



The Biosphere: A Closed System

Grade: 5

Subject Areas:

Life Science, Physical Science,
Social Science,

Skills: modeling,
observing, describing,
predicting, interpreting

Duration: 1-2 hours

Connections:

chemistry, earth science,
energy, plant science, natural
resources

Vocabulary

lithosphere

atmosphere

ozone layer

hydrosphere

biosphere

carbon

chlorophyll

carbon dioxide

global warming

climate

nitrogen cycle

Objective:

Students will learn about the biosphere and will model the biosphere by making and observing a closed terrarium.

Materials

- 1–2 L glass or clear plastic bottles w/ lids
- sterilized potting soil (14-20 cups)
- clean pea-sized gravel (10-15 cups)
- activated charcoal (4-5 cups)
- natural twigs, bark, lichen and/or rocks
- 2 six-packs of humidity-loving houseplants (coleus, ferns, ivy, etc.)
- 4-5 plant sprayers full of water
- 4-5 large-mouth plastic funnels (can be made)
- 4-5 wooden dowels
- masking tape and marking pens
- copies of the student activity (see attached)
- poster or digital picture of the Earth from space

Standards

Strands: Excellence in Environmental Education Guidelines

Strand 1 —A) Questioning: Learners are able to develop, focus, and explain questions that help them learn about the environment and do environmental investigations. **F) Working with models and simulations:** Learners understand many of the uses and limitations of models. **Strand 2 —2.1 The Earth as a Physical System: B) Changes in Matter:** Learners understand that the properties of the substances that make up objects or materials found in the environment. **Strand 2 —2.2 The Living Environment: A) Organisms, populations, and communities:** Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments. **C) Systems and connections:** Learners understand major kinds of interactions among organisms or populations of organisms. **Strand 2 —2.4 Environment and Society: E) Environmental issues:** Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that people in other places around the world share many of the issues they are concerned about locally.

California State Educational Standards:

Physical Sciences: 1a. Students know that during chemical reactions the atoms in the reactants rearrange to form products with different properties. **1g.** Students know properties of solid, liquid, and gaseous substances, such as sugar, water, helium, oxygen, nitrogen, and carbon dioxide. **h.** Students know living organisms and most materials are composed of just a few elements.

Life Sciences: 2f. Students know plants use carbon dioxide and energy from sunlight to build molecules of sugar and release oxygen.

Earth Sciences: 3a. Students know most of Earth's water is present as salt water in the oceans, which cover most of the Earth's surface.

Background

Layers of Earth

If one learns about Earth on a planetary scale, it is sometimes viewed as the third rock from the sun. Earth indeed is mostly made of rock. The inner layers of Earth make 99% of Earth's mass. These hidden layers both solid and liquid are mostly made of the same materials as meteorites and other solid bodies found in space: iron and nickel. The solid assorted rocky layer that covers the surface of the Earth is referred to as the **lithosphere**.

Above the lithosphere is the atmosphere. The **atmosphere** includes all of the gases that surround a planet. On Earth, the atmosphere ends where the vacuum of space begins, about 700 miles up. Our atmosphere is mostly made of nitrogen and oxygen, although it wasn't always this way. The lower atmosphere is where all weather occurs. The upper atmosphere includes the **ozone layer**. This layer protects us from harmful radiation that is constantly striking the Earth from space.

When you view Earth from space, it looks blue because the majority of Earth is covered by water. Two thirds of the planetary surface is covered by our ocean. The sun and the ocean together are the engines behind our global weather system. Water is an essential ingredient for life. All water on Earth is part of the **hydrosphere**. It includes all the places you can find water including the ocean, the sky, rivers, lakes, and even underground.

Between the atmosphere and the lithosphere, is another sphere or layer— the biosphere. The **biosphere**

is unique because it is a living layer. It is defined by where life exists and extends from the deepest reaches of the oceans to the tops of the clouds. Even so, compared to the other layers, it is thin. This thin layer is an integral part of maintaining the balance of certain systems required to support life. For instance, it is life itself that transformed our atmosphere into one rich in oxygen necessary to support large organisms like ourselves. It is the one place where all of the other spheres work together. As far as we know, Earth is the only planet to have a biosphere.

Circles of Life

Like the atmosphere which is constantly changing creating clear

and cloudy skies in different places, the biosphere is ever changing too. Plants and animals are constantly growing and dying. When small marine animals die, they slowly sink to the bottom of the ocean forming layers that eventually create rock called limestone and/or chalk. When something like a tree dies in the forest, it supplies nutrients that other plants and animals can use to live. Through life and death nutrients are utilized and then recycled. One of the important elements recycled over and over again is carbon.

All life on Earth is made of **carbon** rich molecules. Our bodies are mostly water and carbon. When you burn something whether it is a log in a fire or a pie in an oven, a black substance is left behind called charcoal. Charcoal is almost pure carbon. Plants and

Local Connection

Great Pacific Garbage Patch

There are at least five places in the ocean where currents concentrate floating garbage forming large dispersed mats. These currents are referred to as gyres. Located between California and Hawaii is one of the largest of these gyres, and it has collected debris into this North Pacific Gyre forming what is sometimes called the Great Pacific Garbage Patch. This floating raft of marine debris is a spinning vortex that changes over time. It spins in a clockwise direction and forms a mat of garbage larger than the size of Texas.

Research vessels are now beginning to study and analyze marine debris, the most involved to date is called the Algalita. The Algalita is shedding light on plastic debris in our oceans, and the biological impact of plastics on marine life and the human food chain. Based on some of their analysis of the garbage found in the Great Pacific Gyre, at least 40% of it comes from land and the other 60% comes from cruise liners, merchant ships, oil tankers, and other vessels. Additional information can be found at: www.algalita.org, including an educational kit available for teachers that includes a sample of sea water full of plastic.

some marine organisms cycle carbon because they have a special pigment called **chlorophyll** within their cells. Chlorophyll absorbs carbon in the form of carbon dioxide. In the oceans, plants called phytoplankton absorb tons of carbon. How carbon is used and recycled is called the **carbon cycle**.

The amount of carbon in the atmosphere is of increasing concern today because **carbon dioxide** traps heat. Too much carbon dioxide and the planet heats up like a greenhouse. For the last one hundred or so years, we have been experiencing climatic change here on earth called **global warming**.

Bacteria and certain plants play an important role in another cycle: the **nitrogen cycle**. Nitrogen is another important element for life. Plants need it to grow properly. Animals get rid of excess nitrogen through their waste. There is a constant cycling of nitrogen as a waste product and as a useful product for plants. Nitrogen has to be in the right form for plants to use, however. They can't take nitrogen gas straight from the atmosphere. They require other living things to convert it for them. This is another example of how the living layer of earth is interconnected.

Life is connected to climate too. **Climate** is the long range atmospheric conditions of a particular area. The King Range National Conservation Area is part of a temperate climate. A temperate climate experiences wet, cold winters, and dry, warm summers. Places like France and Japan also have temperate climates. The vegetation type of an area is a good indicator of a particular climate. Certain climates like those that occur in deserts or in the polar regions, can't support a lot of vegetation. On the other hand, tropical and temperate places can support a tons of vegetation because

these places receive abundant levels of sunlight and water.

All life must have energy to perform vital biological processes. Plants get their energy by absorbing certain wavelengths of light. Animals get their energy by eating food. Scavengers and decomposers get their energy by breaking down once living things. However, the ultimate source of energy for life (except for a few things living in the deep ocean) is the sun. This means life would not be possible without a nearby star; well, maybe not too near.

Life is rare in our solar system because as far as we know, life needs to have water in a liquid state. Earth's position in space allows liquid water to exist. Too close to the sun and all the water would evaporate off the surface. Too far away, all water would be locked in its solid state—ice. Three fourths of Earth's surface is covered by a liquid ocean that feeds the water cycle powered by the sun. The resulting rain and snow eventually fill lakes and rivers, and in some cases will reach the roots of plants or the mouths of animals.

Isolated in Space

The biosphere is a closed system meaning matter does not enter or exit (except for space dust). The amount of water is the same now as it has been for the last 4 billion years. Water continually gets recycled through the water cycle. Sewage, garbage, fallen leaves and other discarded things get reused and recycled through the process of decay by decomposers. The main decomposers are bacteria and fungus. They are constantly breaking down substances into more useable forms which is why dead things don't build up over time. Because of the vital roles vegetation and decomposers have in any ecosystem,

they provide the most stability to any living system.

As people continue to study and understand the large complex systems of Earth, they have come to realize the uniqueness of our biosphere. Compared to the other spheres (lithosphere, atmosphere, hydrosphere), the biosphere is fragile. Most organisms require particular levels of pH, water, nitrogen, carbon and oxygen among other things in order to survive. As a matter of fact, some scientists think of the biosphere itself as a living organism. Living organisms have the ability to maintain themselves through a process called **homeostasis**.

The biosphere is an integral part of the atmosphere, the lithosphere and the hydrosphere. The life forms making up the biosphere exchange gases and cycle nutrients between land, air and water. Today, scientists are discovering that the combined effects of human actions are so great that we are transforming the biosphere in which we live. Our actions could be altering this delicate balance. By understanding that this thin fragile layer is a closed system, we can make choices and take actions that will provide for a sustainable future.

Activity: Biosphere in a Bottle

Preparation

If you have never made a closed terrarium using similar materials as above, it is recommended that you try making one ahead of time. By practicing first, you can inform the students of the potential challenges that are sure to take place during the following activity. Once inside the classroom, different stations should be made: each having all the components necessary to make a complete terrarium.

Procedure

1. A closed terrarium or biosphere bottle, is a great model of the biosphere because no significant amounts of matter can enter or leave. However, within it, energy can be absorbed and from it, energy can radiate freely. In order for the terrarium to work, all of the materials above must be present. These materials include water, carbon, nitrogen, air, space and some living material like plants and bacteria. The biosphere bottle has its own climate, water cycle, carbon and nitrogen cycles. The bottle will have its own unique organisms which will include mostly plants, but others will come from the soil and other items placed inside it. These may include bacteria, fungus, and protozoa.

2. Begin by showing a large picture of planet Earth. Have the students closely observe the features that they see.

- *What kinds of features are visible from space? (oceans, clouds, land, deserts, forest, etc.) (Have the students share some of their written responses)*
- *What types of things are important for supporting life?*

Materials

- 1 –2 L glass or clear plastic bottles w/ lids (what else—plastic milk cartons?)
- sterilized potting soil (14-20 cups)
- clean pea-sized gravel (10-15 cups)
- activated charcoal (4-5 cups)
- natural twigs, bark, lichen and/or rocks
- 2 six-packs of humidity-loving houseplants (coleus, ferns, ivy, etc.)
- 4-5 plant sprayers full of water
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- copies of the student activity (see attached)
- poster or digital picture of the Earth from space

Before discussion begins, have them write down 5-10 things they think are important for a planet to have in order to support life and have them list the features they can see in the picture.

3. After they have given some responses, fill in any missing features. Make sure land or rock, water or oceans, and clouds have been listed. 4. Next, explain to them that certain things like water are recycled over and over and are considered systems. For instance, perhaps they have heard of a weather system or a rock cycle. Explain to them that systems are sometimes referred to as spheres or layers. Write the prefixes: hydro, litho, and atmos on the board. Fill in the meanings of the prefixes with the students help. (hydro = water, litho = rock, atmos = vapor) It is optional for students to take notes.

5. Add the prefix “bio” to the board. Ask the students if they

know what “bio” means. (bio means life or living) Explain to them that today they are going to discuss a closed system called the biosphere. Draw a large circle on the board to represent the biosphere. Inside this circle begin to add components necessary for life. (water, nitrogen, space, oxygen, carbon dioxide, energy, etc.) Remind them that different organisms need different things. Ask: Why is the biosphere considered a closed system? Remind them that energy from the sun comes in but it is not matter. The amount of matter basically stays the same. Give them some examples of this.

6. Continue to explain what defines the biosphere. Briefly discuss decomposition and the water cycle. Remind them that there is no “away” unless something is launched off Earth. For instance, you can have them think of something like a tree. Ask them: What does a tree need to



Activity: Biosphere in a Bottle (cont.)

survive? Where do these components come from? What happens to a tree once it dies? (it decomposes) What does a dead tree turn into as it decomposes (various compounds) What benefit could a tree have once it dies? What main elements is a tree made of? (carbon, hydrogen, oxygen, nitrogen) What main elements are you made of? (the same as above) Where did these elements come from (they are reused and recycled).

7. Try and get the students to understand the elements they are made of came from something else. The very elements that life (including us) ultimately came from the “star stuff” that the Earth is made of. Continue to explain how all living things are interconnected to living and non-living things (rock, water, air). An animal for instance, needs oxygen and gives off carbon dioxide. A plant needs carbon dioxide and gives off oxygen. Ask: How does a plant get its energy? How does an animal get energy? Tell them they are going to attempt to make a closed system to model similar processes they take place within the biosphere.

8. Before breaking the students up into groups, go over the main procedure of how to make a closed terrarium. Show them the different substances used and in what order they are to place them in. This is a good time to share some challenges they will have. Students work best together when everybody has a specific job to do. It is recommend that you give various tasks to all of the students. (the teacher can help you with this part). Write the following tasks on the board: 1) mixing gravel and charcoal; 2) adding soil; 3) planting plants; 4) applying water; 5) clean-up. One easy way to assign a task is to have all of the students count off.

- *Do you think other planets have atmospheres? Which ones? (all but Pluto and Mercury)*
- *How about a lithosphere? (all of the solid planets)*
- *What does Earth have that these other planets don't? (liquid water and life)*

Number 1 is given the first task; 2, the second task, etc. Break the students up in groups of 4–6. You may want to lay down newspaper ahead of time because this activity can get messy. See the itemized instructions on the student worksheet. (attached)

9. This activity required additional follow up. Over the next two to three weeks students should conduct regular observations to truly observe the relationship between the closed terrarium and the closed system of the biosphere. There are a variety of questions that can be given to students referring to several different topics.

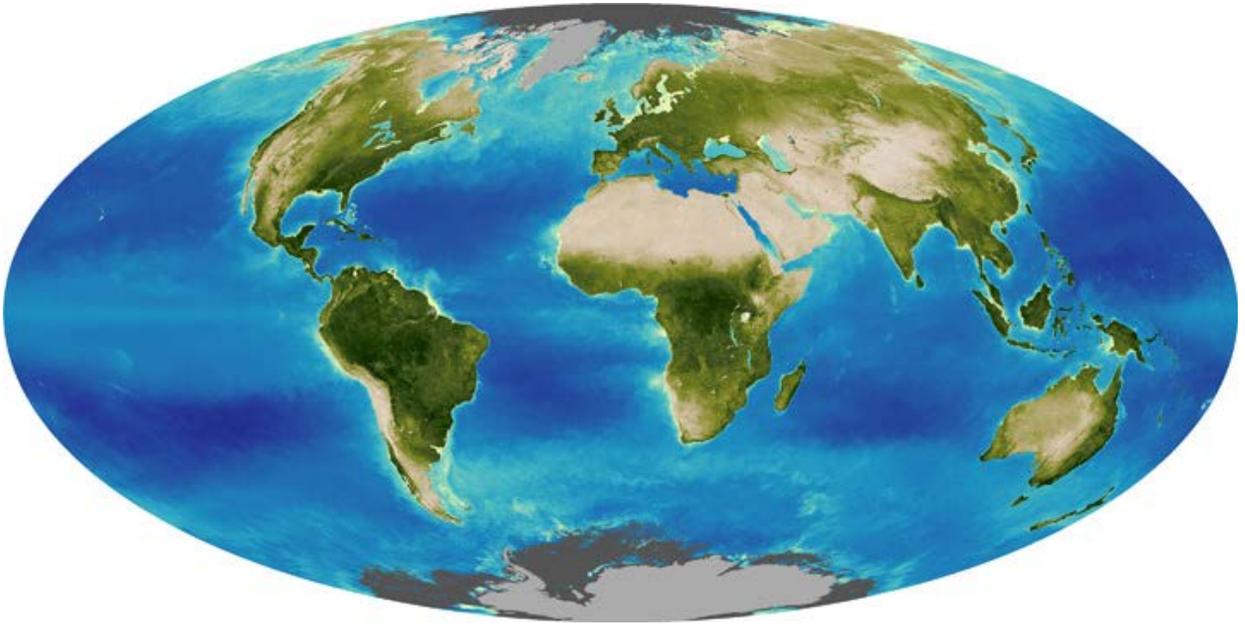


Extensions

- Have the same groups of students design an experiment by having them add a component to their biosphere that wasn't there before. For example: a household product, a cup of marble chips and hydrochloric acid, a piece of food, plant eating beetles, etc.
- Use the biosphere as a way to discuss other large systems like the water cycle.
- Have the students research different biomes. Next, they can incorporate what they have learned into an art project like a collage.
- Make a time capsule. Locate an area outside where various bottles and other trash can be buried. A rough map should be made. Rope this area off. After two to three months, come back and observe how things have changed.

References

- Algalita Marine Research Station, <http://www.algalita.org/research/index.html>, 2011
- A Big Ball of Life, http://www.geography4kids.com/files/land_intro.html, 2010
- Marine Debris, <http://water.epa.gov/type/oceb/marinedebris/index.cfm>, 2011
- Global Biosphere, Earth Observatory, NASA, <http://earthobservatory.nasa.gov/Features/WorldOfChange/biosphere.php>, 2010
- Mussell, David, The Pembina Institute, The Biosphere Bottle, <http://www.geoec.org/lessons/biosphere-bottle.pdf>, 2010 (activity adapted from this lesson)
- The Biosphere: An Integral Part of the Planet and its Climate, http://www.windows2universe.org/teacher_resources/online_courses/biosphere_intro.html, 2010



From NASA Earth Observatory for year 2008 <http://earthobservatory.nasa.gov/Features/WorldOfChange/biosphere.php>

Extension: have students compare changes from 1998 to 2008.

Sample Questions

Is your terrarium an open or closed system? Why?

Without opening up your container, what do you observe?

Can you observe any changes in:
color of plants?
color of soil?
size of the plants
moisture?

What form of water do you observe?

Where specifically in your container is water located?

Is there evidence of plant growth? Explain.

