

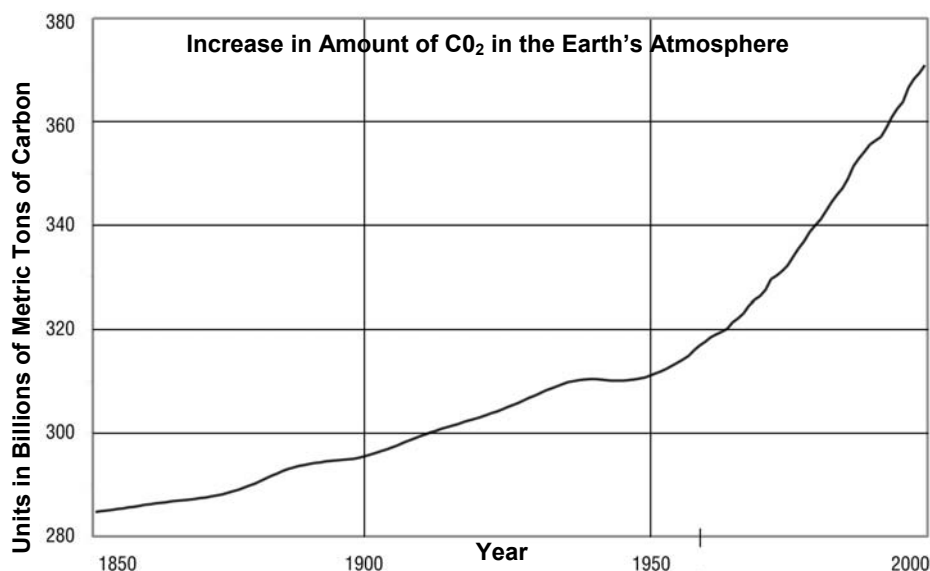
The GREENHOUSE EFFECT a good thing?

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Activity Overview

Certain gases in the Earth's atmosphere such as carbon dioxide (CO_2) and water vapor, known as the greenhouse gases, trap energy from the sun. This is known as the greenhouse effect. The greenhouse effect is necessary to keep the Earth warm enough for life. However, levels of CO_2 in our atmosphere have been increasing dramatically and scientists speculate that this could be causing global warming.



In this activity students will model the greenhouse effect using bottles sealed with plastic wrap and the air they exhale, which is high in CO_2 and water vapor. They will 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™. Students will collect and analyze temperature data in two conditions: a sealed bottle and a sealed bottle into which they breathe.

Conclusion: The bottle with added CO_2 and water vapor will have the highest temperature at the end of the experiment. 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

- High

Materials*

- TI-73 Explorer™
- TI CBL2™ or Vernier LabPro
- TI-73 DataMate
- 2 Temperature Sensors
- Lamp with 100-watt bulb
- 2 Clear 1 L bottles
- 2 Rubber bands
- Black construction paper
- Masking tape
- Plastic wrap
- 1 Pencil



* 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, Gretchen Stahmer, and Sorensen, Richard, published by Vernier Software & Technology, 2002.

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Concept Background

- Each year the total amount of CO₂ in the atmosphere increases by 3.3 trillion kilograms. (See graph below.) Human activities such as emissions and deforestation add CO₂ 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. The 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.
- CO₂ accounts for about 25% of the heat trapped in the Earth's atmosphere.
- Changes in either water vapor or CO₂ 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.

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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 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

- Place the lamp at the same distance from both bottles (about 10 cm) and make sure it is heating both of them evenly.
- Make sure there is not much excess plastic wrap over the sides of the two covered bottles.
- The sensors should be in the middle of the bottle to measure air temperature and not resting on the side. Students can use masking tape on the probe and bottle to position the sensor.
- Since the light bulb radiates heat, direct exposure of the sensor to the light bulb will give different readings than measuring the temperature inside the bottle. To prevent direct heating, surround the area where the sensor is with black construction paper.
- The bottles must be completely dry before starting the experiment. Water inside or outside the bottle may be a source of error.
- In question 8 students use a qualitative approach to determine how fast the temperature changes in each container by observing the steepness of a line graph. In questions 10 and 13 students use their data and the TI-73 to calculate slope with two different methods. If you have not covered slope in your classroom, you may choose to omit Questions 10-15.
- While the data is being collected, the graphing device will display the temperature inside Bottles 1 and 2 and a real-time graph of the temperature inside both containers.
- 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 3-13.)
- 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 13.)
- 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 two conditions using one sensor and share their results with the others.
- Encourage students to answer the questions in Data Analysis in a journal.
- 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>.

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Vocabulary

Biogeochemist A scientist who studies the chemical interactions between the 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 the 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 bottle in Table 1. (Copy the table in your journal.)

Table 1

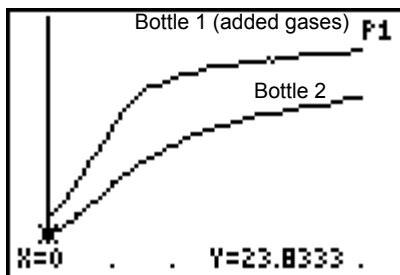
Factors	Bottle 1	Bottle 2
Sealed with Plastic Wrap		
Heat Source		
Added Carbon Dioxide		
Added Water Vapor		

A.

Factors	Bottle 1	Bottle 2
Sealed with Plastic Wrap	✓	✓
Heat Source	✓	✓
Carbon Dioxide Added	✓	
Water Vapor Added	✓	

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 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 bottle 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 bottle at 10 minutes (x = 600)? Record your temperatures in Table 2.
A. *Answers will vary.*



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5. **Q.** Record the change in temperature for each bottle between the 5-minute mark and the 10-minute mark in Table 2.
- A.** *The change in time is 300 seconds.*
6. **Q.** Record the change in temperature for each bottle between the 5-minute mark and the 10-minute mark in Table 2.
- Hint: Change in Temperature = Column 2 – Column 1*

Table 2

Elapsed Time	5 Minutes Temp (°C) (1)	10 Minutes Temp (°C) (2)	Change in Temp (°C) (2-1)	Change in Time (seconds)
Bottle 1				
Bottle 2				

A. *Answers will vary.*

7. **Q.** During the entire 15-minute time period (900 seconds), is the temperature inside each bottle increasing or decreasing?
- A.** *The temperature inside each bottle increases.*
8. **Q.** The steepness of a line on your graph indicates how fast temperature changes. 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 bottle had the fastest increase in temperature between the 5-minute mark and the 10-minute mark?

Hint: Which line is the steepest?

A. *Bottle 1 had the fastest increase in temperature.*

9. **Q.** Which bottle had the slowest increase in temperature during the same time period?
- A.** *Bottle 2 had the slowest increase in temperature.*
10. **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 bottle. 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 bottle between the 5-minute mark and the 10-minute mark. Show your work and record your answers in Table 3. *Note: Use seconds for change in time.*

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



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Table 3

	Slope
Bottle 1	
Bottle 2	

A. *Answers will vary.*

11. **Q.** According to your calculations, which bottle had the fastest increase in temperature between the 5-minute mark and the 10-minute mark?
Hint: Which line had the greatest slope?

A. *Bottle 1 had the fastest increase in temperature.*

12. **Q.** Which bottle had the slowest increase in temperature during the same time period?

A. *Bottle 2 had the slowest increase in temperature.*

13. **Q.** In questions 10, 11, and 12 you used two data-points to find the slope and used the slope to compare the temperature changes inside each bottle. 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 bottle. The letter A (*Figure 1*) on your display will represent how fast the temperature changed. Record the value for A for each bottle in Table 4. (Copy the table in your journal.)

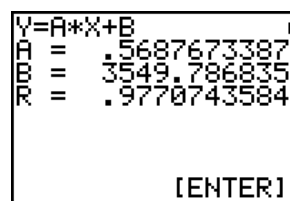


Figure 1

The above values are given as an example.

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

1. Select the Time Interval.

- Press **[ENTER]** to return to the MAIN MENU.
- Select GRAPH and press **[ENTER]**.
- Select SELECT REGION.
- Using the right arrow key **[→]**, move the cursor to the 5-minute mark ($x = 300$), and press **[ENTER]**.
- Using the right arrow key **[→]**, move the cursor to the 10-minute mark ($x = 600$), and press **[ENTER]**.



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2. Calculate the rate of change for Bottle 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 Bottle 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).

Table 4

	(A) 5-minute Interval
Bottle 1	
Bottle 2	

- A. *Answers will vary.*
14. Q. According to your DataMate calculations, which bottle had the greatest change in temperature during the 5-minute interval?
 - A. *Bottle 1 had the greatest change in temperature.*
15. Q. Which bottle had the least change in temperature during the 5-minute interval?
 - A. *Bottle 2 had the least change in temperature.*
16. 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 two factors that influenced the rate of change were the water vapor and CO₂.*
17. Q. Which bottle had the highest temperature at the end of 15 minutes?
 - A. *Bottle 1 had the highest temperature.*
18. How much higher was the temperature than the other bottle?
 - A. *Answers will vary.*



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19. **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.** *Bottle 1 had the fastest increase in temperature because we breathed more CO₂ and water vapor into it. The same thing happens on the Earth. Greenhouse gases (such as CO₂ 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 CO₂ 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.*

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