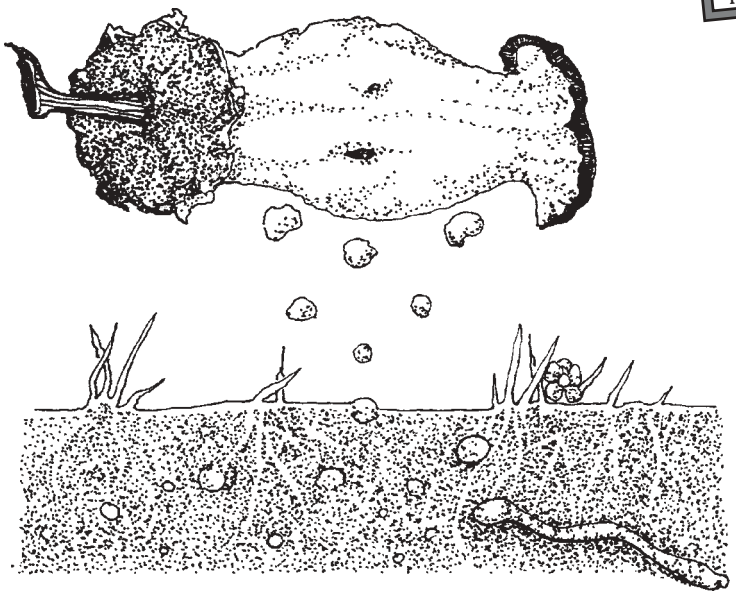
From Apple Cores to Healthy Soil

LEVEL: Grades 2-8
SUBJECTS: Science, Language Arts
SKILLS: Comparing similarities and differences, concluding, controlling variables, demonstrating, developing vocabulary, discussing, experimenting and testing hypotheses, interpreting, listing, observing, predicting, recording, role-playing, writing



BRIEF DESCRIPTION

A composting experiment reveals to students how soil organisms, temperature, air, and water are able to decompose organic waste and enrich soil.

OBJECTIVES

(Note: All four objectives are appropriate for older students; younger students may accomplish only the first three objectives.)
The student will:
- list three reasons for recycling organic waste;
- name four specific organic wastes that will decompose in soil;
- construct a controlled experiment investigating how temperature, air, water, and soil microbes work together in soil to decompose organic waste; and
- describe the nutrient cycle.

ESTIMATED TEACHING TIME

Session One: 45 to 60 minutes.
Session Two: 30 minutes.
Sessions Three to Ten: 30 minutes and short observations over several weeks.

MATERIALS

A bucket of soil from a garden (not commercial potting soil) or from under a rotting log or a layer of decaying leaves; trowels or large spoons; serrated knife; measuring cup; hand lenses or magnifying glasses; white paper; medium-size interlocking plastic blocks, Play-Doh®, or modeling clay; two gallon-size, self-locking plastic bags or other covered see-through containers; enough organic waste to half fill two gallon-size plastic bags: dead leaves, small twigs, vegetable or fruit bits, cores and/or peels (try to include orange peels), grass clippings; transparencies and photocopies of the attached ***A Soil Ecosystem***, ***Nutrient Cycle***, and ***Compost Observation Log*** sheets. **Optional**: microscope, wet-mount slide.

VOCABULARY

aeration, compost, decay, decompose, ecosystem, humus, microbes, nutrient, nutrient cycling, organic, recycle, soil pores, variable (experimental and controlled), waste

RELATED LESSONS

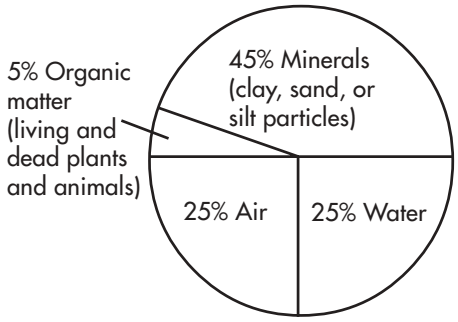
Soil Is Not Trivial
Trash Bashing
Perc Through the Pores
Till We or Won't We?

SUPPORTING INFORMATION

Soil is much more than "just dirt." Life on Earth directly or indirectly depends on soil for food. Most plants get many of their nutrients from the soil they grow in. Animals get their nutrients by eating plants or other animals that are plant eaters.

There are many different kinds of soil. They contain minerals, air, water, and organic matter (bits of decaying plants and animals). The nutrients that plants need are in this organic matter. The proportion of nutrients found in the soil varies; however, a typical soil is 45 percent minerals, 25 percent air, 25 percent water, and 5 percent organic matter. Soil contains many living organisms interacting with each other, which is an example of an ecosystem. See the following diagram and ***A Soil Ecosys-***

tem sheet. The ***Soil Ecosystem*** illustrates a close-up of a hypothetical soil and includes living organisms, the nonliving components of soil, and a circular enlargement of microorganisms. (It shows the kinds of organisms students may or may not find in their soil sample in Session One.)



Soil Diagram

Organisms that were once living, such as plants and animals, make up the organic portion of the soil. Organic matter also contains millions of living microscopic organisms called microbes. Microbes include bacteria, fungi, algae, protozoa, and yeast. Microbes, which decompose organic matter in soil, provide nutrients for plants to grow.

Soil is important not only for growing plants, but also for other forms of life. Living animals and microorganisms in the soil, temperature, air, and water work together to break down or decompose organic matter into simpler elements or compounds. Many microbes use organic matter as a source of food and water to multiply and grow. Soil is nature's great recycler, getting rid of much of Earth's organic waste and turning it back into something useful again - healthy, enriched soil.

This nutrient cycle is very important for students to understand. Nutrients are constantly being transferred between organisms and their environment in a cyclical manner. Plants gather the nutrients they need from the soil and air. The animals in turn eat the plants for their nutrients. Animal urine and excrement provide nutrients for soil. When animals or plants die, they become the organic matter that microbes need to produce the nutrients for the plants. This cycle is an ongoing process.

A compost pile is a contained place in which microbes and other living organisms can help to decompose organic waste. Composting gives us an opportunity to get rid of our organic wastes by recycling them in an Earth-friendly way. Compost piles can:

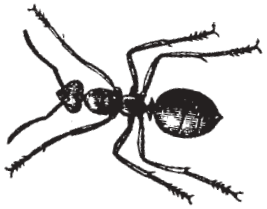
- speed up the natural decomposing process and give us an opportunity to observe the process;
- greatly reduce the amount of waste that goes to landfills, where it does <u>not</u> decompose, but is merely contained;
- reduce the number of plastic bags that would normally be needed to take everything to the landfill; and
- leave us richly fertilized soil for our houseplants, gardens, or fields.

The decomposition process does not occur overnight. It can take from 10 weeks to six months for organic materials to decompose. The rate of decomposition depends on air, moisture, temperature, and the type and size of organic waste. Without adequate aeration (supply of air), most decomposing organisms cannot function properly. Given sufficient air and water, the organisms generate a temperature of up to 150 degrees Fahrenheit and literally "cook" the waste. Compost piles are "turned" to aerate the pile and to reduce the internal temperature. If the temperature gets too high, spontaneous combustion will occur. Smaller, more porous organic waste will decompose faster than large pieces.

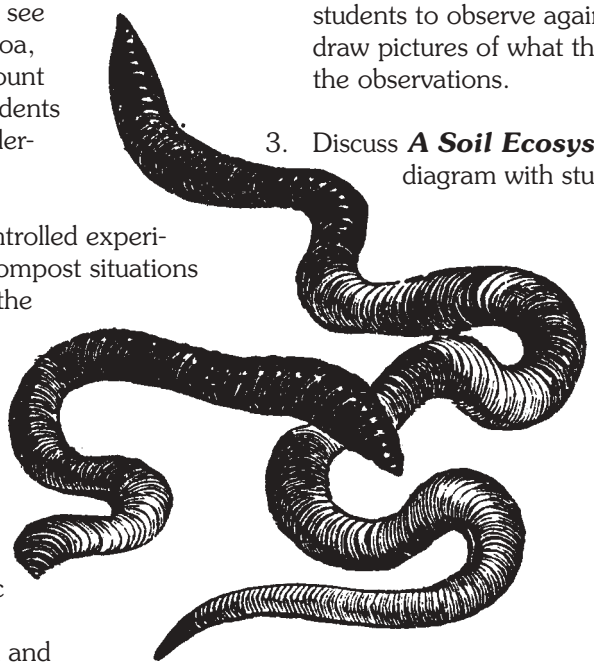
Composting, which includes the use of worms is called vermicomposting (or vermiculture). Worms speed up the breakdown of organic matter by eating the waste and aerating the compost pile. Under favorable conditions, worms eat as much as they weigh each day. The organic matter eaten by the worm is ground up and leaves the worm's body as waste in the form of dark castings (worm excrement). These castings are rich in nutrients (nitrogen, phosphorus, potassium) important for plant growth. Large-scale vermicomposting or vermiculture projects are in progress in several states within the United States as well as in several countries throughout the world. These projects use thousands of worms to compost larger portions of organics in the residential and commercial waste streams. For example, in an experiment in a Florida landfill, more than 175,000 earthworms (100 pounds) were used on a stack of trash 8 feet wide, 30 feet long, and 5 feet high.

What goes into a compost pile? You can add anything organic. (Do not include meats, fats or cheese.) Ideal candidates for a compost pile are:

- soil
- coffee grounds
- twigs
- egg shells
- grass clippings, leaves
- wood shavings
- vegetable and fruit scraps and peelings



During this lesson, students will be examining soil samples, feeling soil particles, and possibly observing some of the visible organisms present in soil. They might see small insects, worms, nematodes (small, elongated, cylindrical, free-living worms), molds (a colony of fungus cells of any color), and some partially decomposed organic matter (bits and pieces of roots and leaves). If students use magnifiers, they will be able to examine the soil samples more closely. But even magnifiers will not enable students to see soil microorganisms, bacteria, protozoa, and small fungi. If available, a wet-mount slide under a microscope will give students the opportunity to see and better understand microorganisms.



The students will be conducting a controlled experiment. Students will create different compost situations in order to investigate the actions of the Soil Recycling Team (microorganisms, temperature, air, and water). The controlled variables are soil (where microorganisms live), temperature, air, and organic waste. Have students keep the controlled variables the same in both situations. They will measure the same amounts of soil and organic waste into each gallon-size bag. The experimental variable that is different and manipulated in one set is water. (For more information about variables in an experiment see Supporting Information in the FLP lesson "Germ Busters.") Other experiments test the variables of air and temperature.

GETTING STARTED

Collect soil samples from gardens, fields or woods. An ideal collection is a wedge of soil from about six inches beneath a garden, a rotting log, or rotting leaves. It is best if the sample has a high organic content, generally represented by a darker color. Make transparencies and photocopies for small groups of students of ***A Soil Ecosystem***, ***Nutrient Cycle***, and ***Compost Observation Log*** sheets copied back-to-back. For Session One, gather white paper; hand lenses or magnifying glasses; and interlocking blocks, modeling clay, or Play Doh®. For Session Two, gather the organic waste (see Materials), soil, serrated knife, and containers. (Do not include meats, fats, or cheese.) For younger students, chop the organic waste into small pieces. **Optional**: Have students bring soil from their own gardens and yards. Find outside storage for the bags if they begin to smell. Alfalfa meal or clean cat litter may be added to absorb odors.

PROCEDURE

SESSION ONE

1. Place a handful of soil on white paper and divide students into small groups around each sample. Have them observe the soil samples and write or draw pictures of what they observe.

2. Distribute the hand lenses or magnifying glasses for students to observe again. Have students write or draw pictures of what they observe now. Compare the observations.

3. Discuss ***A Soil Ecosystem*** transparency and diagram with students. Ask:

   - What is in this illustration that you didn't see in your soil sample?
   - What evidence of plant life do you see? *(plants, leaves, acorn, roots)*
   - What animals are living here? *(worms, insects, spiders, rodents, snail)*
   - Who uses the soil as a home and source of food? *(Most land organisms either directly or indirectly.)*
   - How do air and water get down into the soil? *(Through pores between soil particles.)* See the FLP lesson "Perc Through the Pores."

4. Introduce the ***Nutrient Cycle*** transparency and diagram. Younger students can color the path of organic matter as you discuss it. Introduce the concept of the Soil Recycling Team: insects, worms, and other visible animals, as well as microorganisms such as bacteria, protozoa, and fungi plus temperature, air, and water. Ask:

   - What happens to leaves that fall on the ground in autumn or plants that die? Where do they go? *(They are decomposed and end up as part of the soil, if they are not sent to the landfill.)*
   - What happens to a wild animal that dies in the forest, desert or grasslands? Where does it go? *(It is partially or entirely eaten by other animals and is decomposed, ending up as part of the soil, too.)*

Explain that when things like leaves, grass, trees, and animals die, they eventually end up as part of the soil. Decomposers take them apart just like building blocks, returning nutrients to the soil for other plants to use. It's nature's way of recycling organic waste. When things decompose into soil, they make the soil richer. Plants grow better in rich soil. Ask "What would happen if dead plants and animals didn't decompose?"

5. Younger students will demonstrate how soil's decomposers, the Soil Recycling Team, work together.

   A. Divide students into groups of four.

   B. Give each group some plastic interlocking blocks, modeling clay, or Play-Doh®.

   C. Give each group about five minutes to build a replica of a living animal or plant.

   D. Announce that the time has come for each animal or plant to die.

   E. Have groups place their "dead" animals or plants in one pile. Ask:

      - What's wrong with this picture? *(The plants and animals are not decomposed into smaller pieces.)*

      - What would happen in nature? *(The plants and animals would decompose and return nutrients to the soil.)*

   F. Have groups retrieve their animal or plant. Tell each group member to select one of these roles: microorganisms in soil, temperature, air, water. Have groups simulate the breakdown or decomposition of their animal or plant, recycling it.

   G. Have groups demonstrate the complete nutrient-cycling process made possible through the Soil Recycling Team by making a new plant. The new plant is able to grow because of nutrients made available to the soil.

6. Review and discuss the ***Nutrient Cycle*** diagram. Relate it to the previous group activity and stress the circular arrangement of the cycle. Explain how it demonstrates a give-and-take process. Ask:

   - How does the nutrient cycle work? Why do you think it is important? (See Supporting Information.)

   - Can you think of other cycles in nature or life? (*Seasons, energy, water, rock*.) Do they work in the same way?

   - What kinds of things do you think can be decomposed by the Soil Recycling Team? *(Anything that was once alive or came from a living thing.)* Generate a list of items that can be decomposed.

   - What do you do with organic waste at your home?

   - What else could you do with organic waste?

SESSION TWO

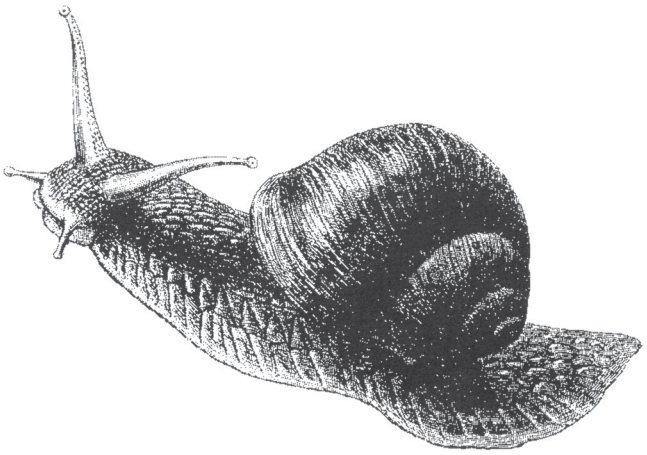
1. Conduct a classroom compost experiment. Create two sets of material containing equal amounts of the following or similar ingredients.

   - vegetable and fruit bits, cores, and /or peels
   - egg shells
   - coffee grounds
   - grass clippings, leaves
   - small twigs
   - soil (not potting soil)
   - gallon-size, self-closing plastic bags or other sealable, see-through containers
   - 1/4 to 1/2 cup of water (put only in one container)

2. You or students chop the organic waste into small pieces for faster decomposition. Put a layer of soil into each of the two plastic bags or containers and alternate layers of waste with soil.

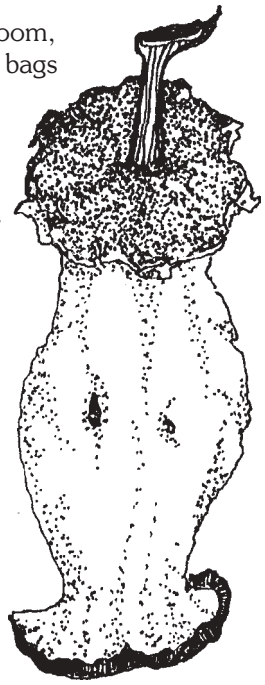
3. Review the concept of experimental and controlled variables and discuss in relation to this experiment. (See Supporting Information.)

4. When the two containers are ready, slowly add 1/4 to 1/2 cup of water to <u>one</u> of them. The soil needs



only to be moistened, not waterlogged. Label this container "Moistened" and the other container "Unmoistened." Distribute the ***Compost Observation Log*** sheet to small groups of students. They list the ingredients and write a prediction or hypothesis about each compost container on their sheet. Place the containers in the same spot (so that both are subjected to the same room temperature) in a warm part of the classroom, but not in direct sunlight. Make sure both bags have air in them.

You may want to place bags inside sealed containers to reduce any possible odor. Have students follow the directions below for the composting situations.



A. **Unmoistened (Control) -** Open the container every couple of days for observations and to stir contents gently with a spoon, providing needed aeration. The stirring will disturb the layers of soil and waste, but does not interfere with the composting process. In fact, the aeration is critical. Do not add any water!

B. **Moistened (Experimental) -** Open the container every couple of days for observations and to stir contents gently with a spoon, providing needed aeration. Check the soil for moisture; add water only if contents start to dry out, keeping the mixture slightly moist to the touch.

SESSIONS THREE TO TEN

1. Continue this process until students see a visible difference in the contents of the containers. Have students date and record their observations every couple of days and note differences on the ***Compost Observation Log***. Older students can complete the questions at the bottom of the log sheet before the summary.

2. As students observe and record the first experiment, use the other four bags to set up the next two experiments. Add 1/4 to 1/2 cup of water to all four bags as in Session Two. Then place two of the bags with the first control bag and use the other two as the experimental variables.

   A. Aeration variable: keep one container closed and do not stir the contents (keeps air out).

   B. Temperature variable: place one container in a hotter or colder location.

3. To summarize, ask:

   - How did the results of each compost container compare with your prediction or hypothesis?

   - Which particular materials decompose more rapidly? More slowly?

   - How long did it take for decomposition to begin?

   - What differences do you see between the "Moistened" and "Unmoistened" compost containers? What similarities?

   - What are the components in soil that work together to decompose organic waste? *(*Soil Recycling Team: *microorganisms, temperature, air, water.)*

   - Why are the soil's decomposers important to us? *(They reduce organic waste and turn it into valuable humus and nutrients in the soil so plants can grow better. See* Supporting Information.)

   - What are four organic wastes that decompose in soil? (Accept anything that was once alive or came from a living thing.)

   - How long does it take to decompose organic waste? *(It depends on moisture, temperature, air, and the type of organic waste to be decomposed.)*

   - How can what you learned in this experiment help you decide what to do with your own organic wastes in the future?

   - Based on the experiment and discussion, what are at least three reasons for recycling organic waste? *(To return organic matter to the soil, to reduce materials deposited in landfills, to speed up the decomposition process, to improve the soil structure.)*

EVALUATION OPTIONS

1. Observe students' participation during the group activities, compost experiment, observation opportunities, and discussions.

2. Evaluate students' drawings and written descriptions of their observations on the ***Compost Observation Log***.

3. Have students list three reasons for recycling organic waste, the four components that make up the Soil Recycling Team, and at least four things that will decompose in soil.

4. Have students draw and/or describe the nutrient cycle.

EXTENSIONS AND VARIATIONS

1. Redesign the experiment using a different experimental variable. Make predictions and observations.

   A. Vermicomposting: include worms in one of the containers. Red worms and red wigglers tend to be more heat-tolerant than night crawlers and, therefore, are more suitable for composting.

   B. Size of organic waste: place large pieces of organic waste in one container.

   C. Single organic waste: use only one type of organic waste (e.g., apple cores) in one container.

   D. Compost additive: include an additive such as fertilizer, lime, gypsum, or compost starters to one of the containers.

2. Obtain thermometers and have students record the temperature in each compost container. Temperatures should be taken at the same location and depth and at the same time each day. Have students graph the temperatures in each compost pile over time.

3. Have students observe the amount of organic waste discarded by the school cafeteria each day. Calculate how much volume this is in a week, a month, a whole school year. Where do these scraps go when they are discarded? Discuss how much landfill space is needed just for this one school's waste. How can the scraps from homes, schools, and other places be recycled?

4. Have students set up compost piles at their home and/or do a school compost pile. Use the enriched soil for growing plants.

5. Invite a waste-management professional, one who is familiar with composting, to the classroom to discuss waste options with students. Ask the person to talk about the percent of wastes generated in the area. See the FLP lesson "Trash Bashing."

6. Investigate further the nutrient cycle and its importance to grow new plants for the food upon which we depend. Divide students into groups and assign each group a "position" in the nutrient cycle. Start at any part of the cycle and have each group stand up and explain its part of the cycle.

CREDITS

A Soil Ecosystem. Adapted from *A Soil Ecosystem*. Natural Resources Conservation Service, United States Department of Agriculture.

Nutrient Cycle. Natural Resources Conservation Service, United States Department of Agriculture.

ADDITIONAL RESOURCES

Appelhof, Mary, Mary Frances Fenton, and Barbara Loss Harris. *Worms Eat Our Garbage*. Flowerfield Press. 1993. ISBN: 0942256050.

Bremner, Elizabeth, Rachael Mabie (editor). *Children's Gardens: A Field Guide For Teachers, Parents and Volunteers*. University of California Cooperative Extension Common Ground Garden Program, Second Edition. 1990. (213) 744-4341. (see the chapter on composting).

Campbell, Stu. *Let It Rot: The Gardener's Guide to Composting*. Storey Books. 1998. ISBN:1580170234.

Cole, Joanna. *The Magic School Bus Meets the Rot Squad: A Book About Decomposition*. Scholastic. 1995. ISBN: 0590400231.

Compost…because a rind is a terrible thing to waste! (manual and two videos) Cornell Waste Management Institute, Center for the Environment. Order From: Cornell University Resource Center, 7 Business and Technology Park, Ithaca, NY 14850. (607) 255-2080. http://www.cce.cornell.edu/publications/

Compost to Reduce the Waste Stream: A Guide to Small Scale Food and Yard Waste Composting. (manual) NRAES, Cornell University Resource Center, 152 Riley Robb Hall, Ithaca, NY 14853. (607) 255-7654.

Compost: Truth or Consequences. (video) Cornell Waste Management Institute, Center for the Environment. Order From: Cornell University Resource Center, 7 Business and Technology Park, Ithaca, NY 14850. (607) 255-2080. http://www.cce.cornell.edu/publications/

Composting in the Classroom: Scientific Inquiry for High School Students. Kendall/Hunt. 1998. ISBN: 0787244333.

Glaser, Linda. *Compost!: Growing Gardens from Your Garbage*. Millbrook Press Trade. 1996. ISBN: 0761300309.

Handelsman, Judith. *Gardens from Garbage: How to Grow Indoor Plants from Recycled Kitchen Scraps*. Econo-Clad Books. 1999. ISBN: 0613013298.

Horton, Robert L., PhD., Joseph E. Heimlich, PhD., James R. Hollyer, and Bill Owens. *Soils Alive!: From Tiny Rocks to Composting, Cycling Back to Nature*. National 4-H Council. 1995. Available through your local Cooperative Extension Office. http://www.fourhcouncil.edu

It's Gotten Rotten (video and teacher's guide). Cornell Waste Management Institute, Center for the Environment. Order From: Cornell University Resource Center, 7 Business and Technology Park, Ithaca, NY 14850; (607) 255-2080. http://www.cce.cornell.edu/publications/

Loesch, Joe. *Buffalo Biff: The Magnificant Recycling Machine (Backyard Adventures)*. Toy Box Productions. 1996. ISBN: 1887729054.

Maceachern, Diane. *Save Our Planet: 750 Everyday Ways You Can Help Clean Up the Earth*. Publisher Unknown. 1991. ISBN: 0440294037.

Nancarrow, Loren, Janet Hogan Taylor. *The Worm Book: The Complete Guide to Worms in Your Garden*. Ten Speed Press. 1998. ISBN: 0898159946.

Pears, Pauline. *All About Compost: Recycling Household and Garden Waste*. Search Press, Limited. 1999. ISBN: 0855328681.

WEB SITES

Adventures of the Garbage Gremlin: Recycle and Combat a Life of Grime. Resource Conservation and Recovery Act, US Environmental Protection Agency (EPA). 2002. 1-(800) 424-9346. http://www.epa.gov/epaoswer/non-hw/recycle/gremlin/gremlin.htm

Composting in Schools. 2002. http://www.cfe.cornell.edu/compost/schools.html

Dirtland and Animal Pavilion at the Microbe Zoo. 2002. http://commtechlab.msu.edy/sites/dlc-me/zoo/

Garbage and Recycling. 2002. http://www.epa.gov/kids/garbage.htm

Planet Protectors Club. 2002. http://www.epa.gov/epaoswer/osw/kids.htm

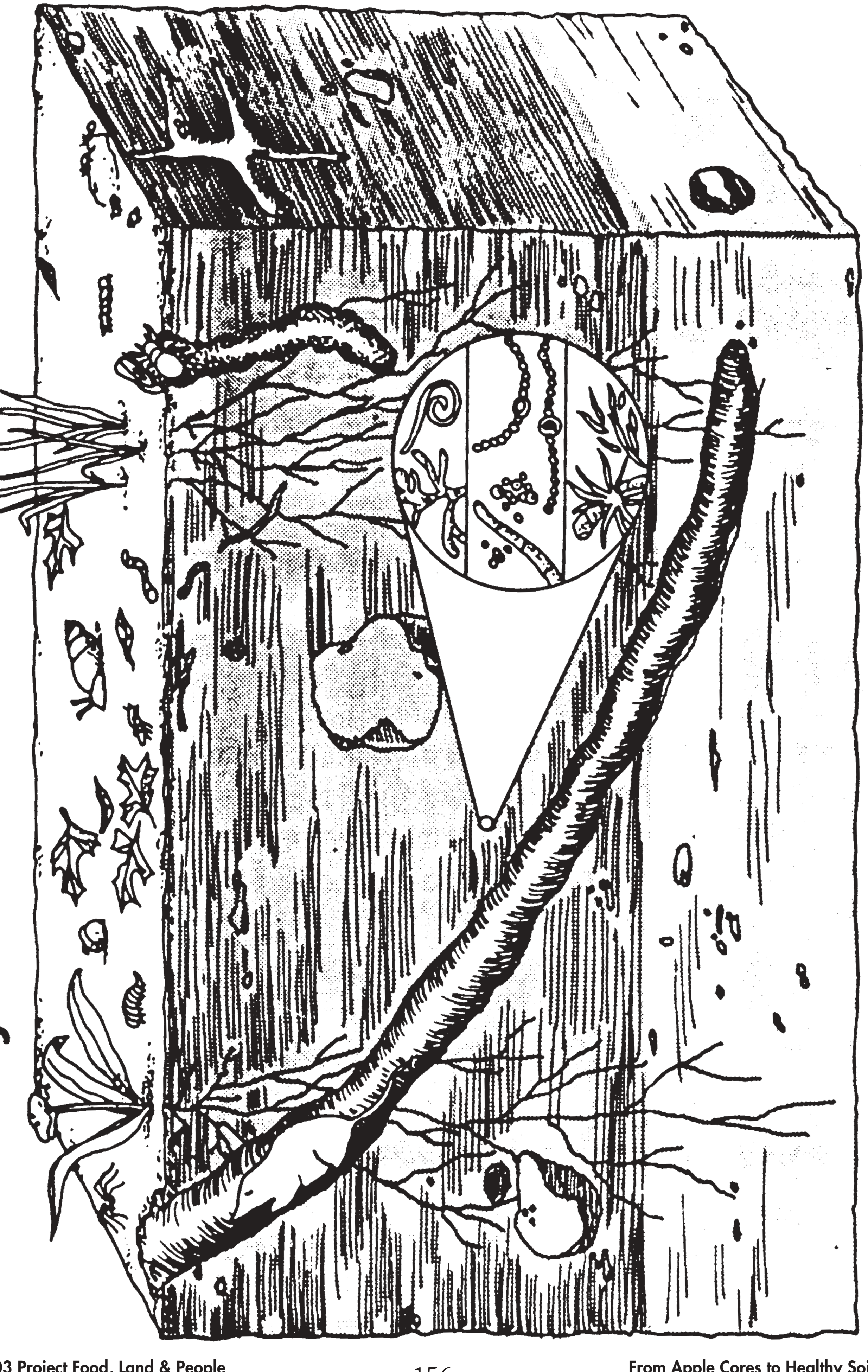
Reduce, Reuse, Recycle. 2002. http://www.epa.gov/epaoswer/non-hw/muncpl/reduce.htm

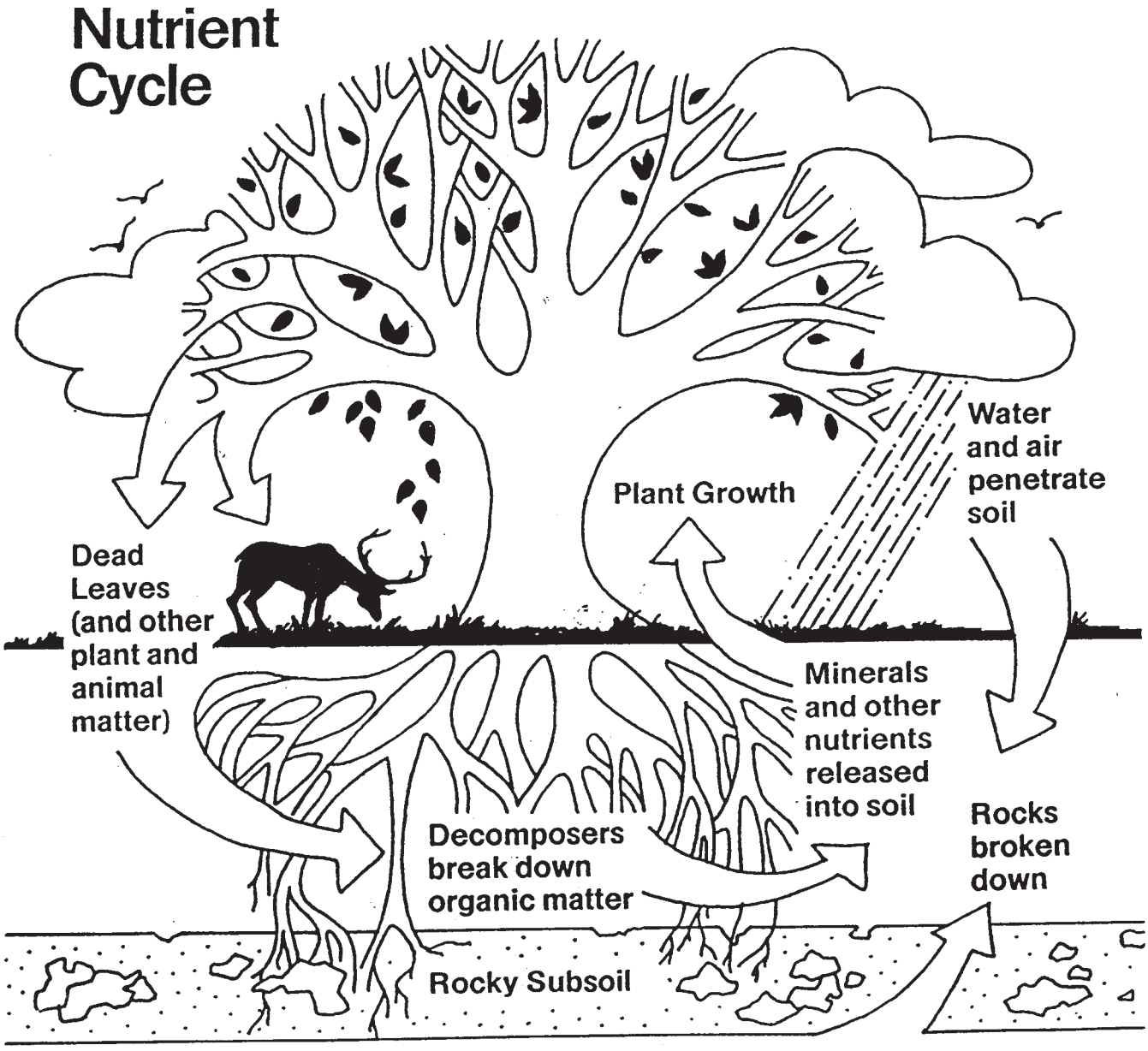
Waste and Recycling. EPA Student Center, Municipal Solid Waste. 2002. http://www.epa.gov/students/

EDUCATOR'S NOTES

 Conceptual Framework Reference: I., I.C.1., I.C.4., I.D.1., I.D.3., I.E.1., III., III.B.1.c., VI., VII.A.3., VII.A.5.

A Soil Ecosystem





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COMPOST OBSERVATION LOG

Names:_____

1. List the ingredients in your compost containers.

2. Write a prediction or hypothesis about what will happen in each compost container.
   A. Unmoistened -

   B. Moistened -

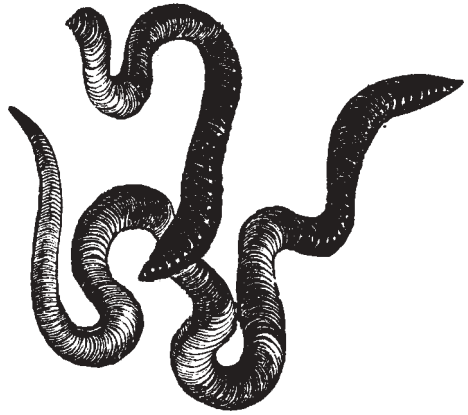
3. Record your observations in the two columns below.

4. How are the observations in the columns different? Why?

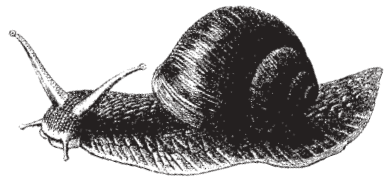
5. How are they similar? Why?

6. How did the results compare with your prediction or hypothesis?

7. What is in soil that decomposes organic waste?



COMPOST OBSERVATION LOG (Continued)



Date	**Control** (temperature)	**Experimental** (temperature)
Date	**Control** (air)	**Experimental** (air)

The soil is the source of life, creativity, culture, and real independence.

David Ben Gurion (1886-1973),
Hazon VeDerek, 1951