The GREENHOUSE EFFECT a good thing?

T E A C H E R

Activity Overview

How do greenhouse gases affect global warming?
The greenhouse effect is necessary to keep the Earth warm enough for life! However, increased levels of greenhouse gases, such as carbon dioxide (CO_2) and water vapor, can increase the effect. Scientists around the world debate whether these gases are responsible for global warming. In this activity, students model the greenhouse effect. They compare temperature changes from a heat source in an open-air container, and two containers of greenhouse gases (one with more greenhouse gases than the other).

Students simulate the greenhouse effect using beakers covered in plastic wrap and the air they exhale – high in CO_2 and water vapor. They simulate the sun with a lamp, and collect temperature data with Temperature Sensors that are connected to a TI CBL2™ or Vernier LabPro and a TI-73 Explorer™. By measuring and graphing temperature changes in an open-air and two covered beakers, they observe: a) air in the covered beakers warms faster, and b) this warming is greater in the beaker with more CO_2 and water vapor.

Conclusion: Increases in carbon dioxide and water vapor may escalate the greenhouse effect and contribute to global warming.

Activity at a Glance

Grade: 4-9
Subject: Science
Category: Life Science, Earth Science, Physical Science
Topic: Greenhouse Effect, Greenhouse Gases, Climate, Heat

Time Required
- Three 45-minute periods

Level of Complexity
- Medium

Materials*
- TI-73 Explorer™
- TI CBL2™ or Vernier LabPro
- TI-73 DataMate
- 3 temperature Sensors
- Lamp with 100-watt bulb
- 3 600 mL beakers
- 3 rulers
- Tape
- Soil
- Plastic wrap

* This activity has been written for the TI-73 Explorer™ but you can easily substitute the TI-83 or TI-83 Plus. Also see Appendix A for steps on how to transfer DataMate to your graphing device and how to use DataMate for data collection.

Adapted from "Experiment 24-The Greenhouse Effect", *Earth Science with Calculators,* written by Johnson, Robyn L. DeMoss, Stahmer Gretchen, and Sorensen, Richard, published by **Vernier Software & Technology,** 2002.

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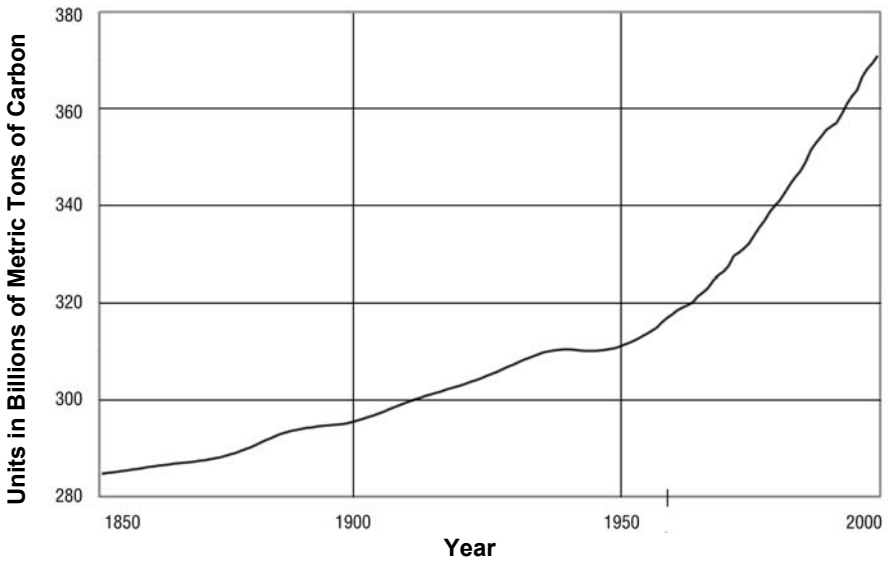
Concept Background

- Each year the total amount of CO_2 in the atmosphere increases by 3.3 trillion kilograms! (See graph below.) Human activities such as emissions and deforestation add CO_2 into the atmosphere.
- Greenhouses are in use during all seasons of the year. In the winter, they allow us to grow plants despite cold weather. Radiation from the sun passes through the glass, warms the interior, and stays trapped, keeping the greenhouse consistently warm. Earth is like a huge greenhouse.
- The greenhouse effect keeps the Earth warm. Without it humans could not survive!
- The most important greenhouse gas is water vapor. It accounts for about 65% of the heat trapped in the Earth's atmosphere.
- CO_2 accounts for about 25% of the heat trapped in the Earth's atmosphere.
- Changes in either water vapor or CO_2 may affect global climate patterns.
- The Earth's surface temperature has risen by about 1/2 a degree Celsius in the past century according to the National Academy of Sciences. They have linked this increase in temperature to increased greenhouse gases in the atmosphere. This is cause for concern.

Increase in Amount of $C0_2$ in the Earth's Atmosphere



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National Education Standards

Science Standard C: Life Science
Students should develop an understanding about the structure and function of living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and the diversity and adaptations of organisms.

Science Standard D: Earth & Space Science
Students should develop an understanding of the structure of the Earth system, Earth's history, and the relationship of Earth to the rest of the solar system.

Science Standard F: Science in Personal & Social Perspectives
Students should develop an understanding of personal health, populations, resources environments, and natural hazards. Students should also learn about the role of science and technology in society.

Geography Standards 7-8: Physical Systems
Students should learn how physical processes and human activities can shape the patterns of the Earth's surface, how Earth-sun relationships affect physical processes and patterns on Earth, and how to predict the consequences of physical processes on the Earth's surface.

Geography Standard 14: Environment & Society
Students should understand how human actions modify the physical environment.

Math Standard: Data Analysis and Probability
Students should develop an understanding about how to collect, organize, display, and interpret data.

English Language Arts Standard 3
Students should apply strategies to comprehend, interpret, evaluate, and appreciate text.

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Preparation and Classroom Management Tips

- When taping the Temperature Sensors to the rulers, make sure you do not cover the sensor tips with the tape.
- Place the lamp at the same distance from all three beakers (about 10 cm) and make sure it is illuminating each of them evenly.
- Small containers or jars (all the same size) may be used instead of the 600 mL beakers. Black paper can be used instead of soil to simulate the Earth.
- Make sure there is not much excess plastic wrap over the sides of the two covered beakers.
- This activity works well with students in working groups or as a demonstration.
- If you do not have enough Temperature Sensors, each group can collect data for one of the three conditions (open air, greenhouse, or greenhouse gases) using one sensor and share their results with the others.
- Encourage students to answer the questions in Data Analysis in a Journal.
- The graphing device will measure and display time in seconds. Consider discussing with students unit conversion from seconds to minutes (see Data Analysis section, questions 3-11.)
- The method used by DataMate to determine the rate of change is called the "Line of Best Fit". DataMate will analyze all 20 data points within the 5-minute interval and determine a mathematical expression that best represents the data collected (see Data Analysis section, question 11.)
- Create your own student questions for use on your students' TI graphing devices using the Texas Instruments StudyCard applications. For more information, go to

  http://education.ti.com/us/product/apps/studycards/scresources.html

Vocabulary

Biogeochemist A scientist who studies the chemical interactions between Earth's living features (such as plants and animals) and its non-living features (such as atmosphere, rocks, and water).

Deforestation A process that involves cutting down, burning, clearing, or otherwise damaging forests.

Decompose To be consumed and broken down by bacteria and other microorganisms after death.

Fossil A rock containing a trace of an ancient organism.

Global environmental change A change in the environment that occurs throughout the world.

Greenhouse Gas Any gas present in Earth's atmosphere that is particularly effective at preventing the planet from radiating heat.

Hypothesize To suggest a scientific explanation that seems reasonable and can be tested with experiments.

Photosynthesis The process by which plants use sunlight, carbon dioxide, and water to make their own food (sugar). Oxygen is a by-product.

Sustainable use Use of an ecosystem's resources (such as water, or trees in a forest) that allows time to replenish what is used and continues to meet the needs of the organisms that depend on it.

Terrestrial ecosystem A group of land-based living things interacting with each other and their environment.

Transpiration The process by which a plant absorbs liquid water through its roots, pulls the water upward, and then releases water vapor through its leaves.

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Data Analysis

1. **Q.** Use a ✓to identify the factors that relate to each beaker in Table 1. (Copy the table in your Journal.)

Table 1

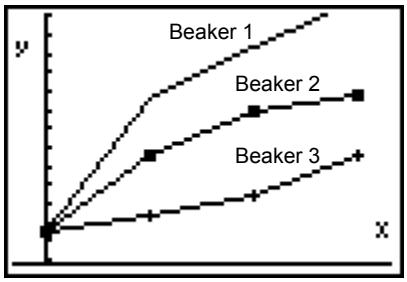
Factors	Beaker 1	Beaker 2	Beaker 3
Covered			
Uncovered			
Heat Source			
Added Carbon Dioxide			
Added Water Vapor			
Soil Present			

A.

Factors	*Beaker 1*	*Beaker 2*	*Beaker 3*
Covered	✓	✓	
Uncovered			✓
Heat Source	✓	✓	✓
Carbon Dioxide Added	✓		
Water Vapor Added	✓		
Soil Present	✓	✓	✓

2. **Q.** Draw a sketch of the graph created by your graphing device.

A. *Answers will vary. See sample graph below.*



Move the cursor along each curve to answer questions 3-5 and record your answers in the table provided.

*Use the arrow keys to move the cursor along each curve. Use the left and right arrow keys (◄, ►) to move the cursor along a curve. Use the up and down arrow keys (▲,▼) to move the cursor from one curve to the next. The **time** (**x**) and **temperature** (**y**) values of each data point are displayed below the graph. (**Note:** The matching Sensor number for each curve is displayed in the upper right corner of the screen).*

3. **Q.** What is the temperature of each beaker at 5 minutes (x = 300)? Record your temperatures in Table 2. (Copy the table in your Journal.)

   A. *Answers will vary.*

4. **Q.** What is the temperature of each beaker at 10 minutes (x = 600)? Record your temperatures in Table 2.

   A. *Answers will vary.*

5. **Q.** Record the time interval (change in time) in seconds between the 5-minute mark and the 10-minute mark in Table 2.

   A. *The change in time is 5 minutes.*

6. **Q.** Record the change in temperature for each beaker between the 5-minute mark and the 10-minute mark in Table 2. (**Hint:** Column 2 – Column 1 = Change in Temp)

Table 2

Elapsed Time	5 Minutes Temp (^{o}C) (1)	10 Minutes Temp (^{o}C) (2)	Change in Temp (^{o}C) (2-1)	Change in Time (seconds)
Beaker 1				
Beaker 2				
Beaker 3				

   A. *Answers will vary.*

7. **Q.** During the entire 15-minute time period (900 seconds), is the temperature inside each beaker increasing or decreasing?

   A. *The temperature inside each beaker increases. The temperature inside Beaker 3 does not increase significantly.*

8. **Q.** The steepness of a line on your graph indicates how fast the temperature is changing. For example, a steep line indicates that the temperature is changing quickly. A line that is almost flat indicates that the temperature is changing slowly.

   According to your graph, which beaker had the fastest increase in temperature between the 5-minute mark and the 10-minute mark? (**Hint:** *Which line is the steepest?*) Which beaker had the slowest increase in temperature during the same time period?

   Question 8 was provided for the lower grades. If the mathematics is beyond the student's grasp, the teacher can choose to omit questions 9-11.

   A. *Beaker 1 had the fastest increase in temperature. Beaker 3 had the slowest increase in temperature.*

9. **Q.** Another method to find how fast the temperature is changing within the specified time interval is to find the slope of each line on your graph. The **slope of a line** is defined as the rate of change between two points on a graph. The slope formula will give a numerical value to compare how fast the temperature is changing in each beaker. The greater the slope, the faster the change in temperature. Using the formula for slope (see below) and the values you recorded in Table 2, find the slope of the lines representing the temperatures inside each beaker between the 5-minute mark and the 10-minute mark. Show your work and record your answers in Table 3. (Copy the table in your Journal.) **Note:** Use seconds for change in time.

$$\text{SLOPE} = \frac{\text{Change in Temperature}}{\text{Change in Time}}$$

Table 3

	Slope
Beaker 1	
Beaker 2	
Beaker 3	

A. *Answers will vary.*

10. **Q.** According to your calculations, which beaker had the fastest increase in temperature between the 5-minute mark and the 10-minute mark? (**Hint:** *Which line had the greatest slope?*) Which beaker had the slowest increase in temperature during the same time period?

A. *Beaker 1 had the fastest increase in temperature. Beaker 3 had the slowest increase in temperature.*

11. **Q.** In questions 9 and 10 you used two data-points to find the slope and used the slope to compare the temperature changes inside each beaker. DataMate can also be used to make the same comparisons by looking at all the data points within the 5-minute time interval. Follow the steps below to determine how fast the temperature is changing inside each beaker. The letter A (*Figure 1*) on your display will represent how fast the temperature changed. Record the value for **A** for each beaker in Table 4. (Copy the table in your Journal.)

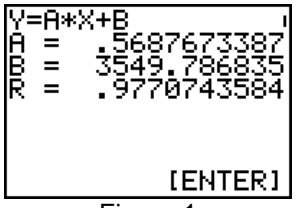


Figure 1

Find the rate of change between the 5-minute mark and the 10-minute mark of the graph for each beaker using DataMate.

1. Select the Time Interval

a. Press [ENTER] to return to the MAIN MENU.
b. Select GRAPH and press [ENTER].
c. Select SELECT REGION.
d. Using the right arrow key [▶], move the cursor to the 5-minute mark (x = 300), and press [ENTER].
e. Using the right arrow key [▶], move the cursor to the 10-minute mark (x = 600), and press [ENTER].

2. Calculate the rate of change for Beaker 1

a. Press [ENTER] again and select MAIN SCREEN to return to the MAIN MENU.
b. From the MAIN MENU, select ANALYZE.
c. From the ANALYZE OPTIONS MENU, select CURVE FIT.
d. From the CURVE FIT MENU, select LINEAR (CH 1 VS TIME).

3. Calculate the rate of change for Beaker 2

a. Press [ENTER] twice to return to the ANALYZE OPTIONS MENU.
b. From the ANALYZE OPTIONS MENU, select CURVE FIT.
c. From the CURVE FIT MENU, select LINEAR (CH 2 VS TIME).

4. Calculate the rate of change for Beaker 3

a. Press [ENTER] twice to return to the ANALYZE OPTIONS MENU.
b. From the ANALYZE OPTIONS MENU, select CURVE FIT.
c. From the CURVE FIT MENU, select LINEAR (CH 3 VS TIME).

Table 4

	(A) 5-minute Interval
Beaker 1	
Beaker 2	
Beaker 3	

A. *Answers will vary*.

12. **Q.** According to your DataMate calculations, which beaker had the greatest change in temperature during the 5-minute interval? Which beaker had the least change in temperature during the 5-minute interval?

A. *Beaker 1 had the greatest change in temperature. Beaker 3 had the least change in temperature.*

13. **Q.** Based on your data and your data analysis, what factor(s) had an effect on how fast temperature changed? (**Hint:** You may refer to Tables 1, 2, 3, and 4.)

    A. *The three factors that influenced the rate of change were the plastic cover, water vapor and CO_2.*

14. **Q.** Based on your data and your data analysis, and the information about greenhouse gases from the JASON XV Research Article, describe how the increase of carbon dioxide in the atmosphere may be responsible for changes in our planet's climate.

    A. *Beaker 1 had the fastest increase in temperature because we breathed more CO_2 and water vapor into it. The same thing happens on Earth. Greenhouse gases (such as CO_2 and water vapor) trap energy from the sun in our atmosphere, which makes it warm enough for life. However, there can be too much of a good thing. Scientists believe increases in CO_2 and water vapor in our atmosphere may be responsible for global warming. This can have dangerous effects on climate, water levels, and ecosystems around the world.*