1 Greenhouse Gas Investigations

Through an experiment, students explore Earth’s greenhouse effect. Students graph results of 3 scenarios to draw conclusions about how greenhouse gases affect air temperature.
Inquiry/Critical Thinking Questions

• What is the greenhouse effect?
• What are some greenhouse gases, and what activities produce them?

Objectives

Students will:
• Review examples of greenhouse gases and how they are produced
• Investigate how greenhouse gases affect air temperature
• Explore effects of different greenhouse gases
• Discuss connections between human activities and greenhouse gases

Time Required

50 minutes (Allow extra time if an extensive review of the included introductory material is required.)

Key Concepts

• Greenhouse effect
• Greenhouse gases
• Scientific inquiry

Subject Areas

• Science (Earth, Environmental, Physical)
• Mathematics

National Standards Alignment

National Science Education Standards (NSES)

• Standard A: Science as Inquiry
• Standard B: Physical Science
• Standard D: Earth and Space Science
• Standard F: Science in Personal and Social Perspectives

Vocabulary

• greenhouse effect—process by which certain gases in Earth’s atmosphere trap energy from the sun (as infrared radiation, or heat) that has been reflected off Earth’s surface; this process warms the earth’s surface
• greenhouse gas—any gas in the atmosphere capable of absorbing infrared radiation (heat) reflected from the earth’s surface
Materials/Preparation

- Thermometers, 3 per group of 4-5 students
- Glass containers (e.g., jars, beakers, tumblers), 3 identical containers per student group
- (Optional) Plastic cling wrap, 2 small pieces per student group
- Paper towels, 1 per student group
- Handout: Data Table, 1 per student group
- Graph paper, 1 sheet per student group
- Warm water to wet paper towels
- Sunny location or heat lamp

Activity

Introduction

1. Ask students if they have ever seen or been inside a greenhouse. If no one has, ask if they have been inside a car that has been parked in the sun all day. Why do they think the air inside a greenhouse or a car is so much warmer than the outside air? (Heat energy from the sun passes through the glass and is retained within the greenhouse. Because the energy stays inside the greenhouse, the inside air is much warmer than the air outside.)

2. Tell them that they will do an experiment that simulates the “greenhouse effect.” Greenhouse gases act somewhat like windows in a greenhouse, trapping the sun’s energy near Earth’s surface.

   Note: The process by which air warms in a greenhouse is not identical to the greenhouse effect. While greenhouse gases absorb and reemit heat radiating from Earth’s surface, the glass in a greenhouse traps the heated air.

3. Ask them to share what they know about the greenhouse effect. What is it? Is it a bad thing? Could we live without it? (No, Earth would be too cold for many organisms to survive without the greenhouse effect.)

   Note: This sharing activity could take the form of a KWL chart (What I Know. What I Want to Know. What I Learned.).
4. Ask students if they can name any greenhouse gases. What are some sources of these gases?

Note: You may want to write gases and sources on the board as students name them. Or, write the following greenhouse gases and their sources on the board as an introduction to some of the major greenhouse gases:

- Water vapor—evaporation (from Earth’s natural water cycle)
- Carbon dioxide (CO$_2$)—burning fossil fuels and plant matter, deforestation, volcanic eruptions
- Methane (CH$_4$)—decomposition/decay, livestock waste, decomposing waste in landfills
- Nitrous oxide (N$_2$O)—fertilizer production, burning fossil fuels and wood, agricultural soil processes (nitrification and denitrification)
- Synthetic gases (e.g., fluorinated gases, CFCs)—industrial processes, manufacturing

Steps

1. Divide the class into groups of 4–5. Each group should have 3 thermometers, 3 identical glass containers, 2 small pieces of plastic cling wrap (optional), 1 paper towel, and 1 piece of graph paper.

2. Make sure all thermometers read the same temperature. Within each group, 3 people are responsible for taking temperature readings on the 3 thermometers every minute. A fourth student is responsible for writing down the data.

3. Directions for each group: Either in a sunny spot (a window sill receiving direct sunlight, an open sidewalk, etc.) or under a heat lamp, place 1 thermometer in an uncovered glass container. Place 1 thermometer in a second glass container and cover the top of the container with plastic wrap (if you are using a jar or drinking glass, you can dispense with the plastic wrap by simply turning the glass upside down). Place 1 thermometer in a third glass container with a damp paper towel that has been held under warm water. Cover the top of the container with plastic wrap (or turn it upside down, if you did this for the other container).

Note: This last scenario with the damp paper towel has been shown to have the most variability in the classroom. To demonstrate the ability of water vapor to retain heat most effectively, warmer temperatures are required.
4. Ask students to predict which environment will be the warmest after 20 minutes.

5. Instruct students to take initial readings from all 3 thermometers and record this information in the data table.

6. Students continue collecting and recording temperatures every minute for 20 minutes, recording temperatures in the data table. (The covered/damp container should become the warmest, and the uncovered container should remain the coolest.)

7. Next, tell students to move the thermometers away from the heat source, keeping the covered thermometers covered. Ask students to observe which environment retains the most heat and which temperature drops the fastest. (The covered containers should retain more heat. The uncovered container should lose heat fastest.)

8. Instruct students to graph all 3 scenarios (uncovered, covered/dry, and covered/damp) on a single graph. Students can use 3 different colored pens to graph, or use symbols on each line to differentiate between the 3 treatments. Alternately, students can use a computer graphing program.

9. After groups have completed graphing the experimental data, begin a class discussion using the following reflection questions.

Reflection

1. What factors were “controlled” (identical for all 3 treatments) in this experiment? Why would we be unable to trust the results of the experiment if these variables were not controlled?

2. If the thermometers in the covered glass containers did NOT indicate higher temperatures than the uncovered thermometer, what factors could have produced your results? Explain any possible sources of error or things you would do differently if you tried the experiment again.

3. Gases in Earth’s atmosphere, such as carbon dioxide, act much like the glass did in this experiment. Why did temperatures increase in the covered/dry container more than in the uncovered container? How do you think increasing amounts of carbon dioxide will affect temperatures on Earth?

4. Water vapor is a natural greenhouse gas. How does water vapor affect air temperature? How do you think temperature would be affected by adding other greenhouse gases?
5. Many greenhouse gases, including some that occur naturally, are produced as a result of human activities. Predict what will happen to temperatures on Earth if we continue to add more greenhouse gases to Earth’s atmosphere.

6. How can we lessen our impacts on Earth’s climate?

**Writing Extension**

Have students write a brief research paper to explain how different activities are linked to various greenhouse gas emissions. Tell them to be specific when explaining how activities generate greenhouse gas emissions. For example, why does burning a forest result in carbon dioxide emissions? How does raising livestock contribute to methane emissions?

**Action Project**

In small groups, have students create an experiment or activity to help young children understand the greenhouse effect. Have students test and improve upon their ideas. Partner with younger student buddies or a local elementary school so that the students can see these activities in action.

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**Additional Resources**

**Websites**

- [http://www.climateclassroom.org](http://www.climateclassroom.org) — The National Wildlife Federation (NWF) has put together an online Climate Classroom. Here, you can download their excellent slideshow, “What’s Up with Global Warming?”

- [http://lwf.ncdc.noaa.gov/oa/climate/gases.html](http://lwf.ncdc.noaa.gov/oa/climate/gases.html) — The National Climatic Data Center, a division of the National Atmospheric and Oceanic Administration (NOAA), provides basic information about specific greenhouse gases, sources, and trends.


- [http://gaw.kishou.go.jp/wdcgg/gas.html](http://gaw.kishou.go.jp/wdcgg/gas.html) — The World Data Centre for Greenhouse Gases, a website maintained by the Japan Meteorological Agency, provides basic information on numerous greenhouse gases.

Hypothesis

Predict which one of the three environments will be the warmest after 20 minutes, and explain why you expect this.

Procedures

1. Make sure that all 3 thermometers read the same temperature.
2. Near a heat source, place one thermometer in an uncovered glass container.
3. Next to the uncovered glass container, place one thermometer in a second glass container. Cover the top of the container with plastic wrap.
4. Next to the second glass container, place one thermometer in a third glass container with a damp paper towel that has been held under warm water. Cover the top of the container with plastic wrap.
5. Make sure that all thermometers are equidistant from the heat source so that they receive the same amount of heat energy.
6. Record the temperature of all three thermometers every 60 seconds for 20 minutes. Record data below.
7. After 20 minutes, move the three containers away from the heat source and observe what happens to the temperature in each container.
### Data Table

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### Results

Which environment warmed the most?

After you removed the containers from the heat source, which one retained the most heat?