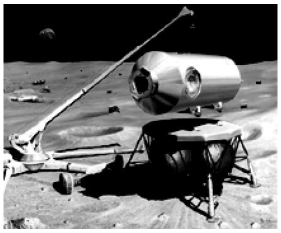


Lunar Biosphere

Purpose

To build a biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time.

Background [also see "Teacher's Guide" Pages 14, 15]

Earth is the ultimate **biosphere**, literally a "life ball." It holds and sustains all life known to humanity. As men and women look to traveling and living beyond our blue planet, we see conditions that are too harsh to sustain life as we know it.

Conditions on the Moon are not favorable for sustaining life because of the absence of water, organic topsoil, and **atmosphere**. Also **lunar** days (equal to 14 Earth days) and nights are very long. Water must be brought from Earth or made using oxygen from lunar **regolith** and hydrogen from Earth. Nutrients need to be added to lunar regolith and plants have to be grown in a self-enclosed system. What's more, artificial light must be used during the long, dark periods.

This activity challenges students to create a working model of a lunar biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time.

Preparation

Review and prepare materials listed on the student sheet. Here are some suggestions.

Seedlings: About two weeks prior to this activity, sprout the seedlings for use in the biospheres. Successful biospheres have been made using mung, radish, and peanut. Tomato seedlings can also be used, as well as ferns, vines, and simple garden weeds.

Soil materials: Collect bins or bags to hold the variety of soil materials: vermiculite, permiculite, cinder, gravel, sand, silt, clay, and fertilizer.

Animals: Students should collect live critters to live in the biospheres. These can include -- insects (ants, cockroaches, beetles, etc.), mollusks (snails, slugs, etc.), arachnids (spiders, etc.), and crustaceans (sow bugs).

Plastic bottles for biospheres: Use 2-liter soda bottles with the black base. Remove the black base by submerging it in a large pot of hot (but not boiling) water. This softens the glue holding the base onto the bottle without melting the plastic. Take off the label. With an exacto knife or razor, cut off the top spout of the bottle. For safety, it is best not to allow students to do the cutting. You may place the spout with your other plastic recyclables as it will not be used in this activity. Prepare one container per student.

Lunar Biosphere

The students will plug the holes in the black base with wax, tape, or clay. The base must be watertight. They will then fill the base with a predetermined soil mixture. They will add water, seedlings, and animals as decided by the team. Finally, they will invert the plastic container into the base, seal it with clear, plastic tape, and label it. The label should include the student's name, names of team members, date, and time the biosphere was sealed.

In Class

After discussing the background information and purpose of this activity, divide the class into cooperative teams of 4 students each.

Biosphere mobiles

Have each team create a hanging mobile with the theme "Biosphere." Each hanging component represents one part of the living Earth system, e.g., water, plants, animals, people, air, Sun, soil, etc.

After mobiles have been balanced and hung from the ceiling, have the students predict what would happen if one part were removed or just shifted. Ask the students to shift or remove one part. Does the biosphere remain balanced? Ask the students to try to rebalance and hang their mobiles. Have them relate what they see to what might happen if a part of any biosphere is changed or removed.

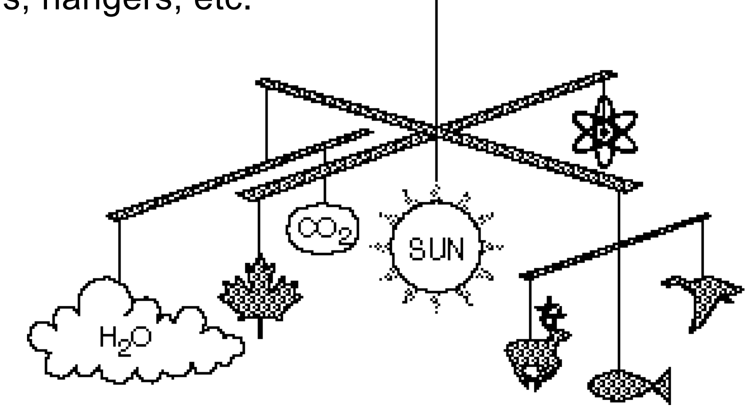
Materials

cardboard or heavy-weight paper

markers or crayons

string

something to use as the frame -- wooden chopsticks, other kinds of sticks, plastic drinking straws, hangers, etc.



Lunar Biosphere

Making Biospheres

After discussing the importance of a balanced biosphere, you may choose to have the students number themselves from 1 to 4 for a role assignment within each team:

1 = Botanist - person who studies plants,
2 = Agronomist - person who studies soils and crops,
3 = Science Specialist - person who relates conditions of soil and water to optimal plant growth,
4 = Zoologist - person who studies animals.

Distribute the "Team Member Information Sheets." Students are responsible for reading and sharing the data contained on their own sheets. Have them log their shared information on their worksheet -- as outlined in Question 3 on page 133.

Before the actual construction, each team must decide the following for their lunar biospheres:

1. best lunar soil mixture
for example, vermiculite, permiculite, cinder, sand, gravel, fertilizer, etc.

2. amounts of each type of soil material
for example: 10 Tablespoons of sand
10 Tablespoons of silt
10 teaspoons of vermiculite
1/2 teaspoon of fertilizer

3. optimal lighting
for example: direct sunlight, shade, artificial lamp, etc.

4. optimal amount of water to add to the biosphere before sealing it
for example: 5 Tablespoons of water

5. kinds and amounts of seedlings and animals to include inside
for example: mung, radish, peanut seedlings -- use just one type or a combination. If these are not available, then other seedlings can easily be used. Other examples include ferns, vines, and garden weeds. Have students explain why they made their choices. Students can also do preliminary research on their organisms.

Note: Each lunar biosphere must include plants and animals.

Lunar Biosphere

After teams have discussed and decided these five points, then each student will make his/her own biosphere.

The biospheres must be completely sealed with clear, plastic tape.
No air or other materials can go in or out.
Once the biosphere is sealed, it cannot be opened again.

Each lunar biosphere should be labeled with the student's name, names of team members, date, and time it was sealed. Put this label on the black base.

After the biospheres are built, they should be set under the lighting conditions chosen by the teams.

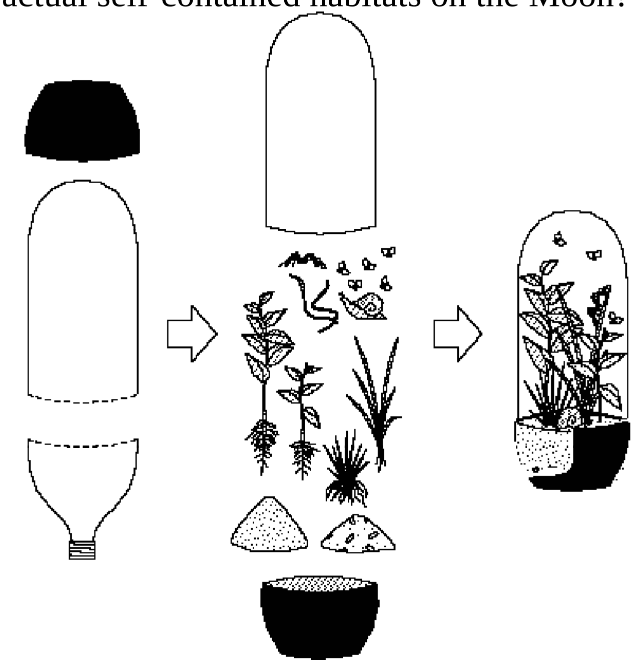
A “Data Sheet” and an “Observation Sheet” are provided for student use.

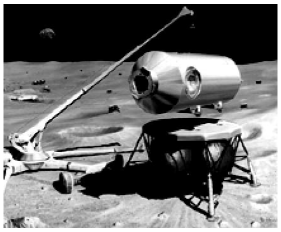
Wrap-up

Are some lunar biospheres doing better than others?

What are some of the factors leading to the success or failure of the biospheres?

Based on this experience of making a model lunar biosphere, what is your opinion on the potential success of actual self-contained habitats on the Moon?





Lunar Biosphere

Purpose

To build a biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time.

Key Words

biosphere

soil

atmosphere

organism

photosynthesis

agronomist

botanist

zoologist

Materials

"Data and Observation Sheets"

"Team Member Information Sheets"

measuring cups & spoons

plastic 2-liter bottle, cut

vermiculite

permiculite

cinder, gravel, sand

silt, clay

fertilizer

seedlings and animals

water

clear, plastic tape

lamp

Procedure for Teams

1. Discuss and list the questions you may want to ask before you start to build a lunar **biosphere.**

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2. How and where could you find possible solutions to these questions?

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3. List all important information you obtained from the **botanist, agronomist, science specialist, and zoologist** that will assist you in planning the most efficient and effective lunar biosphere possible.

Procedure for Each Person

4. Fill out the "**Biosphere Data Sheet**" with your team's choices of best **soil mixture, types and numbers of seedlings and other organisms, optimal lighting conditions, and the optimal amount of water** to add to the biosphere before sealing it. Remember that you are striving to create a living system that will remain balanced over a long period of time.

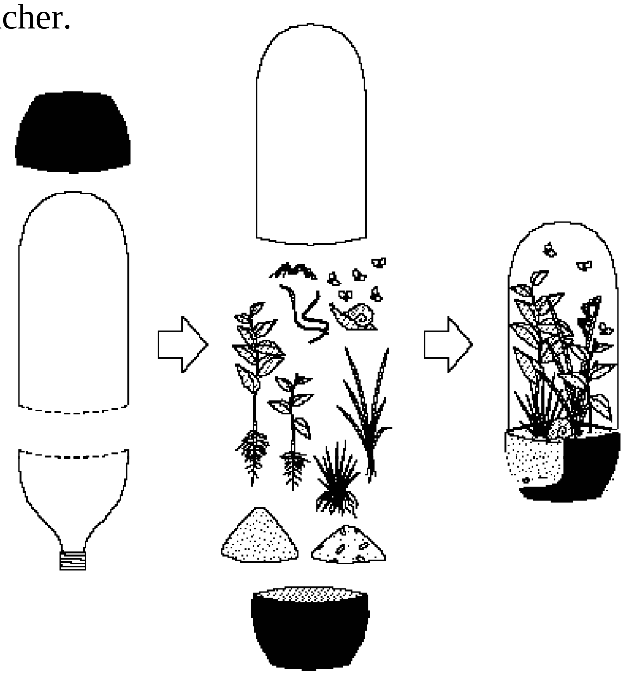
5. Obtain a pre-cut **plastic bottle** from your teacher and build your personal biosphere following the team's recommendations.

6. Seal your biosphere with clear, **plastic tape**. We are simulating a lunar biosphere, therefore no air or other materials can go in or out. After your biosphere is sealed, it cannot be reopened.

7. Label the biosphere with your name, names of your team members, date, and time it was sealed. Put the label on the black base.

8. Set your biosphere under the **lighting** conditions chosen by the team.

9. Fill in the "**Biosphere Observation Sheet**" as directed by your teacher.



Team Members: Name: ______________________________

Date: ________________

Lunar Biosphere - Data Sheet on Materials Used

Soil Material	Amount Used

Seedlings / Animal organisms	Amount Used

Lighting Conditions:

Amount of water added to Biosphere before it was sealed:

Date and Time it was sealed:

Team Members:

Name: ______________________________

Date: ________________

Lunar Biosphere - Observation Sheet

Date	Lighting Conditions	Height of Seedlings (cm)			Observations	Color Sketches
		Mung	Radish	Peanut		

Name: ________________________________

Date: ________________

Lunar Biosphere

Team Member Information Sheet

for Botanist

Mung bean, *Phaseolus aureus*
origin: India, central Asia

The mung bean, a bushy annual which grows 76 - 90 meters tall, has many branches with hairy bean-like leaves. Flowers are yellowish-green with purple streaks and produce long, thin, hairy pods containing 9 - 15 small yellow seeds. Seeds are used to produce bean sprouts.

Radish, *Raphanus sativus*
origin: temperate Asia

The radish produces white, red, or black roots and stems under a rosette of lobed leaves. It is an annual or biennial plant, which grows several inches high. Radishes should be planted 1 cm deep, and will sprout in 3 - 7 days. When planted together with other root crops, radishes can be used to decoy pests, and the spaces left in the soil when they are pulled out provide growing room for the other root crops, which grow more slowly.

Peanut, *Arachis hypogaea*
origin: South America

The peanut, an annual vegetable which belongs to the pea family, grows from 15 - 76 cm tall. Flowers are small yellow clusters that grow on stems called pegs. Pegs grow downward and push into the soil. Nuts develop from these pegs 2.54 - 7.6 cm underground.

Name: ______________________________

Date: ________________

Lunar Biosphere

Team Member Information Sheet

for Agronomist

Soil has four functions:

1) supply water to plants,
2) supply nutrients (lunar regolith, however, needs to have nutrients added to it),
3) supply gases (oxygen and carbon dioxide), and
4) support plants.

The ideal soil holds moisture and nutrients while letting excess water drain to make room for air.

Types of soil:

clay - small particles, less than 1/256 mm, which pack closely. Poor drainage.
sand - irregular particles between 1/16 mm and 2 mm. Holds very little water.
silt - between clay and sand-size particles. Not very fertile, packs hard.
loam - a mixture of clay, silt, and sand. The best kind of soil.

Name: ______________________________

Date: ________________

Lunar Biosphere

Team Member Information Sheet

for Science Specialist

Growing Conditions

Mung bean - grows best in full sun, in a rich, well-drained soil. It shouldn't be allowed to dry out completely.

Radish - is a cool season crop, and can take temperatures below freezing. It can tolerate partial shade. Soil should be well-drained. If water supply gets low, then radishes become woody.

Peanut - needs lots of Sun and warmth. It is relatively tolerant of dry soil. These seeds are very sensitive to fertilizer.

Soil - can be improved by the addition of fertilizers, which provide nutrients to the plant. This makes the plant healthier, and better able to resist disease and pest attacks.
Vermiculite and perlite are "puffed up" minerals that are used to lighten heavy clay soils with air spaces, or to help sandy soils hold more water. They do not directly provide nutrition to the plants.

Name: ______________________________

Date: ________________

Lunar Biosphere

Team Member Information Sheet

for Zoologist

Mung bean - has no serious pest or disease problems.

Radish - has no serious disease problems. Maggots and aphids may be a pest problem, but radishes are usually harvested quickly enough so these do not have much effect.

Peanut - may be attacked by nematodes, aphids, and in some areas, by rodents.