Activity: Bottle Ecosystems

Lesson Summary
This lesson has students recycling pop bottles to create ecosystems. Students create aquariums and terrariums. Through the construction of these students learn about the complex relationships and the delicate balance of ecosystems.

Ohio Standards Correlations
Standard: Life Sciences

Grades 3-5 Benchmark B: Analyze plant and animal structures and functions needed for survival and describe the flow of energy through a system that all organisms use to survive.

Indicator(s)
Grade Five
1. Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis.
3. Trace the organization of simple food chains and food webs (e.g., producers, herbivores, carnivores, omnivores, and decomposers.)

Grades 3-5 Benchmark C: Compare changes in an organism's ecosystem/habitat that affect its survival.

Indicator(s)
Grade Five
4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity, and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.
5. Support how an organism's pattern of behavior is related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the ecosystem.

Time
Initial setup requires approximately 60 minutes for the terrarium and aquarium. Each day of observations requires 15-30 minutes but daily observations are not required

Materials

Per group for bottle preparation:

3 2–liter pop bottles per group, scissors, Removing Labels Handout (Attachment A), Bottle Basics and Cutting Tips Handout (Attachment B), Bottle Cutting Directions (Attachment C)

Materials per group for terrarium:

Setting up the Terrarium Handout (Attachment E), various seeds, 1 rubber band, 1 permanent marker, small rock, twigs and leaf matter, 1 spoon, 1 cup of water, 2 plastic cups, 1piece of fiberglass screen cut to 4" by 4", 2 cups of soil, 1 dropper, 1 cup of gravel, 1 toothpick, 1 hand lens, animals such as crickets and isopods (these will not be needed initially)

Materials per group for aquarium:

Setting up the Aquarium Handout (Attachment G), 1 deep base unit from bottle A, water, 2 plastic cups, 1 cup of gravel, 2 paper towels, 1 – 2 sprigs of elodea, 10 duckweed plants, 2-3 droppers of algae, 1 dropper, 1 hand lens, 1 spoon, 1 metric ruler, 1 permanent marker, animals such as pond snails and mosquito fish (these will not be needed initially)

Background

Every student has seen an animal eat another animal or a plant, even if only on television. As students learn about how different living organisms interact with each other, their minds begin to ask questions of why and why not. This experiment will allow students to understand how to answer these questions. This experiment helps to explain processes such as photosynthesis as a primary source of energy, energy transference to other organisms, and carrying capacity of a closed ecosystem. There are many variations of this experiment that teachers or students may want to pursue.

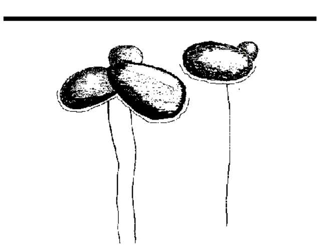
Blue-green algae (cyanobacteria) are the largest prokaryotic cells, and they often grow as strings of cells forming long thin "beaded" filaments in the water. They also exist in the soil in large numbers. These cells have chorophyll in their cytoplasm (but no chloroplast organelles). They use sunlight as the source of their energy, making simple sugars from carbon dioxide and water through the process of photosynthesis. Since they make their own energy storage molecules from inorganic materials, they are placed in the functional ecological group with plants, collectively known as **autotrophs** (meaning self-feeding). Cyanobacteria are very important components in the food chains of soil and water environments. Like all autotrophs, they are **primary producers** of organic chemicals that other organisms rely on and consume to live. Without these organisms and the one-celled eukaryotic algae, the small, water-dwelling animals would have no food sources. In turn, there would be nothing for minnows and larger water organisms to eat, and thus, nothing for fish to eat. This bleak scenario is actually carried out annually in many small ponds when herbicides wash in from surrounding crops, leaving the ponds devoid of life. When this happens, frogs, toads, wading birds, and ducklings that depend on the ponds for food starve as well.

Duckweed, elodea and algae help to keep ecosystems healthy. These producers will not only provide the necessary exchange of gases (respiration/photosynthesis) in the ecosystem but they will provide food and shelter for animals.

Duckweed is a very tiny plant that floats on top of the water. Natural populations of duckweed are usually mixtures of several duckweed species and other water plants. Duckweed plants can reproduce rapidly in the right conditions and this can cause problems in an ecosystem if they block light from getting to other organisms. Duckweed reproduces by asexual reproduction in a process called vegetative propagation.

Elodea is a dark green plant that is easy to grow and is sturdy. It will adapt to its environment growing thin if light is limited. It is often referred to as the water weed. The American elodea lives entirely underwater with the exception of small white flowers which bloom at the surface and are attached to the plant by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. It also often overwinters as an evergreen plant in mild climates. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is vegeatative propagation, a type of asexual reproduction. It is this plants most important method of spreading, with seed production playing a relatively minor role.

There are many varieties of algae. They come in various sizes and colors (additional important above).



Duckweed

Elodea

It is suggested that mosquito fish are used in the ecosystems because they are strong fish. The mosquito fish is a small and stout, dull grey, robust fish with a rounded tail and a terminal and upward-pointing mouth adapted for feeding at the water's surface. These features and their small size make them resemble the tropical guppies. Mature females reach a maximum overall length of 7 cm (2.5 inches) and males reach only 4 cm (1.5 inches).

Pond snails are also suggested because of their ability to adapt. In particular the ramshorn snail. The term ramshorn snail is used in the aquarium trade to describe any kind of snail whose shell is planispiral, meaning that it is a flat coil. Such shells resemble a coil of rope, or (as the name suggests) a ram's horn. These ramshorn snails breathe air. Although most are extremely small, some may reach a size of two and a half centimeters (one inch). The shells range from translucent through various shades of brown to a dark, nearly black color. The dark color appears to originate from dietary materials not generally available in the home aquarium, although many varieties from ponds will be this dark shade. Ramshorn snails generally will eat only the most delicate plants, preferring algae, uneaten fish food, and dead fish.

Mosquito fish

Snail

Live materials can be ordered through Carolina Biological

Teacher Tips

Have students bring in clean 2 liter pop bottles, leaf matter, small rocks and small twigs prior to starting this lesson.

Make your own bottle construction before introducing them to your students. Cutting the bottles is easy but a little practice will improve your skills and allow you to work out details for materials, as well as any unexpected problems. There are small variations from one brand of pop bottle to another so to be sure that the bottles fit together properly have students use the same brand of beverage. For example, one group may use all Pepsi bottles another group could use all Coke bottles.

Bottle Ecosystems can be adapted to all levels of the inquiry continuum and can be adapted for all grade levels. For younger children you may want a volunteer to cut the bottles in advance.

This project is best carried out in groups. Each group can be composed of students at different levels of understanding.

If you have a classroom digital camera, photos can be added to student's journals.

None of the organisms used in this inquiry will cause human sickness or disease. If the organisms are spilled on the counter or on skin, simply wipe up with a paper towel and wash hands.

Procedures

<u>Getting Started</u> – Preparing for the Bottle Ecosystems

1. Have each group remove the labels from 3 2-liter pop bottles (see Attachment A for Label Removing Directions).
2. Pass out Bottle Basics and Cutting Tips (Attachment B) with the students.
3. Have students mark 3 2-liter pop bottles as Bottle A, Bottle B, and Bottle C. Have students cut each of these bottles following the directions on Bottle Cutting Directions Attachment C.
4. Have the students write their names/group name on the side of the containers using a permanent marker or wax pencil, after cutting. A small piece of masking tape with student's name on it could also be used. You may want to have students label the bottle pieces by letter so that it is easier to have them identify as they are used.
5. Have each group place all cut bottle pieces into a box or garbage bag with their names on it so they can take out the bottle pieces as they need them.

<u>Doing Science</u> – Building the Bottle Ecosystems

1. Pass out Setting up the Terrarium (Attachment E) and go over the directions. Have students set up their terrariums.
2. Have students make daily observations in their science journals. Optional: Terrarium Observation Journal (Attachment F).
3. Pass out Setting up the Aquarium (Attachment G) and go over the directions. Have students set up the aquarium.
4. Have students make daily observations in their science journals.
5. After a couple of weeks animals can be added to the aquarium. Suggested animals are 2 pond snails and 2 mosquito fish.

6. Once the plants in the terrariums have grown for 4-5 weeks then animals can be added. Suggested animals to add are 2 crickets and 2 isopods.
7. Once animals have been added then the aquarium and terrarium can be connected. See Bottle Ecosystem Final Assembly (Attachment D).

Wrapping Up

1. Ask each student (or group of students) to define a food web as they experienced it in the experiment.
2. Ask each student (or group of students) to hypothesize whether the percentage of each organism was appropriate for the experiment, or if changes would produce a healthier ecosystem.

Extensions

Science

- Polluted Bottle ecosystems. Suggested pollutants would be vinegar, fertilizer and salt. Be aware that some organisms may die if pollution occurs.

Reading/Writing

- Have students write about their ecosystem.

Removing Labels
Attachment A

Once you have collected bottles, you will need to remove the labels. Most labels are attached by a heat-sensitive glue. Resist ripping off the labels, or you may end up with many small pieces of label stuck to the bottle.

A hair dryer will remove the label and base from your bottle easily. Set the hair dryer on **low**. Hold your bottle about 10 cm away from the blowing nozzle, and move it rapidly up and down so that the air warms the seam of the label. Gently pull on an edge of the label until you feel the glue begin to give. This takes about 4 seconds.

Bottles are made from polyethylene teraphthalate. This is a generally inert plastic, but it will warp easily if overheated, so keep the bottle moving. Leave the bottle cap on or fill the bottle with water first to prevent warping.

A quieter way to remove the label and base from your bottle is to fill it about 1/4 full with **very warm water** (49 - 65 degrees C or 120 - 150 degrees F; hotter than this may warp your bottle). Cap the bottle in order to retain pressure inside so the bottle doesn't crumple, and tip it on its side to warm the glued seam. After a few seconds pull on a label corner and the entire label should come off easily.

Glue may be left on the bottle after the label is removed. If this offends your aesthetic sensibilities, rub a small amount of peanut butter onto the glue. As you rub, the oil in the peanut butter causes the glue to ball up so it can be pulled off. Then wash your bottles with soap and warm water and dry them.

Adapted from http://www.bottlebiology.org

Bottle Basics and Cutting Bottles Tips
Attachment B

Basic Parts of a Bottle

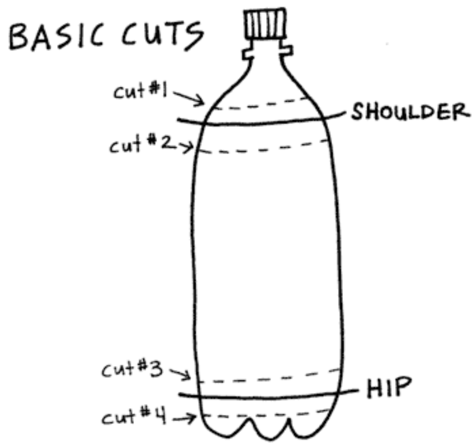
Cutting Bottles
The easiest way to cut a bottle is to cut along a marked line with scissors. Once you have decided where to cut a bottle, place it on its side in the corner of an empty drawer, tray, or box. Brace the bottom of the bottle against a corner of the box. Rest a pen or wax pencil against the edge of the box, so the tip rests against the bottle where you want your cutting line. Slowly turn the bottle. Two people make this job easy.

Use **erasable felt tip pens** or wax pencils to make cutting lines because they don't smear and can be easily removed. Make sure your bottle is dry before marking. If you want lines that last, use a permanent marker.

Draw all of your cutting lines first (it's hard to do once the bottles have been cut), and then use a utility knife to begin the bottle cuts. You only need a cut big enough to insert the top arm of a scissors. You will make a smoother cut with the top arm of the scissors inside the bottle, so insert the top arm into your initial cut and snip around, following your cutting line. Don't worry about ragged edges; they are easy to snip away with scissors once the bottle is in pieces.

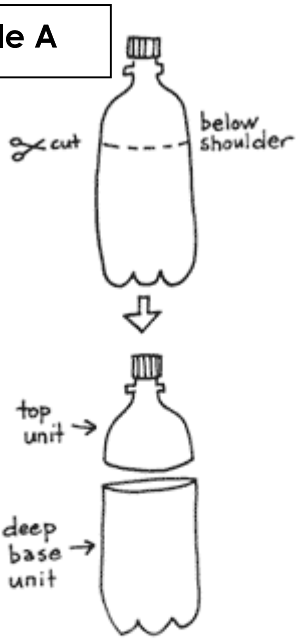
Adapted from http://www.bottlebiology.org

Bottle Cutting Directions
Attachment C

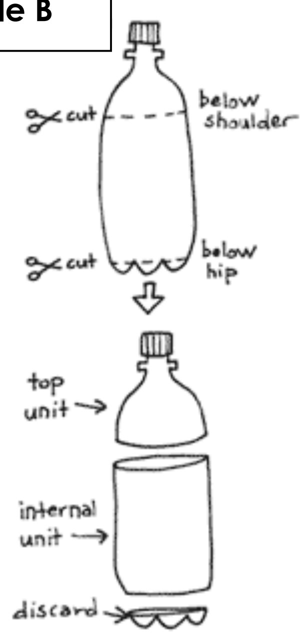


Cutting Directions:

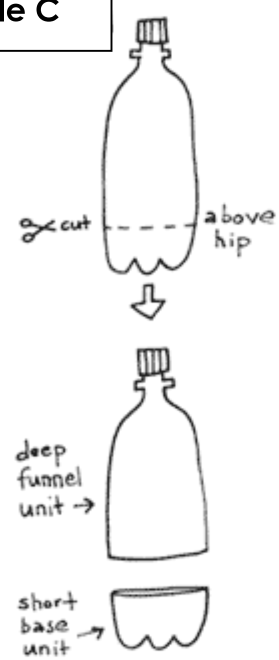
Bottle A



Bottle B



Bottle C



Adapted from http://www.bottlebiology.org

Bottle Ecosystem Final Assembly
Attachment D

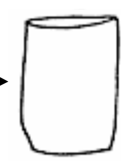
Short Base Unit from Bottle C →

Place the short base unit on top of the deep funnel unit and attached with tape if needed

Deep Funnel Unit from Bottle C inverted is the terrarium unit →

Place the deep funnel unit inside the internal unit and secure with tape.

Internal Unit from Plan B →



Place the internal unit inside the deep base unit and secure with tape.

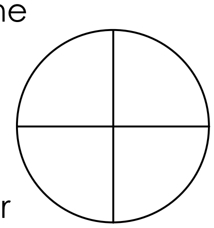
Deep Base Unit from Bottle A is the aquarium unit →

Insert completed ecosystem page

Setting up the Terrarium
Attachment E

Materials per group:
deep funnel unit from bottle C
1 bottle cap
1 rubber band
1 marker
small rock, twigs and leaf matter
1 spoon
1 cup of water
3 plastic cups
1 piece of fiberglass screen cut to 4" by 4"
2 cups of soil
1 dropper
1 cup of gravel
various seeds such as grass, alfalfa, Wisconsin fast plants, and mustard
2 toothpicks
1 hand lens

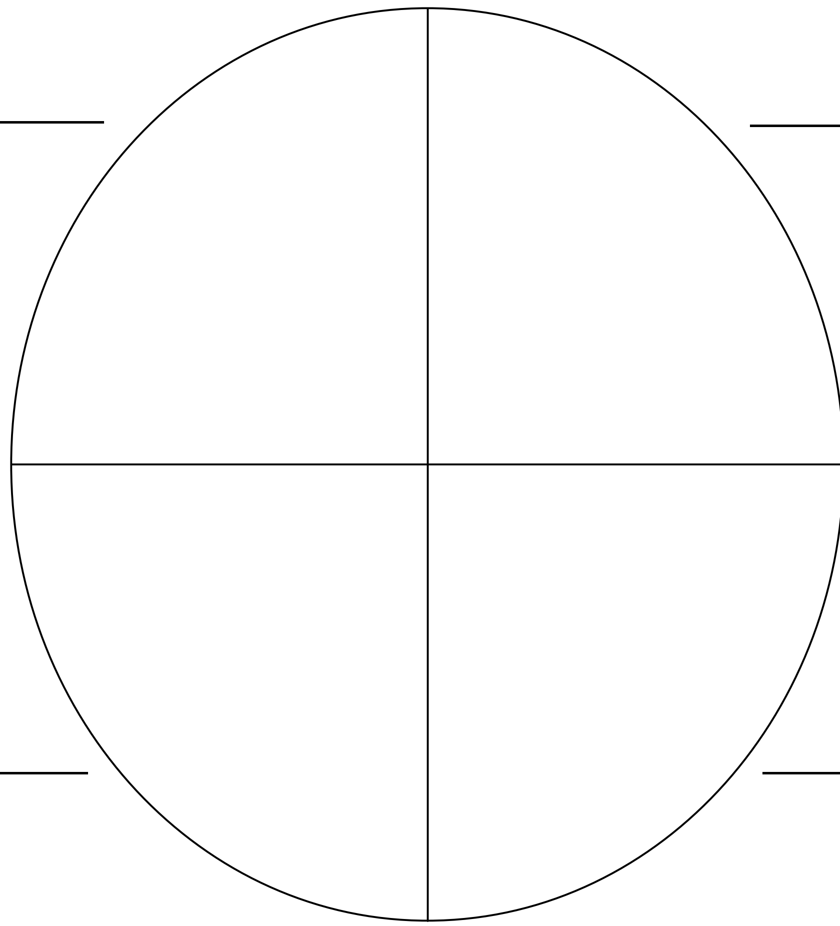
1. Take the Deep Funnel Unit from Bottle C and remove the bottle cap. Set the cap aside because you will need it at the end of this lesson. Place the fiberglass screen over the mouth of the bottle and secure with a rubber band.
2. Set the bottle, neck down onto a plastic cup. The bottle will not be steady setting in the plastic cup so one student will need to hold it steady. Add one cupful of gravel to the bottle. Add two cupfuls of soil on top of the gravel. Spread the soil out evenly in the bottle. Be careful not to get gravel and mud on the sides of the bottle.
3. Divide the surface of the soil into four equal parts. You may use your finger tip or a toothpick to do this. Looking down into the bottle it should look like the figure provided.



4. Use a permanent marker to label the outside of the bottle leaf matter and the names of the three seeds that your group will be using.
5. Plant your seeds and place your other organic matter in your terrarium so that it coincides with the labeling on the outside of the bottle.
6. Be sure to record in your journal the number of seeds that you planted in each section of your terrarium.
7. Get one cup of water and using a water dropper, wet the soil thoroughly. Place your cap back over the fiberglass screen.
8. Sketch and label your terrarium in your journal.

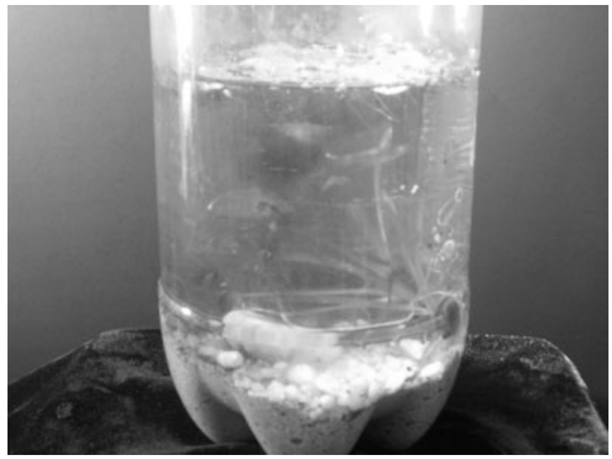
Student Name ____

Terrarium Observation Journal
(Optional)
Attachment F



Setting up the Aquarium
Attachment G

Materials needed per group:
1 deep base unit from bottle A
water
2 plastic cups
1 cup of gravel
2 paper towels
1 – 2 sprigs of elodea
10 duckweed plants
2-3 droppers of algae
1 dropper
1 hand lens
1 spoon
1 metric ruler
1 permanent marker



1. Use the deep base unit from bottle A and place one cup of gravel at the bottom of it.
2. Use a cup to fill your bottle with water until it is approximately 3 to 4 cm from the top. Use your metric ruler to measure the distance your water is from the top of the bottle.
3. Use the permanent marker to make a small mark on the bottle to indicate the water line.
4. Add 1-2 sprigs of elodea to the bottle. Measure the plant and record its size. The elodea can be planted in the gravel or allowed to float freely.
5. Use your spoon to scoop out your duckweed. Place them on a wet paper towel and count out approximately 10. Put in your bottle.
6. Use your dropper and place 2-3 droppers of algae into your bottle.
7. Sketch and label your aquarium.