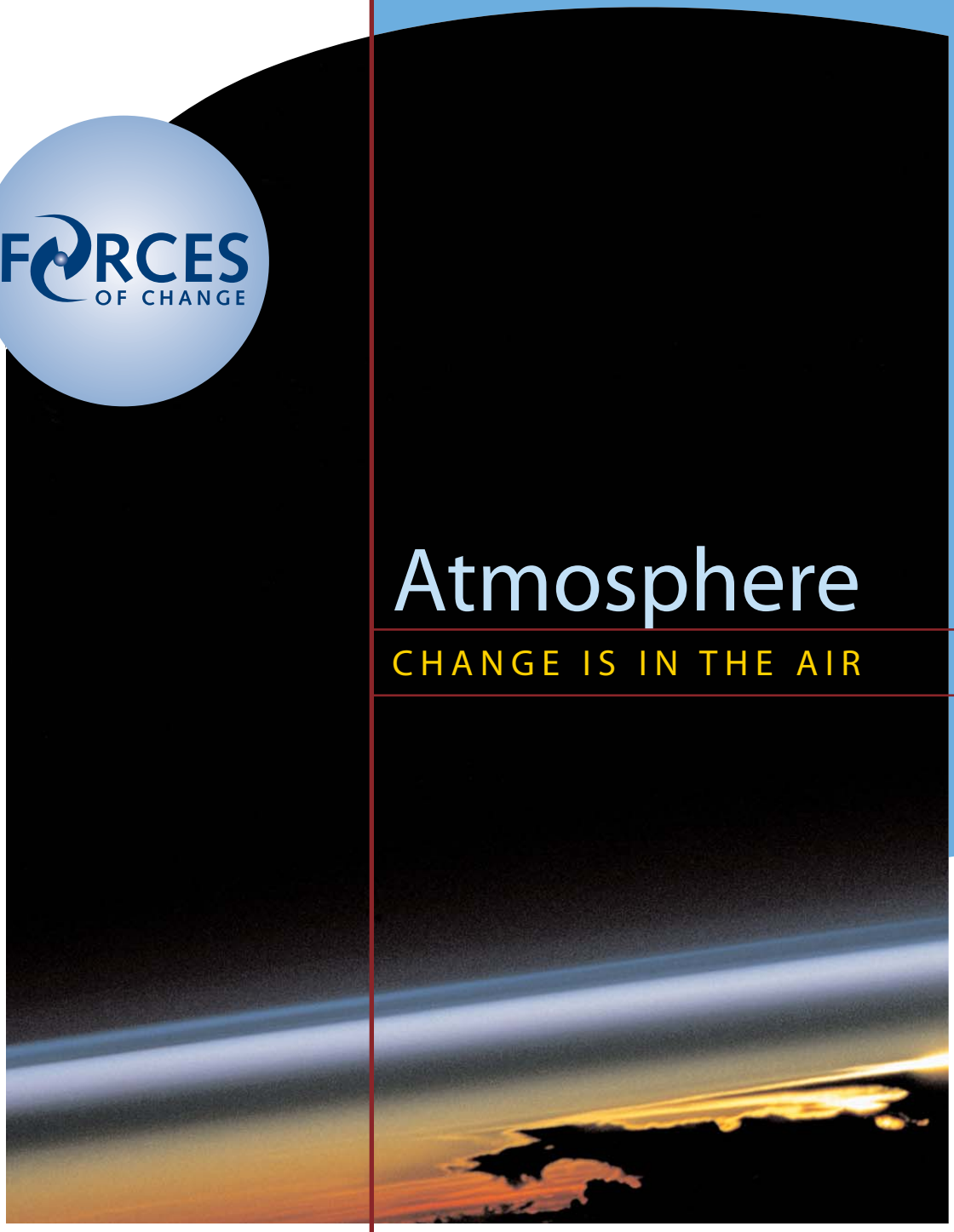
Activity 7

Greenhouse Gas in a Jar

FORCES OF CHANGE

# Atmosphere

## CHANGE IS IN THE AIR



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ACTIVITY 7

# Greenhouse Gas in a Jar

**Overview**

Students create a greenhouse gas, carbon dioxide, through a simple chemical reaction, measure the effect of the gas on air temperature, and relate their findings to the greenhouse effect in our atmosphere.

**Grade Level**

6–9

**National Standards Alignment**

*National Science Education Standards*
Earth and Space Science, Content Standard D, Grades 9–12, Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans. Grades 5–8, The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle.

**Time**

Two class periods (40–50 minutes each)

**Materials**

- 3 small thermometers
- 3 two-liter plastic soda bottles, rinsed and dried, labels removed, with the tops evenly cut off with a utility knife so the sides are straight and the bottle sits flat when turned upside down.
- 1 jar or beaker small enough to fit through the mouth of the soda bottle
- Baking soda
- White vinegar
- 1 clock or watch
- Sunlamp or access to a sunny area to perform the experiment

**Safety Considerations**

Students should wear goggles, aprons, and disposable gloves when mixing the baking soda and vinegar. The room should be well ventilated.

**Vocabulary**

**GREENHOUSE GAS** — gases made up of two or more atoms that absorb heat from the sun that radiates from Earth's surface. Greenhouse gases include carbon dioxide, water vapor, and methane.
**RADIATIVE HEAT** — heat reflected from a surface
**GREENHOUSE EFFECT** — heating caused by the capture of radiated heat from Earth's surface by the chemical bonds in greenhouse gases
**FOSSIL FUEL** — fuels such as gasoline and coal that come from the remains of plants and animals buried millions of years ago

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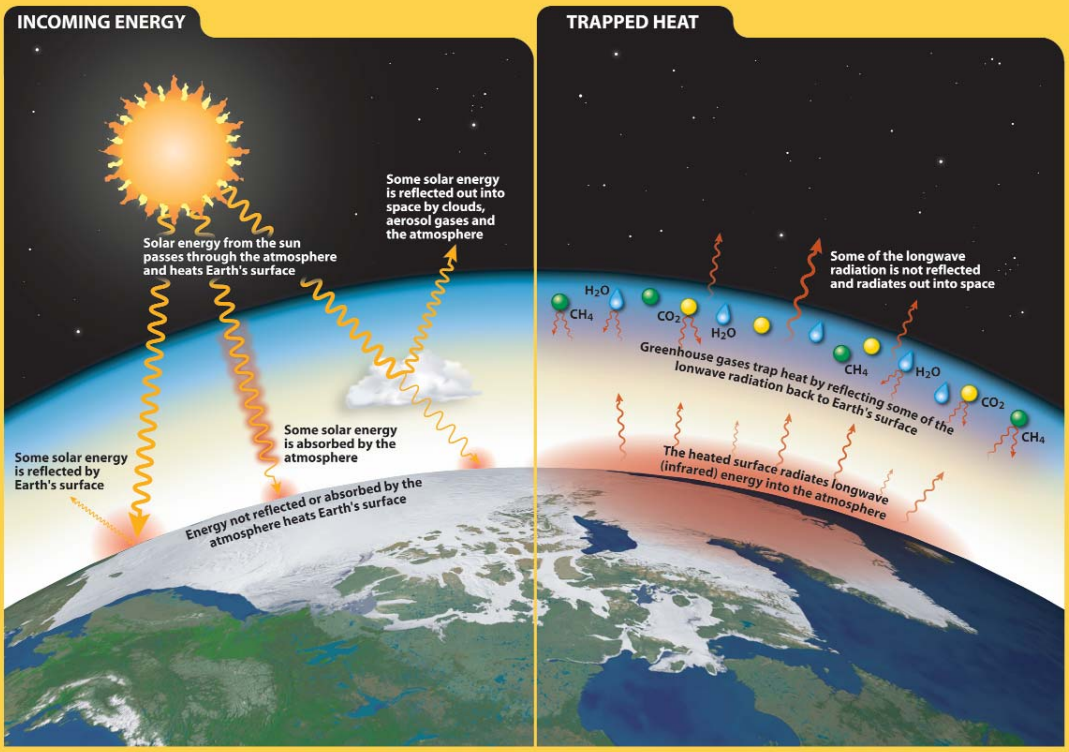
## OBJECTIVES

Students will be able to:

1. Define the greenhouse effect and illustrate how it is a physical phenomenon.
2. Define how a physical effect is intensified by changing the components.
3. Describe how their observations apply to Earth's atmosphere.




**Greenhouse gases absorb the sun's long-wave radiation that reflects off Earth's surface—warming the planet.**

Graphic by The M Factory © Smithsonian Institution

## Background

Without its atmosphere to retain the sun's heat, Earth would be cold and nearly lifeless. The average temperature would be about—18° C (0° F) instead of the 15° C (60° F) it is now. Carbon dioxide, water vapor, and methane are greenhouse gases that make Earth habitable.

Greenhouse gases are made up of at least two atoms. Bonds between the atoms absorb heat that radiates from Earth's surface and would otherwise be lost in space. Greenhouse gases keep Earth warm much as a greenhouse keeps plants warm in winter.

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## Background (continued)

Some heating of the atmosphere occurs when molecules, aerosols, and particles in the air absorb radiation from the sun. Some heating occurs from contact with Earth's surface, which absorbs most of the sun's energy and emits long-wave radiation back into the atmosphere. Greenhouse gases reflect that long-wave radiation back to Earth's surface and make it hotter still.

Baking soda is sodium bicarbonate ($NaHCO_3$ ). Vinegar is acetic acid ($HC_2H_3O_2$). When the two substances are mixed, the bicarbonate ion ($HCO_3$+) from the baking soda combines with a hydrogen ion ($H^-$ ) from the vinegar to form carbonic acid ($H_2CO_3$), which readily decomposes into carbon dioxide gas ($CO_2$) and water ($H_2O$), according to these two equations:

$NaHCO_3 + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2CO_3$
$H_2CO_3 \rightarrow CO_2 + H_2O$

## Activity

1. Group the students and explain the activity and any background information. Ask students to predict what will happen to their two different temperature sets. Record their predictions on a board or large chart paper.
2. Distribute the materials. Each group should place its thermometers a few inches apart under the sunlamp or in direct sunlight.
3. Wait about three minutes so that the thermometers will give accurate readings, and then have the students record the time and the temperature readings on all three thermometers.
4. In the small beaker, place 30 g (one ounce) baking soda. Carefully add 60 ml (two ounces) vinegar. As soon as the mixture foams up (it is creating carbon dioxide), place one thermometer near the beaker and cover the beaker and thermometer with one upside-down soda bottle.
5. Each group should now place a soda bottle upside-down over another of their thermometers. If the thermometer is too large to remain horizontal inside the bottle, it can lean against an inner side. Every two minutes, for ten minutes, the students should record the readings of both thermometers. Continue to read the temperatures every five minutes for a total of 30 minutes.
6. When all the groups are done, have them examine their observations and compare them to their predictions. How accurate were their predictions? Explain what happened in the experiment.

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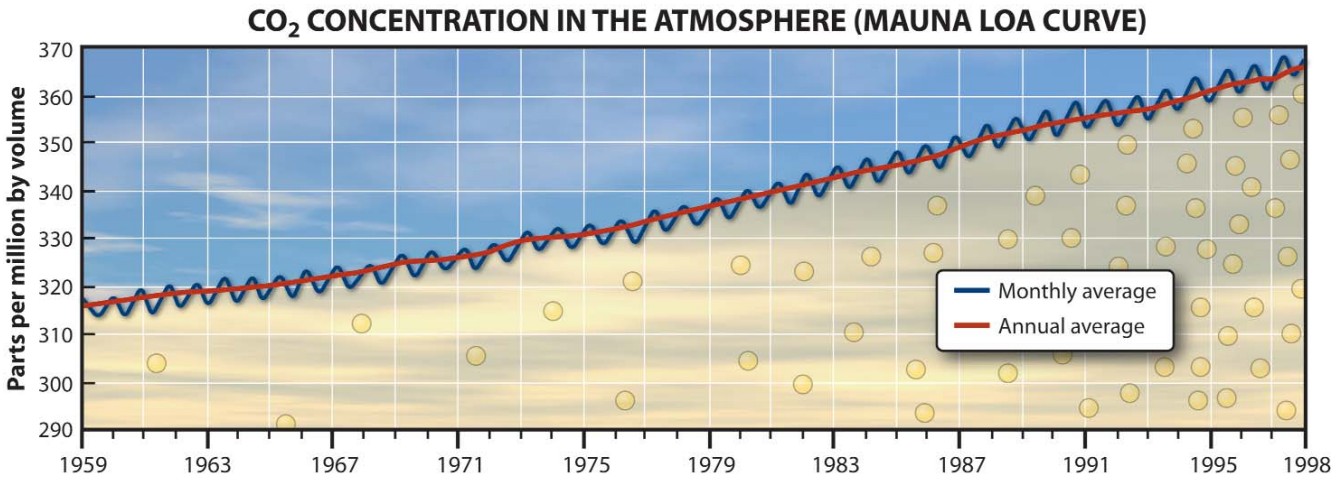
## Explanation

The air over the exposed thermometer is constantly changing, and as it gets warm it is replaced by cooler air. Because the air in the bottles cannot circulate to the rest of the room, it stays in the sunlight and gets warmer and warmer. The bottle with carbon dioxide traps even more heat and warms even faster than room air, which contains only a trace amount of carbon dioxide. A similar trapping of heat happens in the Earth's atmosphere. Sunlight passes through the atmosphere and warms Earth's surface. The heat radiating out from the surface is trapped by greenhouse gases. Both the atmosphere and the bottles allow light to enter and trap that energy when it is converted to heat. They work differently, however, because the bottles keep in the heated air, while greenhouse gases absorb radiative heat.




**A steady rise in the concentration of carbon dioxide in the atmosphere has been measured atop the Mauna Loa volcano in Hawaii since 1958. Since the Industrial Revolution began, the amount of $CO_2$ in the atmosphere has increased by 31 percent. That's higher than at any time in the past 100 million years.**



## References

http://www.umich.edu/~gs265/society/greenhouse.htm