INTEGRATED PEST MANAGEMENT

Unit 3 Lesson 6
Biosphere - Building a Balanced World

Focus Areas: Biodiversity; Science

Focus Skills: Comprehension, observation, critical thinking, scientific experimentation

Level of Involvement: MAXIMUM

University of Connecticut
College of Agriculture and Natural Resources
Cooperative Extension System

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Dedicated to Reducing Pesticides

Objective

To observe the connection between CO_2 (carbon dioxide) depletion and photosynthetic activity

Essential Questions

* Why was it difficult to grow food in the environment of the Biosphere?
* Why do scientists think (hypothesize) that the level of carbon dioxide developed to such dangerous levels?
* How does the natural world adjust the amount of gases?
* What are the effects of excessive carbon dioxide and other greenhouse gases on the atmosphere?
* What are the effects of rising temperatures on biodiversity?

Essential Understandings

* There is a relationship between carbon dioxide production and photosynthetic activity.
* Carbon dioxide levels can be dangerous to the balance of gases in the earth s atmosphere.
* Carbon dioxide levels contribute to the condition known as the g reenhouse effe c t which impacts biodiversity.

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Background

The Living Greenhouse

The greenhouse effect on earth is the naturally occurring phenomenon that allows life to exist on this planet. The gases are produced as a result of events in nature as well as from human actions. These gases form a protective layer of atmosphere that shields the earth from the harmful effects of the sun s rays. The gases act like the glass in a greenhouse by allowing the shorter ultraviolet rays of the sun to enter the atmosphere while trapping the long wavelengths of infrared radiation and reflecting them back. The blanket of greenhouse gases provides heat at the lower levels of the atmosphere and enables the earth to have sufficient warmth to support life. When this mix of chemicals is out of balance, many problems occur.

The major gases that make up this important protective layer include carbon dioxide, nitrogen oxides, methane, and human-made chlorofluorocarbons (CFCs). Eighty percent of greenhouse gases come from the burning of fossil fuels used in energy production, emissions from factories, and increasing deforestation of the planet. Nature also releases greenhouse gases through volcanic activity, lightning, weathering of certain types of bedrock, and the decomposition of organic matter.

Carbon dioxide is principally produced through the burning of fossil fuels and by deforestation. Nitrogen oxides come from burning gasoline, coal, and oil. Methane is the by-product of bacterial decomposition. Chlorofluorocarbons are compounds that, before being outlawed, were used in refrigeration, plastics, and propellants. They were 15,000 times more effective in trapping the heat to the earth and are seen as a major contributor to the current problem of global warming.

The ozone layer is the name of the highly protective shield the earth has against the sun s dangerous ultraviolet rays in one of the highest atmospheric levels called the stratosphere. At the lower levels, ozone reverses its protective role and serves as a heat-trapper of dangerous greenhouse polluting gases. Ozone is a by-product of burning fossil fuels and, as such, is a pollutant when trapped close to the ground.

Background

The Living Greenhouse (continued)

Scientists have been studying the holes that have been appearing in the ozone layer for more than a decade. They have discovered that human activity is increasingly weakening the shield, which is capable of repairing itself, but only with heroic conservation efforts on the part of Earth s population of over six billion people.

Use the Following Questions for Class Discussion to Elicit the Information Provided in the Teacher Background:

* What are the names of the major types of gases that make up our atmosphere?

* What activities or events contribute to their formation?

* What evidence do scientists have that there is a global climate change? (Have students collect newspaper and magazine articles to support this series of biosphere experiments and discussions. Create a bulletin board for news events.)

* Explain and illustrate the concept of the greenhouse effect .

Challenge

Build a successful biosphere!

Logistics

Time: 45 minutes
Group size: 25
Space: a classroom or science lab

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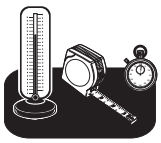


Materials

water

3 test tubes

test tube stand/rack

phenol red (CO_2 indicator)

drinking straws

sprig of *Elodea* (available at pet stores and aquarium supply stores)

boiling apparatus

marker pen

notebook

Handout 1 Biosphere 2 - No Home Away from Home *

* single copy provided

Preparations

1. Before starting this lab, boil the water, then cool to room temperature.

2. Prepare copies of Handout 1 Biosphere 2 - No Home Away from Home .

Activity

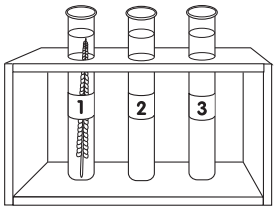
Introduction

CO_2 Uptake

A critical problem inside Biosphere 2 was the unexpected and dangerous buildup of CO_2; trees and other vegetation should have absorbed the gas, as they do on Earth. Some theories to explain the rise of carbon dioxide include: a smaller ratio of trees and other vegetation grew in the Biosphere than on Earth; microorganisms in the very rich soil contributed to excessive levels; the concrete walls of the Biosphere itself may have produced outgassing; or, decaying materials broke down faster than expected, thus releasing more CO_2 into the atmosphere of Biosphere 2.

On Earth, excess CO_2 is taken up by green plants during photosynthesis. This activity on carbon uptake lets you observe the connection between CO_2 depletion and photosynthetic activity.

Involvement



1. Fill three test tubes with room temperature water.
2. Number the test tubes 1, 2 and 3.
3. Add a very small amount of phenol red to each tube (powder or liquid). Note the color of each solution in your observation log.
4. Using a clean straw, have participants exhale briefly into tubes 1 and 2 until the color just changes to yellow.
5. Place a generous sprig of *Elodea* in tube 1.
6. Cover all three tubes and set them aside in bright light.
7. At the end of your 45-minute period (30 minutes in the tubes is ideal, but color change will occur in less time), examine the color of each tube.
8. Record observations in the observation log.

Follow Up

1. Why did you boil the water, then cool it?
2. What color does phenol red appear when in the presence of CO_2?
3. What color changes occurred at the end of the time period?
4. What do your observations suggest?
5. Do you think the results would be different if the tubes were placed in the dark? Explain.
6. Is tube 3 an experimental control? Explain.

Follow Up Answer Key

1. To remove dissolved air
2. Yellow
3. Tube 1 turned back to red
4. The sprig of *Elodea* in tube 1 used up the CO_2
5. Yes. Photosynthesis would not have occurred; therefore the CO_2 level in tube 1 would not have dropped.
6. Tube 3 is not a control; tube 2 is the control setting. Tube 3 is kept as a color standard from which a color change back to the original red can be measured.

Assessment

1. What might this experiment tell us about the role of plants in the environment?

2. What about in Biosphere 2?

3. If plants absorb CO_2 in the atmosphere, why might the levels of CO_2 continue to rise inside Biosphere 2?

4. What are some of the factors causing carbon dioxide levels to increase on Earth?

Assessment Answer Key

1. Plants play an essential role in controlling the balance of gases in the atmosphere.

2. The ratio of trees and other vegetation that grew in the Biosphere was smaller than the actual ratio on the Earth.

3. The levels of carbon dioxide continued to rise in Biosphere 2 because the bacteria in the soil released CO_2 that became bound up in the cement. With the carbon dioxide trapped, the plants couldn't remove the molecules carbon atoms and release oxygen atoms. The O_2 and CO_2 cycle of gas exchanges was interrupted.

4. Human activity, burning of fossil fuels and deforestation.

Follow Through

Take a virtual tour of Biosphere 2 on the World Wide Web at http://www.bio2.edu/virtualtour/

Procedure: Refer to **Background** to guide group discussion.

1. Discuss, as a group, the types of gases that make up our atmosphere. Make a list of the more common gases and the activities or events that form them.

2. Discuss the concept of global climate change and the greenhouse effect. Ask participants what the greenhouse effect is and how it works. Have the group illustrate the greenhouse effect.

3. Ask participants to name common gases that make up the air we breathe. Have them name and list human activities or natural processes that form these gases. Generate a list from newspapers and magazines.

4. Illustrate the concept of the greenhouse effect using an aquarium, thermometers, and a light source.

Extension

Set up a bulletin board to show the names and symbols of gases and the natural processes or human activities that form each gas. Pictures found in magazines or newspapers can be used.

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Handout 1

Background - Biosphere 2: No Home Away from Home

In 1991 scientists attempted to recreate our earth environment; our planet before it had been polluted. Biosphere 2, a glass-enclosed, self-sustained ecosystem was built in Arizona at a cost of $200 million. It was designed to contain all of the Earth elements eight humans would need: soil, water, air, animals, and plants. It would be an experiment to see if we could design a system capable of supporting human life without any help from the outside.

The 139,935 square-foot facility imitated the natural ecosystems of the earth. There were miniature forests, lakes, streams, and oceans. The eight people were sealed into Biosphere 2 in September and were expected to plant and harvest their own food, drink water cleaned naturally, and breath air recirculated by plants. In less than 18 months the perfect world evolved into a true ecosystem that poisoned itself. Oxygen concentration dropped from 21% to 14%, the same amount present at 17,500-foot altitude, which was barely enough to keep the crew alive and threatened all life.

Scientists later learned that it was incredibly difficult to achieve the balance of our natural world. Biosphere 2 evolved into an environment choked by CO_2 and nitrogen, entangled by uncontrollable weedy vines, where cockroaches and katydids thrived along with little else. Of the 25 small animal species, 19 became extinct. All the pollinating insects died so the plants that required pollinators could not reproduce. Most of the insects became extinct, leaving ants overrunning the entire ecosystem. While the trees and food plants barely survived, plants such as morning glories thrived in the carbon dioxide-rich atmosphere. Weedy vines grew in abundance, crowding out other plants and strangling food crops. No herbicides were used, so all weeding was done by hand, an exhausting job.

Fresh H_2O became another issue due to the nutrients that leached from the soil and polluted the water system. The water had to be cleaned by flowing it over algae mats that then had to be removed, dried and stored. Scientists later discovered that the concrete walls ate the oxygen and left the human occupants with barely enough to breathe.

The chain of events that led to the suffocating atmospheric conditions began in the rich soil, which contained large amounts of organic material necessary to grow food. As the bacteria in the soil consumed this matter, they also used up a lot of the oxygen. The bacteria released carbon dioxide, which became chemically bound up in the cement. With the carbon dioxide molecules trapped, the Biosphere's plants were unable to remove the molecules' carbon atoms and release their oxygen atoms for the human inhabitants and other animals to breathe. The O_2 and CO_2 cycle of exchange of gases was broken and this led to an O_2 shortage. Nitrous oxide levels in the air rose to 79 parts per million, a level that makes absorption of B12 (a vitamin critical to brain function) difficult.

In order to complete the experiment, the Biosphere 2 was opened and oxygen was pumped in. The eight people living in B2 had to make an enormous, almost heroic, personal effort to maintain ecosystem services that most people take for granted. It was a bold experiment and according to many observers, it failed miserably.

What lessons have we learned?

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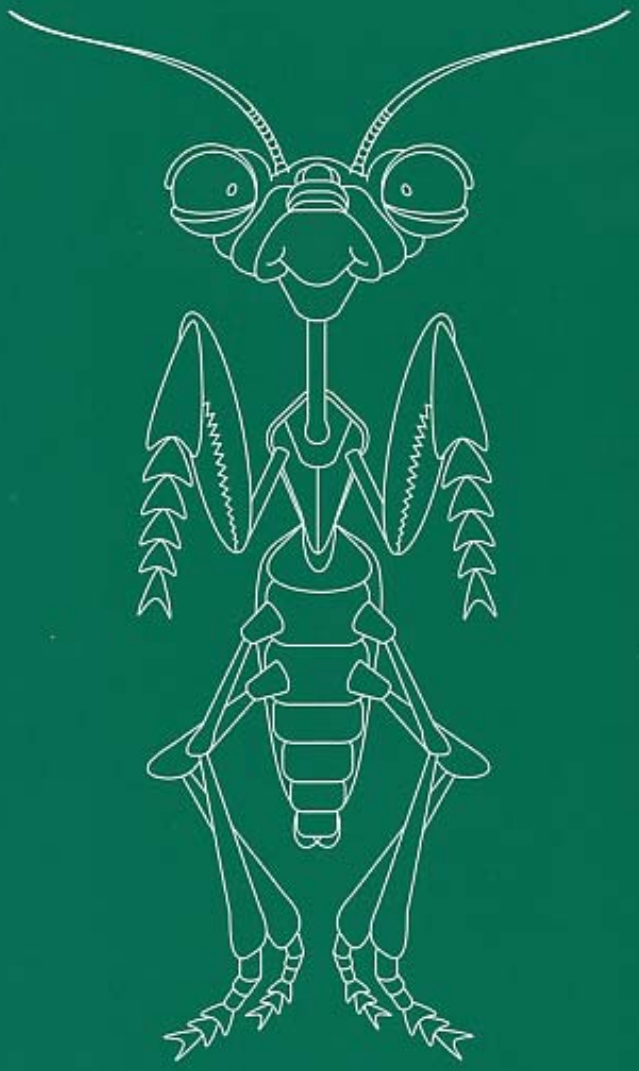

"The Wild West: Model Planet"
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"Newton's Apple Episode #1509: 'Greenhouse Effect - How Does the Loss of Ozone Affect our Climate?' and 'Bubble-Greenhouse Effect - Student Activity' "
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