Teaching Activity: Modeling the Greenhouse Effect

Introduction: The surface of the Earth, warmed by solar radiation, has an average temperature around +18 degrees C (59 F). This is much cooler than the surface of the Sun, so the energy emitted from the Earth's surface is at much longer wavelengths than solar radiation. This terrestrial radiation is located between 4 and 100 micrometers (mm) in the infrared band of the electromagnetic spectrum. *Infrared radiation* is the heat you feel when you hold your hand near a warm radiator. Your hand, like everything else in the universe, radiates heat. Heat and light are both forms of energy, but unlike visible light, infrared radiation can be absorbed or "trapped" by certain gases in the atmosphere.

The infrared energy that is absorbed in the atmosphere makes the air warm. The air in turn, radiates heat which is still at infrared wavelengths. Some of this heat goes back toward the surface, warming the land, the water and the living organisms. This atmosphere-surface cycling of heat energy is known as the *greenhouse effect* and the gases involved in this process are called *greenhouse gases*. The greenhouse effect is a natural, integral part of the Earth system. Without it, we would not be here. Our planet is comfortably warm for life because it is surrounded by a "blanket" of air that keeps the Earth some 33 degrees C warmer than it would be otherwise, and allows for the existence of oceans of liquid water and living creatures like ourselves.

Objectives:

- To form a model of the heating of the Earth's atmosphere;
- To provide an opportunity to build and test a physical model analogous to the atmospheric greenhouse effect;
- To practice setting up a controlled experiment, recording data, graphing and analyzing results;

Important Terms: Greenhouse effect, energy, greenhouse gases, longwave radiation, shortwave radiation, electromagnetic spectrum, infrared heat, visible light;

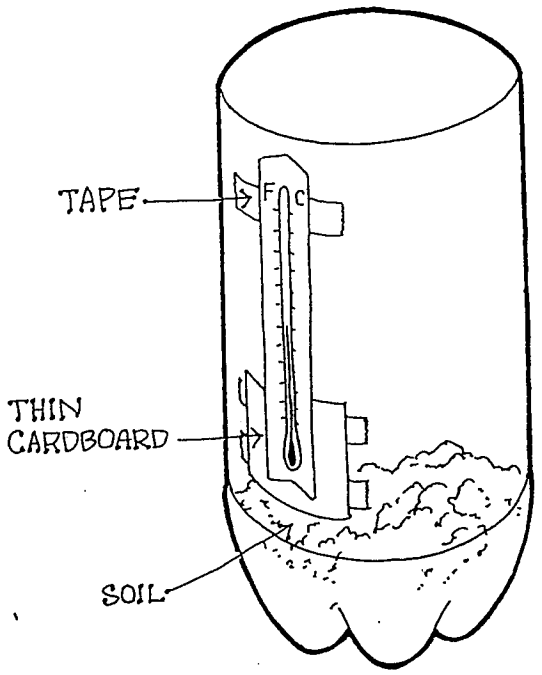
Materials: Two cut-off plastic soda bottles, 2 thermometers, masking tape, plastic wrap, scissors, colored pencils, graph paper, dark soil, sunlamp;

Procedure:

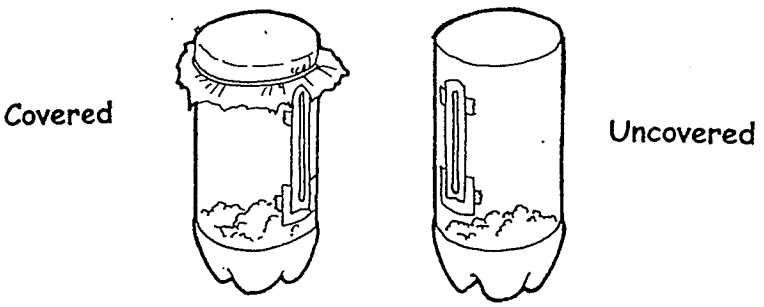
1. Have students tape a thin piece of cardboard over the bulb of each thermometer to protect it from direct heat.

2. Students should then add 2 cm of soil to each bottle.

3. The thermometer should then be tapped the side of each bottle about 2 inches from the top and above the level of the soil. **(See drawing that follows.)**
    - Students should record the temperature of the thermometer on the **Data Table**.



4. Instruct students to place plastic wrap over the top of one of the bottles and tape it shut. The other bottle should be left uncovered.



5. Both bottles should then be placed in either direct sunlight or directly under a sun lamp.

6. Students should begin measuring and recording the temperature in each bottle every minute for 15 minutes.
    - Students should record their measurements in the **Data Table.**

7. At the end of the investigation, students should complete the activities in the **Collecting and Analyzing Data** and the **Drawing Conclusions** sections.

Student Activity Sheet: Modeling the Greenhouse Effect

Introduction: The surface of the Earth, warmed by solar radiation, has an average temperature around +18 degrees C (59 F). This is much cooler than the surface of the Sun, so the energy emitted from the Earth's surface is at much longer wavelengths than solar radiation. This terrestrial radiation is located between 4 and 100 micrometers (mm) in the infrared band of the electromagnetic spectrum. Infrared radiation is the heat that you feel when you hold your hand near a warm radiator. Your hand, like everything else in the universe, radiates heat. Heat and light are both forms of energy, but unlike visible, infrared radiation can be absorbed or "trapped" by certain gases in the atmosphere.

The infrared energy that is absorbed in the atmosphere makes the air warm. The air, in turn, radiates heat which is still at infrared wavelengths. Some of this heat goes back toward the surface, warming the land, the water and living organisms. This atmosphere-surface cycling of heat energy is known as the *greenhouse effect* and the gases involved in this process are called *greenhouse gases.* The greenhouse effect is a natural, integral part of the Earth system. Without it, we would not be here. Our planet is comfortably warm for life because it is surrounded by a "blanket" of air that keeps the Earth some 33 C warmer than it would be otherwise, and allows for the existence of oceans of liquid water and living creatures like ourselves.

Objectives:

- To form a model of the heating of the Earth's atmosphere;
- To provide an opportunity to build and test a physical model analogous to the atmospheric greenhouse effect;
- To practice setting up a controlled experiment, recording data, graphing and analyzing results;

Procedure:

1. Tape a thin piece of cardboard over the bulb of each thermometer to protect it from direct heat.

2. Add 2 cm of soil to each bottle.

3. Tape the thermometer to the side of each bottle about 2 inches from the top and above the level of the soil. **Check your teacher's set-up!**
    - Record the temperature of the thermometers on the **Data Table**.

4. Place a piece of plastic wrap over the top of one of the bottle and tape it shut. Leave the other bottle uncovered.

5. Begin measuring and recording the temperature in each bottle every minute for 15 minutes.
    - Record the measurements in the **Data Table.**

6. At the end of the investigation, complete the activities in the **Collecting and Analyzing Data** section and the **Drawing Conclusions** section.

DATA TABLE:		
TIME (minutes)	BOX TEMPERATURES	
	COVERED (* C)	UNCOVERED (* C)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Collecting and Analyzing Data:

1. Set up a graph on the sheet provided illustrating the measurements you entered in the **Data Table.**
   - Label the Y-axis: **Temperature (* C)**
   - Label the X-axis: **Time (minutes)**

2. Plot the data from the **Data Table** onto the graph.
   - Use a different colored pencil for each line.

3. From your graph, which bottle heated up more rapidly?

   _____

Drawing Conclusions:

1. Why did one bottle heat up more rapidly than the other?

   _____
   _____
   _____
   _____

2. If glass, aluminum foil or waxed paper were used instead of plastic wrap, what would be the results? Why?

   _____
   _____
   _____

3. Which bottle is more like a model of the Earth's atmosphere? Why?

   _____
   _____
   _____

4. In what way is the Earth's greenhouse effect different from the bottle?

   _____
   _____
   _____
   _____

Modeling the Greenhouse Effect