

Bottle Biosphere Project

Background Information

A biosphere is a closed system where light is the only thing added. The light provides the energy for life in the biosphere. The needs and the products of each living thing must be balanced so that the environment within remains favorable in terms of available food, water, gases, and necessary fertilizing elements.

Biospheres have long been made to demonstrate the chemical balance of life, but recently they have become more than mere curios. The prospect of prolonged space flight to other planets and space colonies can only be possible if food, oxygen, and water for the humans involved can be produced in the spacecraft or colony rather than hauled from Earth. The idea of a self-contained miniature Earth out in space that can keep people alive for long periods has sparked a great deal of study about biospheres.

Many early studies explored simple systems such as people and a one-celled green algae called *Chlorella*. There were at least two problems with a simple algae-human biosphere. One was that although algae produced oxygen and purified water, no one has yet been able to create a complete diet from this algae and algae-fed animals. The other problem was that with only one producer, the whole system could fail if a disease or environment problem slowed algae growth.

More recent studies have involved more familiar food crops such as wheat, rice, potatoes and beans; teamed up with some livestock such as chickens, fish and goats. This kind of a system seems more likely to provide for all the needs of the people involved but has the disadvantage of being more complicated and requiring a larger structure.

There are now biosphere experiments going on in many parts of the world but the Tucson area is a center for these studies. The Environmental Research Laboratory located near Tucson International Airport is studying growing food crops in very small areas in greenhouses. They have been fertilizing these crops with water from small ponds where they grow *Talapia* (a plant-eating fish) that have been specially bred for meat production.

The former Space Biospheres Construction Company began studying large biospheres that people can live in more than 20 years ago. They built a large, sealed glass structure called Biosphere 2 near Oracle, Arizona. The first experiment in this building involved eight people living in a closed system where everything was to be recycled for a period of two years. Although not a complete success, much was learned from the experiment. Biosphere II is now operated by the University of Arizona. It is being redesigned to simulate a variety of environmental conditions on Planet Earth.

Another company that is a world leader in biosphere construction is Ecosphere Associates located right here in Tucson. They have built some of the smallest, longest-lived biospheres yet. Their system is a sealed glass sphere with salt water, marine algae, microorganisms, and bright red Pacific shrimp. It only requires normal room light to keep these organisms balanced. Some of their first spheres closed over ten years ago still have live shrimp inside. Ecosphere Associates markets these attractive shrimp biospheres worldwide and has recently added a land system they call TerraSphere. The TerraSphere contains mosses, ferns, liverworts, and fungi; all simple non-flowering plants. The only animal it supports is a tiny roundworm called a nematode.

Russian scientists have put people into semi-sealed systems for as long as six months, but were unable to recycle water. The people became ill and algae grew all over everything causing the collapse of the system. The science of biospheres is not yet an advanced area of

study. Shrimp and ferns are the highest animals and plants to live long-term in a closed system. No one is known to have kept a fish or a flowering plant long-term (i.e. more than a year). If you can discover how to do it, you may be the first!

The Assignment

Each group of two students must seal a clear container so that no matter can enter or leave it. The goal is to include a community of plants and animals that is planned to balance each other in their chemical needs and waste products and to provide an energy flow from the light that enters the container to all of the living things inside. If this goal is accomplished, the plants and animals will stay alive for the two-week test period and possibly much longer.

Each biosphere should have a bound report with it. The report should be organized into the following five parts:

1. Plan
2. Construction
3. Charts
4. Records
5. Conclusion

1. **PLAN:** Must be turned in and receive an OK from teacher before starting construction.

Things to include:

- A. Type of container and method of sealing it airtight.
- B. Type of physical environment -- land, freshwater, saltwater or combination.
- C. Non-living objects such as dirt, sand, gravel, wood, shells, etc.
- D. Water source (tap, bottled, drinking, purified, aquarium, ocean, synthetic ocean, rock salt brine)
- E. Fertilizing agents added, if any (soil water, Miracle Grow, boiled grain, boiled dried peas).
- F. A list of the major plants and animals you plan to include and their approximate relative numbers. Be sure to plan for greater amounts of life on the lower parts of the food pyramid as shown on pp. 786-787 of the blue Modern Biology text.

2. **CONSTRUCTION:** You must have an OK on your plan before you start this part of your write-up.

Things to include:

- A. Give the date of construction and the date that each organism is added. It might be a good idea to add the plants first and wait until they are growing well before adding the animals and sealing the system. However, if plenty of all organisms are available, you may add everything at once and seal the biosphere right away.

- B. Include as complete a list of organisms as possible. Name all visible living things and use a microscope to identify as many microorganisms as possible. Try to find both the common and the scientific name.
 - C. Give the source of each organism (where you obtained it) as a clue to what other life forms may be “hitching a ride” on it. Also note if you wash the living things you put into your biosphere or encourage small organisms from their environment to enter the system with them.
 - D. Write down what you expect each organism to find to eat in your biosphere.
 - E. Record the actual amount of each organism sealed into the biosphere. Use weight as measured on the triple beam balance if possible. Otherwise, record the size and number of individuals.
 - F. Explain any ways that your actual construction differed from your plans, and why.
 - G. Include in the construction report anything else that you think is interesting that you notice as you build your system.
3. **CHARTS:** The purpose of this section of your report is to illustrate how life may be able to survive in your biosphere. You should have at least two charts. Each should be on unlined paper not less than 8 1/2 x 11" and not more than 18 x 24". You should carefully plan these charts and make pencil sketches first. All drafting and lettering should be neat and clearly readable. Labeled, carefully-drawn pictures of all the organisms in your biosphere should be included somewhere in your charts. You must have at least one of each of the two types listed below.
- A. A chart showing how light energy passes to each organism in the biosphere. It can be in the form of an energy flow chart, food chain, food pyramid, food web, or food cycle. Use the index in your textbook to find examples of many of these types of charts.
 - B. A chart showing how the materials found in living things cycle through the living and nonliving environment of your biosphere. Below are three suggestions for how to do a good chart of this type.
 - 1. The chart could show the carbon, oxygen, hydrogen, or nitrogen cycle in your biosphere. Use the index in your textbook to find explanations of these cycles and examples of charts.
 - 2. Combine several or all of these cycles into one big picture that shows how materials cycle through the environment.
 - 3. Make a chart showing how the chemical processes of photosynthesis and respiration cycle materials back and forth. You can find an example of this kind of chart in the part of the instructions called "The Chemical Balance of Life."

4. **RECORDS:** Your careful, dated records of what happens in your biosphere will be important in learning how closed systems work. Make your first observation the day after you seal the container. Thereafter, make a detailed observation every week, or more often if you notice important changes. Each observation should include a mention of each organism and any changes in their quantity, size, condition, and behavior. Other things to look for would include the appearance of the water, soil, sediment, and the sides of the biosphere.

5. **CONCLUSION:** When the assigned time for the experiment is up, you should write your conclusion. You are encouraged to continue to leave your biosphere sealed. However, if most of your organisms have died, you may wish to open the system and perform an "autopsy". Also, if you wish to end the experiment and return the organisms to their natural environments, you may.

The first part of your conclusion should be a survey of what organisms are still alive and in what quantities. If you are not opening your biosphere, then this survey should be done as best you can using observations from outside your container. If you decide to open your biosphere, then you can try to be more exact in your survey and include weights of larger organisms.

The second part of your conclusion should be an explanation of facts that you learned from keeping a record of observations. This part should only be new things that you did not know when you started your biosphere.

The last part of your conclusion should be a list of changes you would make if you were to make another biosphere similar to the first. Give a reason for each change.

Bottle Biosphere Check Sheet

Components:

Please include each of the following items, **in order**, in your Bottle Biosphere Report. **Label** each section. **Place a check mark** (✓) on the line to indicate that it has been included in your report. Check your Bottle Biosphere Packet for specific details regarding the content of each section. **Staple** this checksheet to the front of your report.

Included Points

- _____ _____ 1. Cover Page
- Title of Report
 - Date
 - Names of All Group Members
 - Period and Course Title
- _____ _____ 2. Plan (include plan that was graded)
- _____ _____ 3. Color drawing of biobottle
- _____ _____ 4. Construction chart & description
- _____ _____ 5. Observations (one set for each lab member)
- At least five observations
 - Each observation must be **dated**
- _____ _____ 6. Cycles Charts in **Color**
- One Chart of each Type (see instructions)
 - Label Key Components of Chart & Type of Chart
- _____ _____ 7. Conclusion & Future Improvements Section