

# Activity #10

## Effects of a Closed Environment on Living Things

**Grade Level:** 9 - 12

**Module:** Cardiovascular

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### Overview

We must understand the interdependent relationships between photosynthesis and animal respiration before we can proceed in developing systems that will allow long term survival in space. Utilizing the processes of photosynthesis and respiration, students investigate living organisms in a closed environment.

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### Key Questions

- What factors are necessary in order to assure that living things can survive and function in a closed environment?
  - What happens to plants when they are placed in an environment saturated with carbon dioxide for a period of time?
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### Time Frame

Varies depending on the expertise of the students.

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## Materials

### For each team of students:

- 8 test tubes
- 4 aquatic snails
- 8 stoppers
- bromthymol blue solution
- 4 stalks of Elodea
- 1 or 2 liter bottle of club soda

### For each student:

- One photocopy each of "Student Record Sheet," "Analyzing Your Data," and "Excess Oxygen Experiment Observations" (masters on the following three pages)

### For the class:

- 1 Overhead transparency of "Setting Up the Test Tubes"

## A Closed Environment

## Student Record Sheet

Directions:

Set up a table like the one below to record your data. You will be recording the color of the solutions each day.

**Table # 1 Solution Color for Test Tubes with Water Only.**

	Elodea A	Snail B	Both C	Water D
Day 1				
Day 2				
Day 3				

**Table # 2 Solution Color for Test Tubes with Bromthymol Blue**

	Elodea E	Snail F	Both G	Water H
Day 1				
Day 2				
Day 3				

### Reflections.

After collecting data, reflect on these questions:

1. Which test tubes were used as controls?
2. What causes the bromthymol blue solution to turn yellow?
3. For each test tube, explain what effects cause the final observed changes.

**EXCESS CARBON DIOXIDE EXPERIMENT      OBSERVATIONS**

**Table # 3**  
**Solution Color for Test Tubes Saturated with CO<sub>2</sub> & Bromthymol Blue**

	Elodea I	Snail J	Both K	Water L
Day 1				
Day 2				
Day 3				

**Reflections.**

After you have collected data, reflect on these questions.

1. Did any of these tubes go from yellow to clear or blue?  
What gas do you suspect replaced the CO<sub>2</sub>?
2. Tube D should remain yellow in color. Tube H should remain blue in color. Tube L should remain yellow in color. Why will this be the case for each of the tubes? Be specific.
3. Why would each of these tubes (D, L, and H) be considered a control for its group?
4. Which of the three sets of test tubes will be considered the control group? Why did you say that?
5. Did tube I clear? How long did it take? Observe tube K; has it cleared? Why do you think this happens?

## A Closed Environment

## Analyzing Your Data

1. In your observations of tubes E through H which of the tubes, if any, are yellow?
2. What is the reason bromthymol blue turns yellow in these tubes?
3. Are any of the tubes blue in color? What does blue indicate?
4. Are any of them clear? What does clear indicate?
5. Which of the tube groups ABCD or EFGH is most likely to remain clear? Why?
6. What do you think is the relationship between photosynthesis and respiration?
7. How is this activity relevant to humans in space? What implications does this study have for space travel and for living in a closed environment?

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## Classroom Activity

### Part A – The Role of CO<sub>2</sub> in Living Systems

1. Have the students write descriptive sentences using each of these words or phrases: carbon dioxide, plant, animal, waste elimination, general health, behavior, photosynthesis, oxygen, respiration, and indicator.

2. Laboratory activity – give the students the following directions:

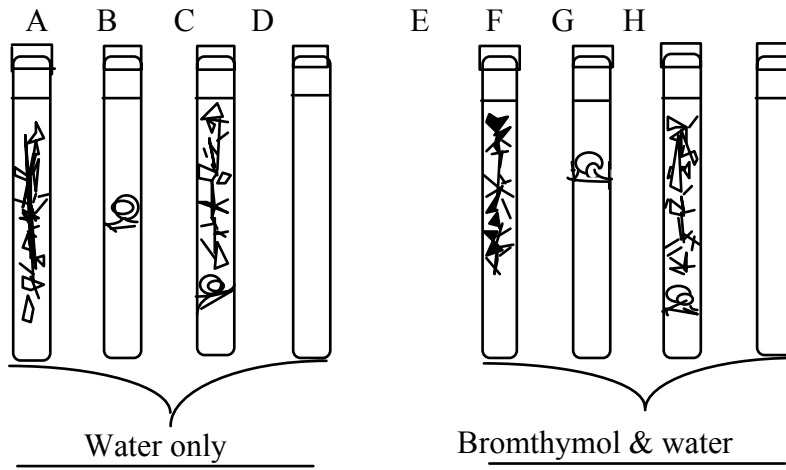
- a. Fill a 15 ml test tube with about 10 ml of clean aquarium water and add about 3 drops of bromthymol blue solution. Using a soda straw, gently blow into the bottom of the test tube. Is there a color change in this solution? What may account for this color change? Use the above measurements for all test tubes in this lab.
- b. Observe the aquarium snails in their natural environment. Record any observation that relates to their movement, feeding habits, waste elimination, general health, and behavior.
- c. Label your test tubes A through H.
- d. Prepare the following test tubes in this manner.

<b>Tubes</b>	<b>Contents</b>
A & E	One stalk of Elodea
C & G	One snail-one Elodea
B & F	One water snail
D & H	Nothing

- e. To test tubes A, B, C, and D add water only.
- f. To test tubes E, F, G, and H add bromthymol blue solution.

- g. Place a stopper on each of the test tubes and place the tubes in your test tube rack.
- h. Place the racks near a light source. See Illustration 1

# Illustration 1. Setting Up the Test Tubes





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## Classroom Activity

### Part B – Effects of Excess Carbon Dioxide On Plants

1. Tell the class that in understanding the role of CO<sub>2</sub> in living systems, it seems ideal that plants require the substance that is the waste product of animal respiration. Place this in the context of the evolution of ecosystems, including the Earth's. We might ask, "What are the effects of excess amounts of CO<sub>2</sub> for respiring animals versus the effects for photosynthetic plants?" We are all familiar with the effects of excess buildup of CO<sub>2</sub> in our own bodies. Just remember the last time you were in a stuffy room full of people without adequate ventilation. (Fell asleep?) However, there is abundant evidence that plants do better and grow faster in an environment rich in CO<sub>2</sub>. Likewise there is some evidence that humans can perform and recover from certain work related tasks when exposed to an environment rich in the waste product of plants. The problems encountered by humans in space are numerous; getting rid of CO<sub>2</sub> is one of the most onerous.

2. Tell the students they will be doing an experiment in an attempt to answer the key question, "What happens to plants when they are placed in an environment saturated with CO<sub>2</sub> for a period of time?"

3. Instruct the students to set up a new experiment as follows:

- a. Wash and reuse the four test tubes that you have previously set up (ABCD), replacing the Elodea and snails as appropriate.
- b. Relabel these test tubes IJKL.
- c. Add three drops of bromthymol blue to each of these test tubes.
- d. Saturate the air space in each test tube with CO<sub>2</sub> from a liter bottle of club soda and seal with a stopper.

See Illustration 2.

4. Have the students record observations on the "Excess Carbon Dioxide Experiment Observations" sheet

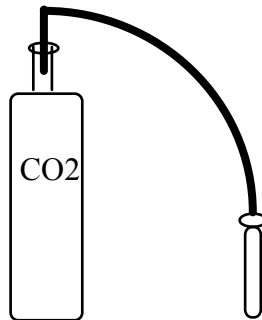


Illustration 2

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## Wrap-Up Session

Allow students to share their findings with others. Students may share information with others in many ways, including:

- Poster sessions
- Video recordings of their investigations
- Electronic presentations of their work using computer software packages such as *PowerPoint*, *Astound*, and *More*
- In-class paper presentations
- Journal entries
- Electronic logs - constructed with computer applications such as *HyperStudio*, *The Digital Chisel*, and *Gray Slate*
- Construct a letter to a friend reporting on what you have learned about closed environments

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## More Activity Ideas

The splint test is traditionally a test for the presence of oxygen. To do this test, light a splint, and allow it to flame for a few moments. Then blow out the flame, remove the stopper, and plunge the glowing ember of the splint into the air space of the tube. If the splint rekindles this is an indicator of the presence of oxygen. Choose one or two tubes to test. Which did you choose? Why?

Another splint test can be for the presence of  $\text{CO}_2$ . In this case you will plunge lighted splint into the air space of the test tube. What should happen? Choose one or two tubes to test. Which did you choose? Why?

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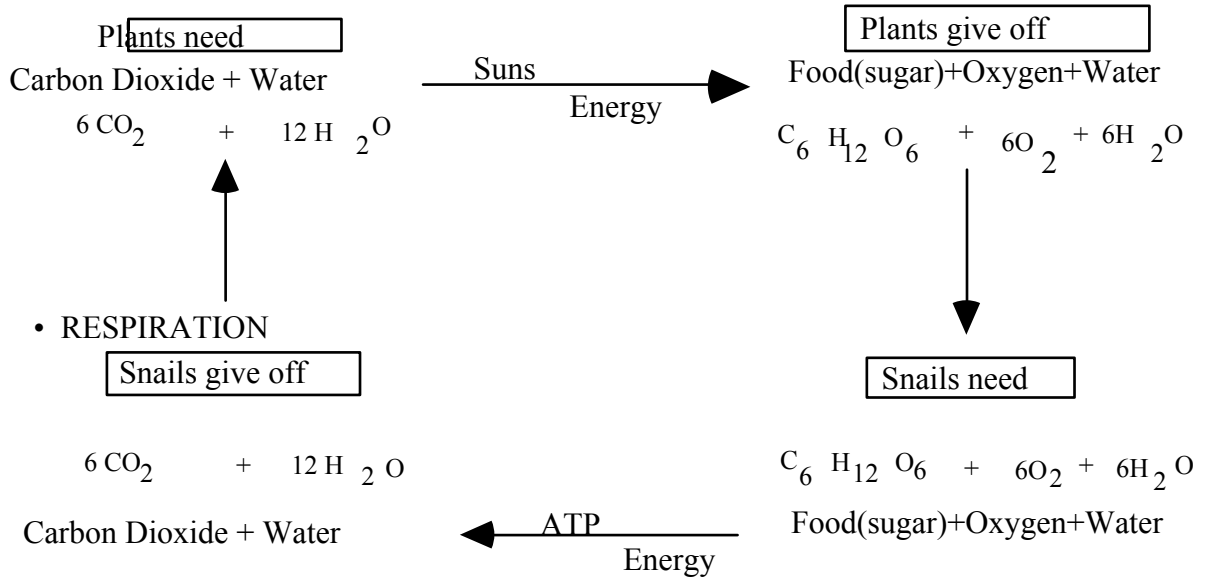
## Background for Teachers

As Earthlings, regardless of the efforts we take and the costs we assume, it's impossible to replicate on Earth exactly the conditions found in space. Students can simulate the kinds of problems living systems encounter in the space environment and reproduce some aspects of that environment in the classroom.

In this activity, we are attempting to replicate a closed system such as that found in a spacecraft or habitat. For life in space, provisions must be made for food supplies, oxygen, gravity, energy, and the disposal (or reclamation) of CO<sub>2</sub> and waste for both humans and plants. By placing snails in a closed system with certain plants, we can take a look at the reactions necessary for the survival of living things.

We can start this experiment with the study of photosynthesis and respiration—both plants and animals are dependent upon this reaction. On current missions, we do not grow plants in spacecraft in order that astronauts may breathe the oxygen—O<sub>2</sub> is supplied artificially. The same is true with all other living system needs; such as waste and CO<sub>2</sub> removal, and the provision of O<sub>2</sub> and energy (food and light)—all are artificially supplied. In the future, we would like to create self-supporting systems so that astronauts living in space will have a renewable source of oxygen gas—thus the emphasis in growing plants in space.

## Photosynthesis



As can be observed in the above diagram, photosynthesis and respiration have the same overall equation, though they proceed in the opposite direction. It is possible to measure several of these reactants and make observations on this closed system.

Organisms interact with many substances in nature. One such substance, carbon dioxide, is exchanged between organisms and their environments during the process of photosynthesis and respiration. This investigation uses an indicator, bromthymol blue, which turns yellow when carbon dioxide is added to a solution. Carbon dioxide and water form a weak carbonic acid solution that is indicated by color change in the 6.0 - 7.6 pH range.

**Vocabulary:**

- Respiration - the process in which living things use food and oxygen to create energy, water and carbon dioxide
- Photosynthesis - the process in which plants combine carbon dioxide, water and sunlight to produce food (sugars), oxygen, and water
- Oxygen - element 16 in the periodic table; essential for respiration
- Carbon dioxide - a compound that has molecules consisting of one atom of carbon bound to two atoms of oxygen
- Carbon - element in the periodic table; essential for "carbon-based lifeforms" like ourselves
- Interdependence - a state of depending on one another
- Reactants - the chemicals that combine together in a chemical reaction
- Indicator - a chemical which changes property (such as color) in the presence of certain other chemicals

**Skills:**

- Recording data
- Analyzing data
- Reporting findings

**Concepts:**

- Photosynthesis
- Respiration
- Interdependence

**Keywords: Cardiovascular, Respiration, Photosynthesis**