the agriculture unit of Biosphere. The Energy Center produces the hot and cold water for heating and cooling, which is accomplished by piping of hot and cold water into the Biosphere 2 to the airhandlers, which would cycle air as needed to cool or warm it. Those waters and the inside of the pipes carrying them are outside of Biosphere 2, permit changes of heat playing a part in Biosphere 2's energetic openness. [11]

With a complete power failure in summer, the greenhouse effect could quickly shoot the temperature inside to uninhabitable extremes. If it's one hundred (100) degrees Fahrenheit outside, in less than an hour it could go up to one hundred and thirty (130), forty (40), or even one hundred and fifty (150) degrees Fahrenheit inside. Plants could die. The heat would force Biosphere 2 crew to break closure and get the animals and themselves out as fast as possible. To prevent power loss, the Energy Center has three generators. The total capacity is about 5.5 megawatts, but Biosphere 2 could probably operate adequately on only a third of that. It would take four separate and simultaneous failures and all three generators plus the power utility for Biosphere 2 to completely lose its electricity.

EATING WELL ON BIOSPHERE 2

Organically grown, chemical-free ingredients will be grown on Biosphere 2. The processing area in the basement is stocked with threshers for grains, mills for grinding everything from wheat to coffee, presses for extracting peanut oil and sugar, coffee and peanut roasters, huller, seed cleaners, drying ovens, and storage bins. The kitchen offers a conventional oven and electric range, a broiler arrangement with the heating element above to reduce smoke, a microwave, a cuisinart, coffee grinder, and the usual assortment of gadgets. The ingredients in the tropical garden is of fine cuisine, from french herbs to tropical garden thyme, coriander, parsleys, lemon grass, sage, garlics, onions, cloves, nutmeg, sesame, ginger, horseradish, peppers and chiles.

There are two cacao trees in the rainforest to tap for a small supply of chocolate. A good selection of dwarf coffee trees, produces good crops of beans. For flour they'll have rice and several types of wheat, including both pasta and bread wheats. There's a machine to process the pasta, too. [12]

DAILY LIFE

The daily lives of the biospherians will be a little different from their lives in Biosphere 1. The doctors will be monitoring their ache, their every stumble and their every calorie of food. Reporters will be watching for every puzzle or problem that may signal a crisis. They will even have video cameras installed around the wilderness biomes and the agricultural biome that can be turned on and off by Mission Control. One modern convenience that will be left behind is toilet paper. The waste disposal system will not be able to handle the problems of decomposing the quantity of toilet paper that eight people will produce. They simply wash off in the traditional European style. Showers are available; they'll have to use less water than they may have been accustomed to. The ration of water per person per day has been worked out. [13]

Wastewater from showers, sinks, laundry tubs, and toilets flows into the gravel of the first of three tanks, where microbial and filtering action breaks down solids. The water then flows into the second tank where plants and microbes work together to break waste down further and use them up as nutrients. In the third tank, more pond than marsh, the water receives a final level of biologic treatment before it is pumped into a utility water tank where it is stored and later used to irrigate agricultural crops.

All residents are expected to put a couple of hours of work into some part of the agricultural area every morning. They must also monitor a mechanical system on the scale of the innards of a cruiser. Observations will be made in the wilderness biomes every day as well. Observation in the wilderness will tell them when it should rain and when to lower the temperature. Observations will also help let them know when to alter the tides. The biospherians have to make sure the pH of the ocean, the marshes, and the stream stays within acceptable ranges to avoid any inadvertent, unnecessary extinction. The hummingbird feeders must be replenished regularly, as well as supplemental food processed and made available to other inhabitants of the wilderness biomes, such as the galagos, until it is certain that the system has reached adequate production rates. [14]

The daily cycle of activities is not simply a sequence of chores; it is a way for the biospherians to manage themselves. Everyone is engaged in the care of both the habitat and the agriculture, as well as the Biosphere as a whole. [15]

PRETEST-POSTTEST

BiosphereII

Circle or fill in the blank the best answer for each of these statements.

1. Another name for the water cycle is the _____ cycle.

a. transpiration b. percolation c. hydrologic

2. Water that falls from the atmosphere to the Earth is called.

a. evaporation b. condensation c. precipitation d. dew

3. The process by which water changes to a gas is called.

a. condensation b. evaporation c. precipitation

4. The process in which water vapor changes to a liquid is called.

a. precipitation b. evaporation c. condensation

5. The space between particles of soil is called.

a. pore space b. zone of aeration c. surface runoff

6. The increasing amount of _____ gas in the atmosphere is a concern to scientists because it might make temperatures around the Earth higher.

a. nitrogen b. methane c. carbon dioxide d. oxygen

7. Water stored in the ground is called.

a. crevasses b. groundwater c. meltwater

8. The process by which Earth's atmosphere is heated is call the

a. coriolis effect b. convection effect c. relative humidity d. greenhouse effect

9. Nature's process work in cycles. _____ are cycles in nature.

a. carbon b. nitrogen c. water d. all of these

10. Water pollution affects

a. wildlife b. drinking water c. all of these

Answers: 1c, 2c, 3b, 4c, 5a, 6c, 7b, 8d , 9d, 10c

LESSON PLAN I

Objective The student will learn how moisture gets into the air.

Experiment Moisture evaporates from soil.

Procedure Fill a flower pot with moist soil and place it on a pair of scales. Either balance the pot of soil with weights or observe its weight. Observe its weight again after twenty-four hours.

Flower Pot With Soil

Weight of soil when balance Weight

Weight of soil after twenty-four hours Weight

What have you observed?

Write your conclusion.

LESSON PLAN II

Objective The student will learn how moisture comes out of the air.

Experiment The Water Cycle.

Procedure Heat some water until it is near the boiling point. Place it in a drinking glass and rotate the glass so as to moisten the sides right to the top. Place some very cold water in a round flask, such as one made from an electric bulb or a Florence flask. See diagram at the bottom of the page.
Write your observation.

Water will evaporate from the hot water, condense on the cool surface of the flask and fall back in droplets into the glass.

Write your conclusion.

This experiment will demonstrate evaporation, condensation and precipitation. This is how the water cycle goes on in nature.

(figure available in print form)

LESSON PLAN III

Objective The student will give examples of the three basic forms of interrelationships that occur within an ecosystem: biotic-biotic, biotic-abiotic, and abiotic-abiotic.

Background An ecosystem is a defined area that is composed of specific types of living things and their physical environment. Ecosystems can be a fish aquarium with a few living plants or the whole Earth with all its living things. The living Earth is called our biosphere.
Most ecosystems are open, which means that interactions often occur between the boundaries of the two ecosystems.

Procedure Divide students into cooperative study groups. Groups are to decide on an ecosystem such a forest, desert, lake, mountain, pond, etc. The students will list living and non-living factors that are associated with that ecosystem, for example, in a desert living factors include sand, hot temperature, etc. Each group should list at least ten (10) living and five (5) non-living components. Students should then think out ways all of these factors interact and describe at least two relationships for each of the following types of interactions.

BIOTIC-BIOTIC ABIOTIC-BIOTIC ABIOTIC-ABIOTIC LIVING/LIVING NON-LIVING/LIVING NON-LIVING/ NON-LIVING

LESSON PLAN IV

Bottle Biology

Objective The student will learn the effect of soil on growing things.

Experiment Get sample of a fertile soil from a flower or vegetable garden, from a wood, from a sandy place, or from a clay bank. Place the samples in bottles or glass jars. Plant seeds in each type of soil and give each the same amount of water.

Observation Which type of soil did the seed sprout first?

Type of soil Bottle 1 Bottle 2 Bottle 3 Bottle 4
Flower/Vegetable Wood Sandy Place Clay Bank Write you conclusion.

LESSON PLAN V

Problem-Solving

Objective The student will discuss ways of solving the problem of the waste disposal system on Biosphere 2.

Problem Toilet tissue is not used on Biosphere 2 because the waste disposal system is not able to handle the toilet paper for eight people. Suggest ways in which the waste disposal system on Biosphere 2 will be able to manage toilet paper in its system.

Procedure Students will divide into groups of four to discuss possible solutions to the problem. Each group will list at least three ideas and then choose what they think is the best solution. Solutions will be listed or charted for each group. Further investigation will be done to initiate hands-on activities.
Biosphere 2 Waste Disposal System Suggestion 1 Suggestion 2 Suggestion 3 Best Solution

Resource List

Yale Forestry and Environmental Studies Library

1205 Prospect Street, New Haven, CT 06511

Choice , February, 1992 feature “Global Change a Bibliography Essay on Scientific and Related Serials.”

United State Department of Energy, Office of Energy Research, Office of Basic Energy Sciences Carbon Dioxide Research Division.

“Atmosphere Carbon Dioxide and the Global Carbon Cycle”, Forestry Library Qc879.8 +D4724 (cc)

Video

American Water Works Association (available on loan through the Regional Water Authority)

“What Do You Know About H2O” (22 Min.)

“Always Pure Never Dirty” (17 Min.)

“Water Follies” (7 Min.)

The American Water Works Association have materials on water available. Write to:

Youth Education Manager

American Water Works Association 6666 West Quincy Avenue Denver, CO. 80235 The people of the Global Relief Organization promote the planting of trees to improve the environment and to solve global warming problems. They believe that you can make a difference by planting trees. You may get further information by writing to:

Global Relief

American Forestry Association P.O. Box 2000 Washington, D.C. 20013 Start a recycling program at work or school. Contact:

Keep America Beautiful	World Resources Institute
9 Broad Street	1709 New York Ave
Stamford, CT. 06902	N.W., Suite 700
	Washington, D.C. 20006

FIELD TRIPS

Beardsley Zoo in Bridgeport, CT. is a thirty-three (33) acre facility nestled in a park setting. The majority of its exhibits are devoted to the rare and wonderful animals of North and South America. The Beardsley Zoo is open year-round from 9a.m. to 4 p.m. every day except Christmas, Thanksgiving, and New Year’s Day. Admission is charged. For schools trips contact: Beardsley Zoo—(203) 576-8082

New Haven Water Co.

Museum at Lake Whitney Whitney Ave. Hamden, CT. Students will learn about water and how it is supplied to their communities. They will learn and do hands-on approach to science, bottle biology and much more. This is a trip worth taking. Bus service is available through the New Haven Board of Education, Department of Transportation, 9:00Ð12:00 p.m.

Schooner Inc.

Long Island Sound City Point New Haven, CT Students will learn about the Long Island Sound, its plants,

animals. They will learn hands-on approaches to looking at and studying the ecosystem.

Sleeping Giant Park

Hamden, CT. Contact: Sleeping Giant Park Association Students will tour nature trails. There are seven (7) official hikes in the Spring and seven (7) in the Fall.

GLOSSARY

Abiotic: nonliving part of the environment **Acid Rain:** precipitation having a pH value less than that of normal rainfall (5-5.6 average). Pure water has a pH of 7. Acid Rain is caused mainly by the burning of fossil fuels such as oil and coal and from exhaust gas from cars and trucks. **Aquifer:** an underground layer of rock, sediment or soil that is filled with water. Water moves through the aquifer very slowly. **Atmosphere:** mixture of gases (air) that surrounds the Earth. **Bacteria:** microscopic one-celled organisms. Some are helpful. Harmful bacteria may cause disease. **Biotic:** living part of the environment. **Cloud:** a visible mass of fine water droplets or ice particles flowing in the air. **Condensation:** the process in which gas changes to a liquid form. **Contaminant:** a chemical that make something impure, infects or makes something else impure. **Dissolve:** condition where solid particles mix, molecule by molecule, with a liquid, and appear to become part of the liquid. **Ecosystem:** all the parts of a certain environment, including the plants and animals, soil, water, air and the sun energy. **Environment:** everything that surrounds a living thing. **Evaporation:** the process in which a liquid changes to a gas. **Factors:** things to consider which might influence or change a result. **Fresh Water:** water that is not salty. **Glacier:** a large mass of ice formed on land. Glaciers move downslope or outward between soil particles or cracks and crevices in rocks. **Hydrologic Cycle:** the water cycle in which water continuously moves from the Earth to the atmosphere and back. **Molecule:** the smallest part of a substance that still resembles that substance; it is usually made up of two or more atoms. **Organism:** a complete, living individual (plant or animal) which may have one cell or many cells. **Pollutants:** contaminants that produce undesirable effects on the environment. **Precipitation:** water from the atmosphere which falls as rain, hail, sleet or snow. **Recycle:** use again. **Runoff:** rainwater or snowmelt which flows over the surface of the ground without seeping into the soil. **Sediment:** pieces of rock and soil produced by weathering and erosion. **Spring:** groundwater seeping or flowing out of the Earth. **Surface Water:** all water, fresh and salty, on the surface of the Earth. Oceans, glaciers, and lakes are examples. **Suspended:** supported or kept from falling through the air or water. **Technology:** knowledge which is used to make products or objects which make life easier. **Transpiration:** a process by which living plants give off water vapor into the atmosphere. **Water Table:** upper limit of the zone of saturation. **Water Vapor:** water in its gaseous state. **Zone of Saturation:** the part of the ground below the water table where all the pores in the soil and cracks in the rocks are filled with water.

Notes

1. Spurgeon, Richard, Usborne Science & Experiments, *Ecology* , Usborne, Spain, 1988, p. 12.
2. Ibid, p. 13.
3. Allen, John, *Biosphere 2 The Human Experiment,* Penquin Books, N.Y., 1991, p. 1.
4. Ibid, p. 33.

5. Ibid, p. 35.
6. Ibid, p. 35.
7. Ibid, p. 69.
8. Ibid, p. 85.
9. Ibid, p. 86.
10. Ibid, p. 86.
11. Ibid, p. 123.
12. Ibid, p. 132.
13. Ibid, p. 133.
14. Ibid, p. 134.
15. Ibid, p. 135.

STUDENT READING LIST

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Lehane, M.S. *; Science Tricks* , New York: Franklin Watts, 1980.

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