Experiment
20

PRELIMINARY ACTIVITY FOR Global Warming

Global warming is an environmental science topic of much concern. The average surface temperature the Earth increased by 0.6ºC during the 20th century, with the increase occurring mainly from 1910 to 1945 and 1976 to 2000. The 1990s was the warmest decade, and 1998 was the warmest year of the century and on record. Growing scientific consensus attributes this global warming to the enhanced greenhouse effect. In this experiment you and your classmates will investigate the greenhouse effect and the enhanced greenhouse effect.

In the Preliminary Activity, you will gain experience using a Temperature Probe and learn technique that can be used in your subsequent research.

After completing the Preliminary Activity, you will first use reference sources to find out more about global warming, the greenhouse effect, and the enhanced greenhouse effect before you choose and investigate a researchable question. Some topics to consider in your reference search are:

- global warming
- greenhouse effect
- enhanced greenhouse effect
- greenhouse gases
- infrared radiation
- anthropogenic effect

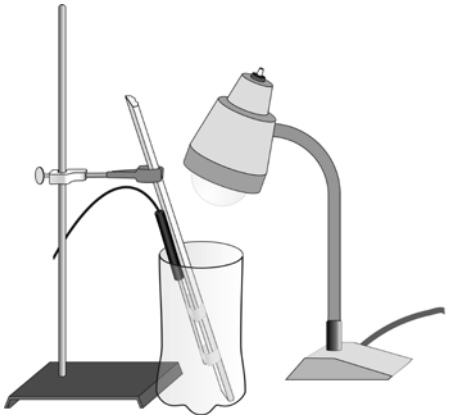

Figure 1

PROCEDURE

1. Connect the Temperature Probe to the interface.
2. Open the data-collection program and set up the program to collect data for 15 minutes.
3. Tape the Temperature Probe to a ruler as shown in Figure 1. The probe tip should be 5 cm from the ruler end, and the tape should not cover the probe tip.
4. Obtain a cutoff bottle and prepare it for data collection
   a. Place the Temperature Probe in the cutoff bottle as shown in Figure 1.
   b. Position a lamp centered above the cutoff bottle. The bulb should be about 5 cm above the cutoff bottle. The ruler should shield the Temperature Probe from direct light emitted by the lamp.
5. Start data collection, and then turn on the lamp.
6. When data collection is complete, turn off the lamp.
7. Use the Statistics function to determine the initial (minimum) and final (maximum) temperatures. Record these values.

QUESTIONS

1. What was the initial temperature in the Preliminary Activity? What was the final temperature?
2. Calculate the temperature change.
3. List five greenhouse gases.
4. List at least one researchable question for this experiment.

Experiment
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Global Warming

OVERVIEW

In the Preliminary Activity, your students will learn data-collection techniques as they use a Temperature Probe to monitor the temperature of the air in a cutoff bottle being warmed by an incandescent bulb. The air in the cutoff bottle simulates the Earth's atmosphere. A student handout for the preliminary activity can be found at the end of the experiment.

During the subsequent Inquiry Process, your students will first learn more about global warming, the greenhouse effect, and the enhanced greenhouse effect using the course textbook, other available books, and the Internet. They will then generate and investigate researchable questions.

LEARNING OUTCOMES

In this inquiry experiment, students will

- Identify variables, design and perform the experiment, collect data, analyze data, draw a conclusion, and formulate a knowledge claim based on evidence from the experiment.
- Gain increased understanding of the greenhouse effect and global warming.

CORRELATIONS

AP Environmental Science Topic Outline Correlation

VII. Global Change, B. Global Warming (Greenhouse gases and the greenhouse effect; impacts and consequences of global warming; reducing climate change; relevant laws and treaties)

IB Environmental Systems Syllabus Correlation

3.4 The Issue of Global Warming

THE INQUIRY PROCESS

Suggested time to complete the experiment

See the section in the introduction, Doing Inquiry Experiments, for more information on carrying out each phase of an inquiry experiment.

I	Preliminary Activity	25 minutes
II	Generating Researchable Questions	15 minutes
III	Planning	15 minutes
IV	Carrying out the Plan	60 minutes
V	Organizing the Data	10 minutes
VI	Communicating the Results	20 minutes
VII	Conclusion	10 minutes

MATERIALS

Make the following materials available for student use. Items in bold are needed for the preliminary activity.

data-collection interface
data-collection program
Vernier Temperature Probe
lamp with 100 watt bulb
cutoff 1.5 L bottle
metric ruler
tape
second Vernier Temperature Probe
second lamp with 100 watt bulb
second cutoff 1.5 L bottle
second metric ruler
plastic wrap
bottled carbon dioxide gas
small spray bottle
others as requested by students

I Preliminary Activity

This inquiry begins with an activity to reinforce prior knowledge of the use of Vernier data-collection technology and to introduce a method for collecting temperature data. You may need to tell your students how to set up the data-collection program to collect data for fifteen minutes.

Sample Results

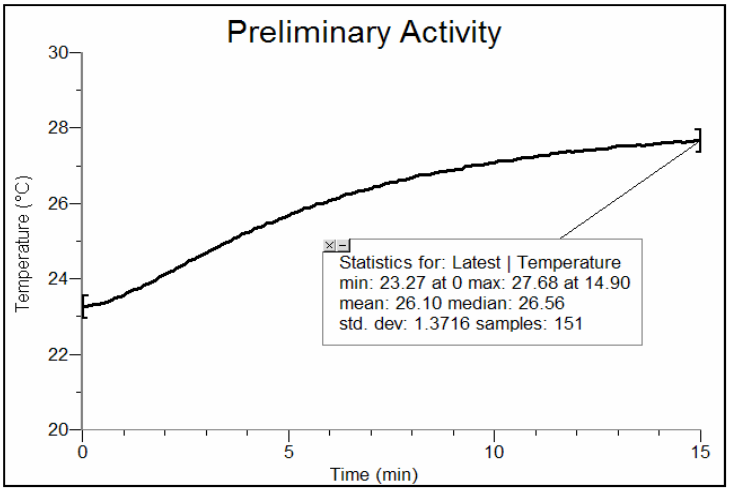

Figure 1 *The warming of air in a cutoff plastic bottle*

Answers to the Questions

1. Answers will vary. In the Sample Results shown above, the initial temperature was 23.3ºC. The final temperature was 27.7ºC.

2. Answers will vary. In the Sample Results shown above, the temperature increased 4.4ºC.

3. The major natural greenhouse gases are water vapor, carbon dioxide, methane, and ozone. A partial list of other greenhouse gases includes nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons, and chlorofluorocarbons.

4. Answers will vary. See the Researchable Questions list below for some possible answers.

II Generating Researchable Questions

See page xiii in the Doing Inquiry Experiments section for a list of suggestions for generating researchable questions. Some possible researchable questions for this experiment are:

- How does carbon dioxide gas affect the temperature inside a cutoff bottle exposed to simulated sunlight?
- How does water vapor affect the temperature inside a cutoff bottle exposed to simulated sunlight?
- How does nitrogen gas affect the temperature inside a cutoff bottle exposed to simulated sunlight?
- How does oxygen gas affect the temperature inside a cutoff bottle exposed to simulated sunlight?
- How does a plastic-wrap cover affect the temperature inside a cutoff bottle exposed to simulated sunlight in a model greenhouse?
- How does the presence of soil in a model greenhouse affect temperature?
- How do the effects of carbon dioxide gas and water vapor on the temperatures inside cutoff bottles exposed to simulated sunlight compare?

There are many more possible researchable questions. Students should choose a researchable question that addresses the learning outcomes of your specific standards.

III Planning

During this phase students should formulate a hypothesis, determine the experimental design and setup, and write a method they will use to collect data. Circulate among the student groups asking questions and making helpful suggestions.

IV Carrying out the Plan

During this phase, students use their plan to carry out the experiment and collect data. Circulate among the student groups asking questions and making helpful suggestions.

V Organizing the Data

See page xiv in the Doing Inquiry Experiments section for suggestions concerning how students can organize their data for their inquiry presentations.

VI Communicating the Results

See page xv in the Doing Inquiry Experiments section for a list of inquiry-presentation strategies.

VII Conclusion

See page xv in the Doing Inquiry Experiments section for a list of suggestions concerning assessment and ways to utilize the results in subsequent instruction.

SAMPLE RESULTS

Student results will vary depending on experimental design.

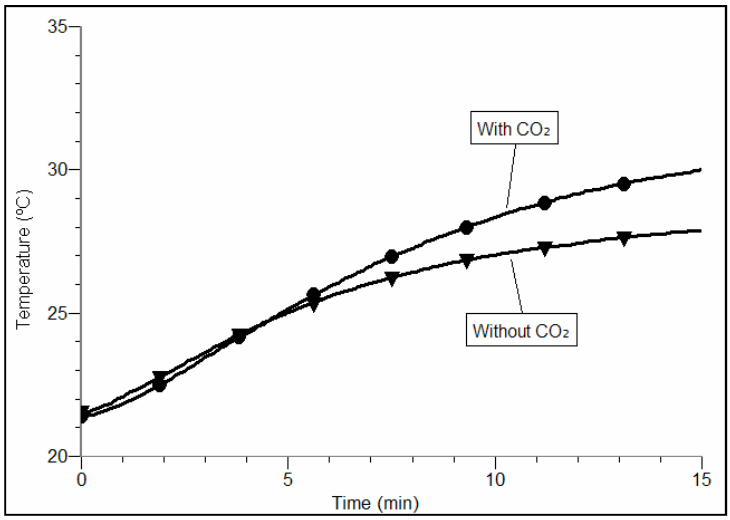

Figure 2 *The effect of carbon dioxide on temperature*

These data were collected while heating uncovered 1.5 L plastic (PET) bottles being illuminated from above. Carbon dioxide was supplied to the bottom of the experimental bottle with a hose prior to data collection.

This investigation addresses the question, "How does carbon dioxide gas affect the temperature inside a cutoff bottle exposed to simulated sunlight?" The temperature of carbon dioxide in the experimental container rose 2.4°C more than the temperature of air in the control container. This demonstrates that carbon dioxide is a greenhouse gas.

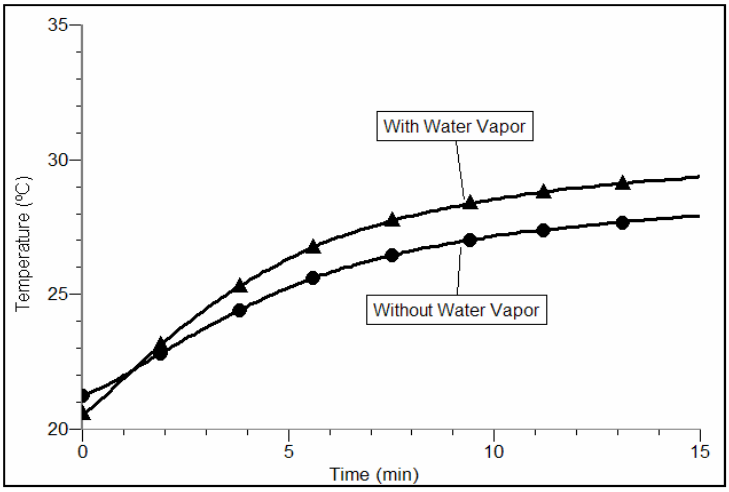

Figure 3 *The effect of water vapor on temperature*

These data were collected while heating uncovered 1.5 L plastic (PET) bottles being illuminated from above. The water vapor was sprayed into the bottle using a small spray bottle.

This investigation addresses the question, "How does water vapor affect the temperature inside a cutoff bottle exposed to simulated sunlight?" The temperature of the air inside the bottle containing water vapor rose 2.2ºC more than the air in the bottle containing air only. This demonstrates that water vapor is a greenhouse gas.

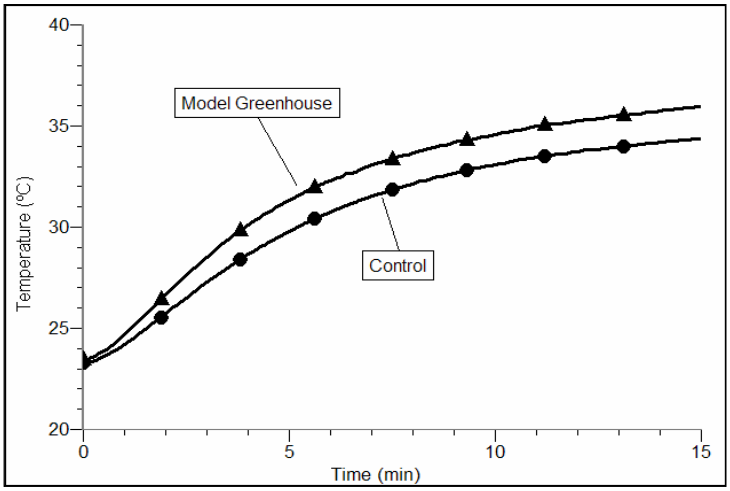

Figure 4 *The temperature advantages of a model greenhouse*

These data were collected while heating 1.5 L plastic (PET) bottles being illuminated by 100 W bulbs positioned 7 cm above the lab bench surface and 4 cm distant from the sides of the bottles. The experimental container (model greenhouse) was covered with plastic wrap.

This investigation addresses the question, "How does a plastic-wrap cover affect the temperature inside a cutoff bottle exposed to simulated sunlight in a model greenhouse?" The temperature of the air in the experimental container (model greenhouse) rose 1.4ºC more than the temperature of air in the control container. The plastic wrap apparently reduced convection (the exchange of air between the inside and the outside). Suppressed convection is a major factor causing greenhouses to stay warm.

TIPS

Experiment Information

1. **Caution:** Because of the explosion potential of a methane and air mixture in this setting, the greenhouse gas methane should not be used in this experiment!

2. Plastic or glass containers can be used in this experiment. Plastic containers work better for the water vapor investigation. The sample data were collected using cutoff 1.5 L plastic (PET) drink bottles.

3. Your students may need to fasten the containers to ring stands to keep them from tipping over. Because of the use of delivery hoses, tipping is most problematic in carbon dioxide investigations.

4. If time permits, you may want student teams to do shortened trial runs in which they measure temperatures with the lamps appropriately positioned at their control and experimental containers to ensure that both heat up at approximately the same rate.

5. Because carbon dioxide is denser than air, the carbon dioxide investigation can be done with the containers uncovered or covered with plastic wrap. For the investigation to be successful, the bulbs must be positioned **above** the containers. If the bulbs are positioned beside the containers convection will carry carbon dioxide from its container and cause unsatisfactory results.

6. Laboratory gas bottles and cylinders, available from a number of suppliers, are the best sources of carbon dioxide gas for this experiment. Flinn Scientific offers carbon dioxide lecture bottles (Catalog number LB1005) and refillable carbon dioxide cylinders (Catalog number LB1060). Use a hose to slowly deliver the carbon dioxide to the bottom of the experimental container. Although often used as CO_2 sources for this kind of experiment, Alka Seltzer tablets placed into water and vinegar mixed with baking soda are much less reliable and often give inferior results. If you chose to generate CO_2 using Alka Seltzer tablets or vinegar and baking soda, use generous amounts of reactants in order to maximize the removal of air from the containers being used.

7. A lighted match, taped to an object such as a stirring rod, can be use to confirm the CO_2 level in an experimental container. The lighted match will be extinguished when it reaches the CO_2 level.

8. A spray bottle that delivers a fine mist will work well for the water vapor investigation. Mist persists on plastic bottle (PET) surfaces better than on glass surfaces.

9. Because heated water vapor rapidly escapes from an uncovered container, the water vapor investigation works better when both containers, control and experimental, are covered with plastic wrap. The lamps should be positioned **above** the containers in this investigation, too.

10. For good results (to power convection) in the model greenhouse investigations, the bottles should be heated on the lower halves of their sides. In the Sample Results, the bulbs were positioned 7 cm above the table top and 4 cm from the bottles.

11. Student groups choosing to do the model greenhouse investigations are likely to design a procedure in which they heat their containers from the top. Be ready to steer them to a revised procedure that involves heating the sides of the containers, if necessary.

12. All Sample Results for this experiment were obtained without the use of soil or black paper simulating soil.

Sensor Information

1. The calibration loaded with an auto-ID Temperature Probe is ideal for this experiment.

2. The sensor of the Stainless Steel Temperature Probe is located at the tip of the probe.

Sensor Check

To tell if your Temperature Probe is working correctly, try the following.

1. Hold the tip of the sensor in your hand and check for the temperature readings to change.

2. If the Main screen of the calculator data-collection program displays –999.9 as the temperature reading, press the CLEAR key to reset the program.

3. If the Main screen of the handheld data-collection program displays –999.9 as the temperature reading, tap the New button to reset the program.