Earth System in a Bottle

Purpose

- To acquaint students with the parts of the Earth system: hydrosphere, geosphere, atmosphere and biosphere.
- To have students use microenvironments to study natural phenomena.
- To introduce students to the concept of a fair test in a scientific investigation.

Overview

In pairs, students will create experimental conditions in terrariums to study what plants need to live. These variables include presence or absence of soil, water, and sunlight. Students will record growth of radish plants as well as observations of the water cycle in their terrariums. At the conclusion of their experiments, students will share their results with the class and discuss how water, Earth materials, air, and sunlight are all necessary to support living things.

Student Outcomes

After completing this activity, students will know about the importance of the hydrosphere and geosphere (and atmosphere) in supporting the biosphere. They will learn how to set up fair tests, record detailed observations, use drawings as scientific records, make sense of experimental results, and share these results with others.

Next Generation Science Standards

- DCI ESS-2A: Earth Materials and Systems
- DCI ESS-3A: Natural Resources
- DCI LS-2A: Interdependent Relationships in Ecosystems
- Science Practice 1 Asking Questions
- Science Practice 3 Planning and Carrying Out Investigations
- Science Practice 4 Analyzing and Interpreting Data
- Science Practice 5 Using Mathematics and Computational Thinking
- Science Practice 8 Obtaining, Evaluating, and Communicating Information
- Crosscutting Concept 4 Systems and System Models

CCSS.ELA Anchor Standards

- W.4 Produce clear and coherant writing...

Time

- Part 1: One 30- to 45-minute class period
- Part 2: One 30-minute class period
- Part 3: 15-20 minutes, three times a week
- Part 4: One 45-minute class period

Level

Elementary (most appropriate for grades 2-4)

Materials

Part 1:

- *Elementary GLOBE* storybook: *All About Earth: Our World on Stage*
- Two blank wall charts

Part 2:

- One of each of the following per group of students (2–4 students): 2 1-liter clear plastic soda bottles, 3 cups potting soil, 10 radish seeds, measuring cup, water, tape, permanent marker, index card, foil, paper towels
- *Earth System in a Bottle Recipe Card* – one copy for each student or group of students

Part 3:

- Multiple copies for each student of the *Earth System in a Bottle Student Activity Sheet* (and a folder to hold these papers)

Part 4:

- Wall charts from Part 1

Preparation

Part 1:

- Read the *Elementary GLOBE* storybook *All About Earth: Our World on Stage* – either read it to the class or have students read it to themselves. The book can be downloaded from www.globe.gov/elementaryglobe.
- Make two wall charts titled: "What do plants need to live?" and "What do we want to learn?"

Part 2:

- Make a copy of the *Earth System in a Bottle Recipe Card* for each student or group of students. Optional: laminate the recipe cards so they don't get wet during this activity.
- Prepare the soda bottles by cutting them as shown in Figure 1.

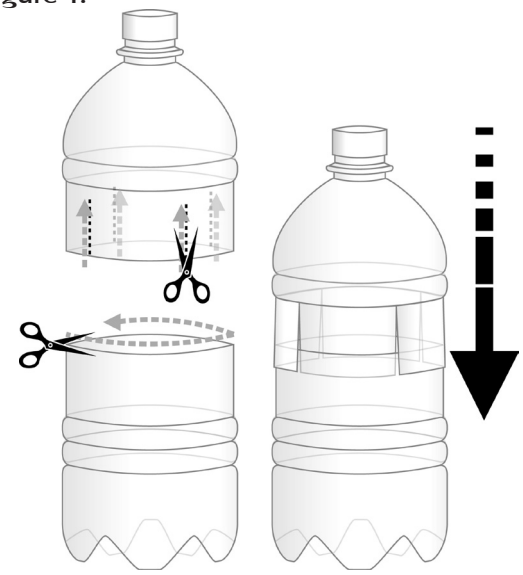


Figure 1: Cut bottle in half and cut vertical slits as shown. Slide top over bottom of bottle, pushing alternate flaps to the inside.

- Prepare stations where student groups can plant their terrariums.
- Plant one terrarium ahead of time to determine the correct ratio of soil to water. The amount of water needed to thoroughly moisten about 3 cups of soil will vary depending on the type of soil available locally and on the moisture content of the soil.
- Spread some of the soil in a large tray, baking sheet or on newspaper and set it to dry out (preferably in a sunny window) for two days. This soil will be used in the "No water" treatment.

Part 3:

- Make copies of *Earth System in a Bottle Student Activity Sheet* so that each group has a blank sheet for each observation they make. Make a folder for each group.

Part 4:

- No preparation necessary.

Teacher's Notes

In this activity, students will plant control terrariums that have all the elements a plant needs to grow (soil, water, light) and other experimental terrariums that lack one of these elements. They will monitor their terrariums closely to gather data on what plants need to grow.

Plants need the following things in order to grow: soil, water, sunlight, and air (oxygen and carbon dioxide).

Soil: Plants need soil to anchor their roots. They also need minerals that they absorb through their roots – these minerals are found in soil and dissolve in water found in the soil before being absorbed by the plant's roots.

Water: Like all living things, plants need water to survive. Plants need water to soften the seed coat - a process that begins germination - and to maintain all their life functions. Water evaporates from the surface of plant leaves in a process known as "transpiration." This process provides the force that allows the roots to draw water up from the soil. Transpiration also cools the plant, just as the evaporation of sweat from our skin surface cools us! Transpiration accounts for 10% of all water contributed to the atmosphere in the form of water vapor.

A note about the phases of water: individual molecules of water are continually leaving the surface of liquid water – evaporating – entering the air in the gas phase. Water in the gas phase – water vapor – is completely invisible. Steam, fog and clouds – visible water in air – consist of tiny droplets of water that have condensed on particles in the air.

Sunlight: Thanks to sunlight, plants are able to make their own food. Plants capture sunlight and use it to create sugars and other molecules through the process of photosynthesis.

Air (oxygen, carbon dioxide, and nitrogen): Plants breathe (respire). Like all living things, they respire to support their life functions and give off carbon dioxide as an end product of respiration. During the daylight hours, they take in carbon dioxide which they use in the process of photosynthesis.

Fair test: A fair test is an investigation or experiment in which one condition (called the independent variable) affects another (dependent variable) while all the other conditions in the investigation are not changed. In all the experiments, plant growth is the dependable variable. For example, the bottle wrapped in foil only has light excluded (the independent variable), while it has the same amount of soil and water as the other treatments. The difference in plant growth (the dependent variable) compared with the plants that receive soil, sun, and water (the control) can then be attributed to the absence of light since the investigation was a fair test. *For this activity, the terrarium that contains soil, water, and light is the control terrarium, and the three terrariums that are missing one element (soil, water, light) are the experimental terrariums.*

Student ideas about what plants need:

- Students may mention CO_2 and may even list it as one of the needs of plants. Rather than entering a discussion about it, simply acknowledge that CO_2 is a gas found in the atmosphere and if the plants have air in the bottle (which they do) the students can assume that the plants will get CO_2.
- Some students may say plants can live without water, based on prior experience with terrariums, or knowledge of desert plants. This isn't actually true and all plants do need water.
- Students may have tried to grow plants in pure sand as a contrast to soil, with varying success.

Logistics for planting with students:
Planting is manageable as a whole class activity if you have one adult per student group. Another option is to have students plant, one group at a time, while the rest of the class is engaged in other activities.

Things to note about the making an Earth System in a Bottle:

- Seed depth: be sure to tell students to plant the seeds only as deep as the seeds are wide. If seeds are planted too deep, the emerging seedling will take longer to find the surface of the soil.
- The order of planting is important: add the water to the soil before adding the seeds. The seeds will float to the surface if watered after planting.
- Soil compaction: students will pack down the soil to different degrees of compactness but this shouldn't affect plant growth.
- Have young students practice measuring the correct amount of water. Often, they put too much water into the bottle.

Results to expect in this activity:

- In the terrarium with no water, the seeds will not germinate.
- In the terrarium with no light, the plants will grow long, spindly, and pale because they contain no chlorophyll. The stems will be white or pale green and extremely floppy.
- In the terrarium with no soil, the plants will germinate and grow by anchoring their roots into the paper. Eventually, they will stop growing because: a) the roots need soil in which to anchor the plant and paper towel doesn't provide enough support, and b) the plant ultimately needs the nutrients it gets from soil. Students may conclude from this that plants don't need soil. Have them

compare the plants to those growing in soil to help them decide.

- Note: sometimes the seed coat is not shed by the growing seedling but traps the first set of leaves. If this happens, you can expect it to begin to get moldy within the first week.

For more information on using plastic bottles to create terrariums, see *Bottle Biology* at www.bottlebiology.org or www.fastplants.org.

What To Do and How To Do It

Part 1: Discussion and Brainstorming

1. Having read the *Elementary GLOBE* storybook *All About Earth: Our World on Stage*, introduce this investigation to the class. Explain to students that they will be using a "micro system" to investigate the same parts of the Earth that the GLOBE Kids did in the storybook, but that they will be doing this from the biosphere (a plant's) point of view.
2. Ask the students, "What do you think a plant needs to live?"
3. Record their answers on a chart. They will likely mention water, air, sunlight, soil, and perhaps carbon dioxide and oxygen.
4. Once you have given all students the opportunity to respond, explain to them that they will be investigating plants' need for water, soil, and light.

Part 2: Planting and Predictions

1. Demonstrate how to plant the seeds in the terrarium. See the *Earth System in a Bottle Recipe Card* at the back of this activity for the instructions/recipe.
2. Have students repeat the steps they observed you make during the demonstration. You can also photocopy the *Earth System in a Bottle Recipe Card* at the back of this activity so students can follow along.
3. Each group will plant one control version of the Earth system and one experimental version of the Earth System. The experimental Earth system will not have one of the following parts of the Earth system: light, soil, or water. Make sure your class creates at least one of these experimental systems. See the *Earth System in a Bottle Recipe Card* for the list of experimental systems.
4. Have the students write down their predictions on an index card, either individually or in their groups, of what they expect to see in the experimental Earth system bottle. Tell them they will be looking at these again at the end of the experiment.

Part 3: Observational Procedures

1. Explain to the students that they will make observations and record them on the *Earth System in a Bottle Student Activity Sheet*.
2. Review the *Earth System in a Bottle Student Activity Sheet* to the students. Every other day, students will record their names, the date, and the system they are observing. Remind them that each terrarium has air in it, so they will always check that box on the student activity sheet. Then they will observe the plants closely. Give the students cues about what to write about - some ideas are: the number of sprouts or leaves, condensation, plant size, color, mold, roots. They will draw the plants in the bottle and may also write notes. Younger students may need assistance with this.
3. Optional: you or your students may want to take photos of the plants as an additional record.
4. Explain to students that they will make observations for 10-15 minutes at specified times on certain days.
5. You may want to monitor students during the first two observation sessions to make sure they are observing and recording in the specified way (though any additional information students want to record is also welcome). Note: at first, teachers might want to model a complete observation session for the class.

Part 4: Sharing Results

1. Once the plants have grown sufficiently to show clear results (this will take 2-4 weeks), have

the students take some time to study all of the observations they have made.

2. Next, have students work in groups to interpret their data.
3. Have the students share their findings in a whole class discussion. Summarize their findings on a chart.
4. Finally, have the students revisit the predictions they wrote on their note cards at the beginning of this activity. Discuss as a class whether their conclusions were similar to or different from their predictions.

Adaptations for Younger and Older Students

Younger students may need help with the following: taping their bottles shut, labeling their bottles, and wrapping the bottles securely in foil.

Younger students might only make drawings on the *Earth System in a Bottle Student Activity Sheet* and might need adult help to write down what they observed. To help young students write about their observations, put a word bank up on the wall of your classroom - this chart can contain words the students might commonly use to describe their observations: plant, grow, tall, green, brown, wet, dry, etc.

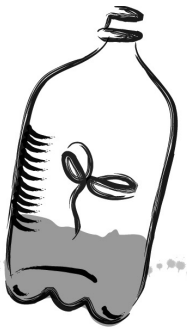
You might consider engaging the older students in a discussion of what constitutes a fair test for whether plants need water, soil, or sunlight. Older students can discuss what they will accept as a healthy plant. What will their criteria be for what a plant that is getting all it needs might look like?

Further Investigations

- **Scientists' Journals:** show your students examples of published journals some well-known scientists kept in the past. Some good examples to use are the journals of Charles Darwin, Henry David Thoreau, and Merriweather Lewis & William Clark. Have the students look for examples of interactions between Earth's components in these journals.
- **Completing the plant life cycle:** here are two options for continuing terrarium investigations.
  1. Keep the terrariums undisturbed on the windowsill and have the students discover that the system in the terrarium supports the plants without any further care from them.
  2. Remove the tops from the terrariums and allow plants to continue growing. Depending what time of year you choose for this activity, students might even be able to harvest radishes!
- **Observe other members of the radish family:** Radishes belong to the family Cruciferae, the cabbage family, which contains about 3,000 species. The family was named Cruciferae because the flowers of plants in this family characteristically have four petals spreading in the form of a cross. Farmers and scientists have bred many of the common food plants we eat today from this family (e.g. radishes, turnips, cabbage, cauliflower, and broccoli). Bring examples in and discuss the diversity of this plant family with the students.
- **Literacy Connections:** Read a science trade book about plant life cycles to your students. Some examples are *The Carrot Seed* by Ruth Krauss and *This Is the Sunflower* by Lola M. Schaefer. After reading the story, have the children write/draw on a paper that is divided into four parts with the following headings: 1) Title; 2) "The plant in this story grew because it had ___" (for example, soil and rain); 3) "The plant would have grown even better if it had ___" (e.g., more sun or more rain); and 4) "My favorite part of the story was when ___."

The Earth System in a Bottle Learning Activity was developed in collaboration with Harold McWilliams and Gillian Puttick from TERC, Cambridge, MA.

Earth System in a Bottle Recipe Card



Earth System in a Bottle Recipe

Each group will make two terrariums. All groups will make a terrarium that has all of the parts of the Earth's systems. Then each group will make a second terrarium that is missing one part of the Earth's systems.

Earth System in a Bottle

1. Put about **three cups of soil** in the bottom section of the terrarium and pat the soil gently until it is fairly firm.

2. Add about a **quarter cup of water** and look at the soil from the side to make sure that all of the soil gets wet. If there's still dry soil, add more water.

3. Drop **4-5 radish seeds** onto the surface of the soil. Use your fingertip to push the seeds just below the soil surface. Sprinkle a little more soil on top of the seeds just to cover them.

4. Place the top section of the terrarium on top, pushing alternate flaps to the inside and outside so that it fits securely. Make sure the lip/top is still on the bottle.

5. Tape the top and bottom sections together to create an airtight seal.

6. Label the terrarium with your groups' names and place it on a sunny windowsill (or under a grow light if you have one).

Experiments

Student groups: check with your teacher to decide which of the three experiments below you are doing.

No light

To darken the terrarium, wrap it with a **sheet of foil** large enough to go around the bottle twice. Crimp the foil securely shut over the top and bottom of the bottle.

No soil

Instead of soil, place a thoroughly **moistened paper towel** in the bottle, folded to fit into the bottom section.

No water

Follow the planting directions above except **omit the water**. Be sure to use previously dried soil.

Earth System in a Bottle Student Activity Sheet

Name _____

Date: _____

This terrarium included:

- ☐ Light
- ☐ Soil
- ☐ Water
- ☐ Seeds/plants
- ☐ Air

Draw what you see in this terrarium.

Write about what you see in this terrarium.

_____

_____

_____