Greenhouse Effect Laboratory Teacher Guide

Driving Question: What impact does the greenhouse effect have on atmospheric temperature?

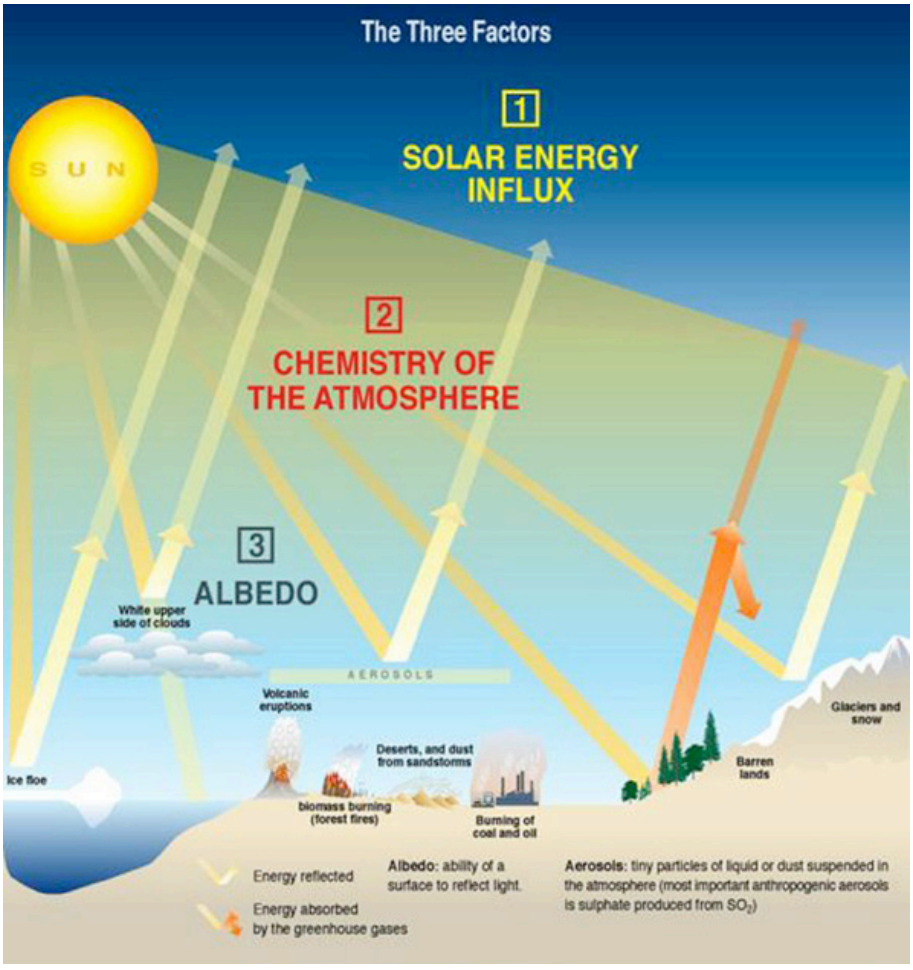
In this activity your students will:

1. Understand the importance of greenhouse gases in our atmosphere.
2. Understand that excess CO_2 intensifies the greenhouse effect.

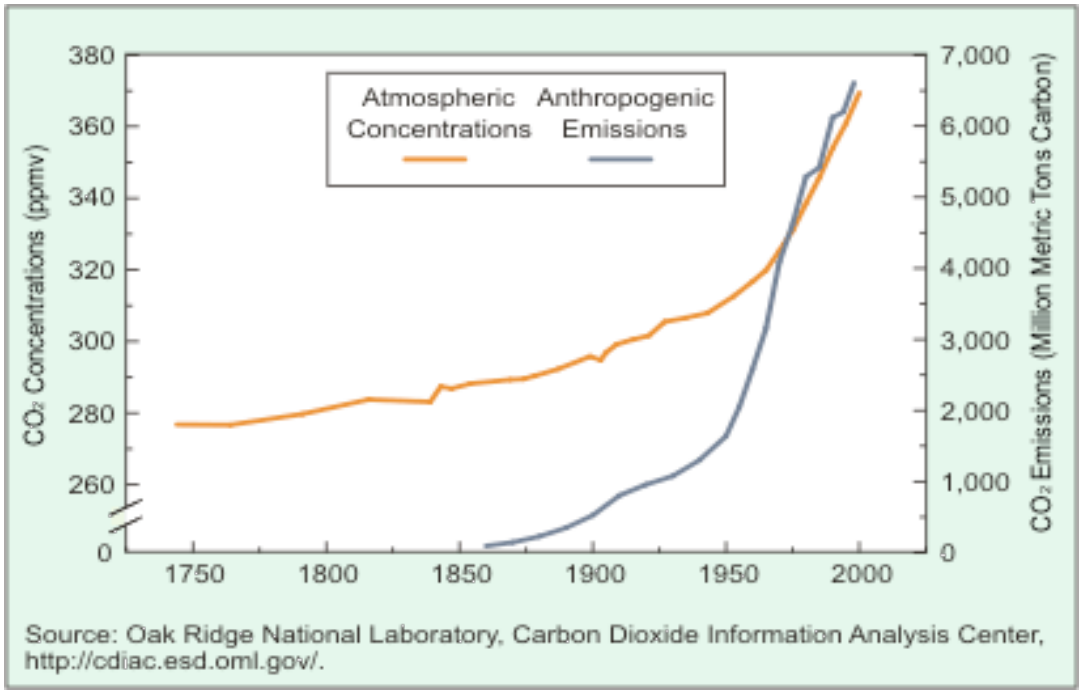
Background Information

What are greenhouse gases?

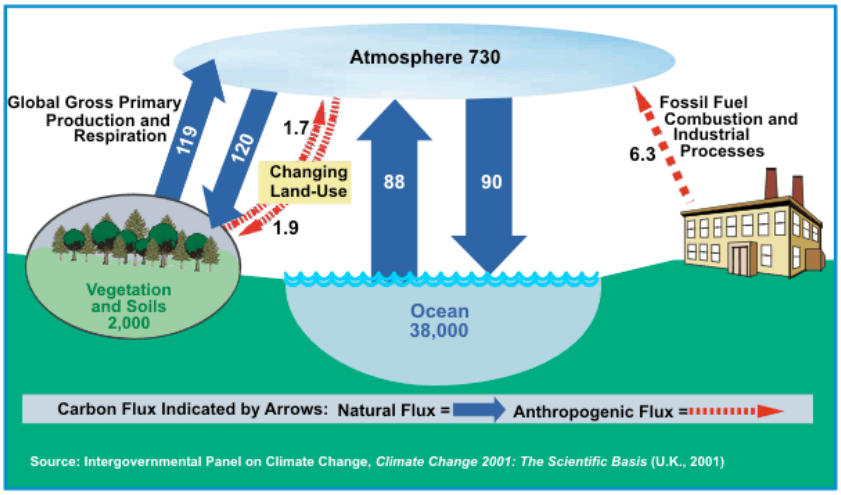
Our atmosphere contains several chemical compounds that scientists refer to as greenhouse gases. The most common greenhouse gases include (in order of quantity): water vapor (H_20), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons (CFCs). These gases allow sunlight to enter the atmosphere freely. When sunlight strikes the Earth's surface, some of it is reradiated back towards space as infrared radiation (heat) and some is absorbed by the Earth's surface. Over time, the amount of energy sent from the Sun to the Earth's surface should be about the same as the amount of energy radiated back into space, leaving the temperature of the Earth's surface roughly constant. Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere. The atmosphere acts as a natural blanket by preventing the Sun's heat energy from radiating back into space, much like a greenhouse traps the Sun's energy to warm someone's plants even in the middle of winter. The natural greenhouse effect helps warm the Earth's surface by about 33°C. Without it, our planet would be too cold for humans to survive.



Why are scientists concerned with greenhouse gases?
The amount of energy arriving from the Sun to the Earth's surface has to be balanced with the amount of energy radiated back into space, leaving the temperature of the Earth's surface temperature roughly constant. When there is a change in the amount of greenhouse gases, it affects the amount of heat trapped within the atmosphere. There are many natural causes for increases in greenhouse gas levels including volcanic eruptions and forest fires. In the last 150 years, human activities such as burning fossil fuels for industry or transportation, deforestation, large-scale agriculture, and production of chlorofluorocarbons have increased greenhouse gas levels resulting in an intensified greenhouse effect.



Carbon dioxide (CO_2) is the greenhouse gas most discussed when scientists examine the history, causes, and predictions of climate change. While other gases also have an effect on heat, CO_2 released into the atmosphere is greatly affected by human activity. During the past 20 years, about three-quarters of anthropogenic (human-produced) CO_2 emissions came from the burning of fossil fuels.



Laboratory Description

This experiment investigates the ability of an intensified CO_2 atmosphere to absorb thermal (heat) energy. Your students will compare differences in the heat absorption (changes in temperature) in an unaltered air sample and in an intensified CO_2 atmosphere.

Equipment List

For 5 classes of 28 students each you will need:

- ☑ 1 gallon of vinegar
- ☑ 5 pounds of baking soda
- ☑ box of plastic wrap
- ☑ 7 high intensity lamps each with a 60 to 100 watt incandescent bulb
- ☑ 14 - 500 ml or 600 ml plastic or glass containers (Note: For clean-up purposes, you may wish to double this amount if teaching consecutive classes.)
- ☑ 14 - thermometers *or* temperature probes
- ☑ 7 wax pencils

For each laboratory team – Students should work in teams of 4.

- ☑ 1 high intensity lamp with a 60 to 100 watt incandescent bulb
- ☑ 2 thermometers *or* temperature probes
- ☑ 2- 500 ml or 600 ml plastic or glass containers
- ☑ 2 pieces of plastic wrap with rubber bands
- ☑ 2 – 35g baking soda
- ☑ 1 – 65 ml vinegar
- ☑ 1 – 65 ml water
- ☑ 1 wax pencil
- ☑ 4 copies of the Greenhouse Effect Student Handout

Classroom Management Notes

1. *Students work in groups of 4.*
2. *Assign students in each group the following tasks:*
    a. ***Temperature monitors (2 students).*** *The temperature monitors read the temperature for each apparatus.*
    b. ***Timekeeper.*** *The timekeeper keeps track of the measurement intervals and tells the other group members when to take measurements.*
    c. ***Recorder.*** *The recorder writes the observations and temperature measurements.*

Step 1: Experimental Set Up

Guide the students through the following steps. ***A modified version of these instructions will be on the Greenhouse Effect Laboratory Student Guide.***

1. Instruct students to prepare the containers.

a. Container 1
    i. Label container 1 - "control"
    ii. Tape the probe or thermometer to the inside of the container. The probe end must be 5 cm above the bottom of the container. Students will be adding liquid and baking soda to the containers in the next step to create the atmospheres. During data collection students need to measure the "atmosphere" temperatures, not the liquid temperatures.
        1. If using a thermometer, remind students to turn the thermometer marks to the outside of the container so they can read the temperature measurements without disrupting the experiment.

b. Container 2
    i. Label container 2 - "CO_2"
    ii. Tape the probe or thermometer to the inside of the container. The probe end must be 5 cm above the bottom of the container. Students will be adding liquid and baking soda to the containers in the next step to create the atmospheres. During data collection students are to measure the "atmosphere" temperatures, not the liquid temperatures.
        1. If using a thermometer, remind students to turn the thermometer marks to the outside of the container so they can read the temperature measurements without disrupting the experiment.

c. Pour 35 grams (g) of baking soda into each container.

d. Instruct students to prepare the cover, but do not yet place it on top of the container. You may want to advise students to practice sealing the container at this point. Students will need to place the covers on the containers **immediately** following the addition of the fluid.

e. Adding the liquid.
    i. Container 1 – "control"
        1. Pour 65 ml of water into the container labeled "control."
        2. Place the cover on the container labeled "control."
    ii. Container 2 - "CO_2
        1. Pour 65 ml of vinegar into the container labeled "CO_2."
        2. Place the cover on the container labeled "CO_2."
    iii. REMINDER: Immediately after liquid is added to each container students need to seal the containers. Be sure the seals are tight.

iv. Instruct students to swirl the containers for 15 seconds to ensure that the baking soda is being dissolved.

2. Instruct the students to place containers directly underneath the lamp. The light should be about 24 centimeters over the containers. Both containers should be placed an equal distance from the light source. (Note: Make sure students make a prediction before turning on the lamp – see below.)

3. Instruct students to complete the ***prediction section*** **on their investigation sheet.** They should predict which atmosphere container will heat the fastest. Which atmosphere container will reach the highest temperature?

Step 2: Conducting the Experiment

Data Collection Overview: The temperature readings for both probes (or thermometers) should be checked and recorded every 2 minutes for a total of 10 minutes. After the 6-minute measurement, students should discuss and note which container has the greatest heat increase. After the 8-minute measurement has been taken, students are to turn off the light. One more temperature reading is made at the 10-minute mark.

Procedure

1. **BEFORE:** Instruct students to measure the temperature in both containers prior to turning on the light bulb. Prompt students to record the temperature in the **BEFORE** column on their Greenhouse Effect Data Collection Table.
    a. Emphasize to your students that it is important to know the temperature both before and immediately after the light is turned on. This provides an initial starting point so changes in temperature can be discussed accurately.

2. **TURNING THE BULB ON**
    a. Instruct students to begin timing immediately after turning the light on.
    b. Instruct students to measure and record temperature in the **0-minute** column on the worksheet.

3. **2-MINUTE INTERVALS:** Students will take and record temperature measurements on their Greenhouse Effect Data Collection Table every **2 minutes for the first 8 minutes of the**

experiment with the light on. Remind students that the time labels at the top of the data chart are elapsed time.

a. Prompt students to record the temperature in the correct time column as needed.

b. At the end of the **6-minute period**, students should discuss and note which container exhibited the greatest greenhouse effect. In other words, which atmosphere container had the greatest heat increase?

4. **Instruct students to turn off the light bulb immediately after the temperatures are recorded for the 8-minute interval. Remind students that they will need to make one more measurement at the 10-minute interval.**
5. Again, instruct students to discuss and note which container has the greatest greenhouse effect (heat increase).
6. At the 10-minute interval, instruct students to measure the temperature for each thermometer or probe**.**
7. **Instruct** students to calculate the **Heat Increase** – the difference between the **start measurement** and **the 8-minute** interval temperature – and record it on their **Greenhouse Effect Data Collection Table**.
8. Instruct students to calculate the **Heat Retention** – the difference between the **8-minute and the 10-minute intervals** – and record it on their **Greenhouse Effect Data Collection Table**.
9. Instruct students to complete the **Greenhouse Effect Analysis Questions #1-6** on their investigation sheet.

Step 3: Group Discussions

Review and discuss question responses from the students' worksheets. See **Greenhouse Effect Lab Assessment** for sample answers.