Lesson 8-Global Warming

# You're Getting Warmer!

## Background Information

The greenhouse effect is a term scientists use to describe the trapping of heat on the surface of the Earth by the atmosphere, a normal atmospheric occurrence. As a result of this, the Earth's surface is about 53 degrees Fahrenheit warmer than it would be without this trapping. The effect is magnified by certain greenhouse gases in the atmosphere, most notably carbon dioxide, methane, nitrogen oxides, and chlorofluorocarbons (CFCs). Methane is a product of natural decay from living (once-living) things. Nitrogen oxides are generally a result of man-made burning and automobile and similar internal-combustion engines. CFCs are a class of chemicals used often in air conditioners, refrigerators, and as the pressurizing gas in aerosol spray cans. While all of these pollutants contribute to air pollution, carbon dioxide is the major greenhouse gas.

Scientists believe that concentrations of greenhouse gases in the atmosphere will double over the next hundred years producing average temperature rises of about 8-10 degrees Fahrenheit. While most scientists believe that the greenhouse effect will gradually warm up the Earth's climate, there are some who believe that the increased cloud cover will eventually reflect more sunlight away from the Earth and lower the average temperature. This increased reflectivity is called the Earth's albedo.

Normally, changes in temperature occur over thousands of years. Plants and animals can adapt to this gradual change. When changes occur rapidly as those caused by the greenhouse effect, the results could be disastrous. This warming can cause the level of the seas to raise as the ice on mountains and at the poles melts. This could result in flooding along coastal areas. Current weather patterns could also change due to global warming. Changes in precipitation could affect the Earth's water

supply. It is possible that dry and wet areas of the Earth would shift. This would force plant life and animals to find new places to inhabit. If natural barriers prevent their movement to these habitats, they may become extinct. Humans would have to adjust their agriculture to these environmental changes quickly. Otherwise, it could bring about famine.

The most significant way we can fight global warming is to consume less energy. People are becoming more aware of what's happening to our planet. They are finding ways to conserve energy. People are using less fossil fuels in industry and in homes. There are programs to set up car pools to work. Alternative, nonpolluting sources of power are being explored. In warmer weather, people are trying to use their air conditioners less. Globally, attempts are being made to stop the destruction of tropical rain forests. Nationally, organizations are initiating large scale plantings of trees. By doing this, they hope to reduce carbon dioxide in our atmosphere.

## Objectives

After completing the lesson, the students will be able to:

1. Understand that the atmosphere traps heat and makes the surface of the Earth warm enough for life.
2. Recognize that air pollution can cause a rise in temperature and ecological decline.
3. Name human activities that can cause air pollution.
4. Name the sources of carbon dioxide in the atmosphere.
5. Conduct sampling and testing procedures like those used in scientific studies of the atmosphere.
6. Distinguish between "natural" and "industrial" sources of carbon dioxide in the atmosphere.
7. State the relative contributions of the industrialized and developing nations to the global warming problem.

## Materials

1. One box of baking soda.
2. 1 gallon of diluted Bromothymol Blue Solution (BTB).
3. One air pump, either bicycle pump or balloon inflator.
4. One 32 oz. bottle of white vinegar.
5. One graduated cylinder or measuring cup.
6. One short candle (about 2" tall).
7. One open clear glass or plastic container with sides taller than the candle.
8. One empty 1 liter plastic soda bottle (or glass wine bottles for better seal) for each group of 4 students.
9. One dropper or squirt bottle, about 6 oz., per group.
10. One teaspoon per group.
11. Three 8 oz. plastic cups per group.
12. Four small clear plastic cups (graduated medicine cups or 3-1/2" oz. clear Solo cups) per group.
13. Three balloons, 8-10" in diameter, in three different colors per group.
14. Seven plastic straws per group.
15. 14 twist ties per group.
16. One roll of masking tape per group.
17. One tray per group.
18. One "You're Getting Warmer Data Sheet" per student.
19. One manila folder.
20. One funnel.

## Preparation

1. Obtain bromothymol blue (BTB) solution from a high school science teacher or a chemical supply house. Buy BTB in the concentrated liquid form. Make a gallon solution of BTB and water. Fill a gallon bottle 9/10ths full with tap water and add BTB concentrate until the solution is a deep, transparent blue. The exact concentration is not critical. However, you should test the solution by pouring 15 ml. (1/2 oz.) BTB solution into

one of the small clear cups. Using a straw, bubble one lungful of breath through the small cup of solution. If the solution turns green, it is OK. If it stays blue or only slightly bluish green, it is too concentrated. Pour out some solution, add more water, and try again. If it turns yellow, it's too diluted and you need to add more BTB.

2. Using the graduated cylinder or measuring cup, make two measuring cups for each group. Measure out 15 ml. (half an ounce) BTB in the measuring cup. Pour it into a small cup and then, with the tape and pen, note the depth on the side of the small cup. Repeat this procedure with a large cup for 100 ml. (3-1/2 oz.) of vinegar.

3. Prepare a half cup of baking soda and two-thirds of a cup of vinegar for each group of four students.

4. For easy distribution, gather the equipment on a tray for each group of students. Plan to use one set of the equipment for demonstration purposes.

5. Use a car with a round exhaust pipe (square tail-pipes are difficult to seal). Prepare a cone for collecting car exhaust by rolling up a manila folder the long way. One end must be larger than the opening of the car's tail-pipe and the other end must be small enough for a balloon to fit over it. Use plenty of tape to hold the cone in shape and to make the sides of the cone airtight. Trim the ends of the cone with scissors if necessary. Make a spare cone and have tape, folders, and scissors on hand when you collect the gas. Practice filling the balloon with car exhaust before class. Approach the exhaust pipe from the side and hold your breath when filling the balloons so you do not inhale the gases.

## Procedure

### Part 1:

1. Ask the students what they already know about the greenhouse effect. Tell the students that ever since the Earth has had an atmosphere, the greenhouse effect has warmed the Earth. However, over the past 100 years, the concentration of carbon dioxide has increased dramatically and the average global temperature has increased by one degree Fahrenheit. Many researchers suspect the increase in carbon dioxide has caused the increase in temperature. Although this is still a matter of scientific debate, the majority of researchers believe that if we do not change the rate at which we burn fossil fuels, the Earth will become warmer by 2-7 degrees Fahrenheit by the end of the next century.

2. Ask the students to tell you what they already know about carbon dioxide gas- what it looks like, where it is produced, and what properties it has.

3. Explain that to detect carbon dioxide the first thing you need is a good supply of the gas. Ask if anyone knows an easy way to make carbon dioxide. (Breathing is an easy way but it doesn't produce pure carbon dioxide.)

4. Reveal that an easy way of making pure carbon dioxide is in a chemical reaction between two common substances: vinegar and baking soda. Ask the students to watch the demonstration.

5. Place the empty soda bottle (or wine bottle) in front of you. Measure 100 ml of vinegar and pour the vinegar into the bottle. Light the candle in the container. Put four heaping teaspoons of baking soda in the bottle using the funnel. Have the students observe what is happening. Ask a volunteer to put his or her finger over the opening of the bottle for a few seconds and report what it feels like. Ask the students to watch what happens as you hold the opening of the bottle directly above the candle

flame and “pour” the gas (not the liquid) onto the flame. (The carbon dioxide will fill up the container blocking the oxygen from getting to the candle and so the flame will go out.)

Part 2:

1. Tell the students that the purpose of the laboratory activity they are about to conduct is to find out how to detect the presence of carbon dioxide. In order to do that, they must first fill the balloon with carbon dioxide gas.

2. Have the students add 100 ml. vinegar to a bottle and then 4 heaping teaspoons of baking soda. The carbon dioxide will drive out all of the air in the bottle in less than a second. The students need to quickly stretch the neck of the balloon over the opening to catch the escaping gas. The balloon should inflate to about four inches in diameter.

3. The students need to tightly tie the neck of the balloon with a twist tie. (Twist the balloon neck immediately after collecting the gas so no gas escapes before you get a chance to tie it off.) Warn students not to puncture the balloon with the sharp end of the twist tie.

4. Demonstrate how to use the air pump to fill a second balloon (of a different color) to approximately the same size as the balloon with carbon dioxide with a sample of air from the room and close it with a twist tie.

5. Pass the air pump around to each group. Allow the students to collect their gas samples.

6. Prepare the next demonstration by measuring and pouring 15 ml. of the blue liquid BTB into a small clear plastic cup. Fill two more cups to the same level.

7. When the students have finished, demonstrate how to test the presence of carbon dioxide with the assistance of a student volunteer.

8. Insert the straw into the neck of the balloon with carbon dioxide and seal it with a second twist tie.

9. Slowly loosen the top twist tie releasing gas until the balloon will just pass through the hole in a roll of masking tape.

10. Clamp off the flow of gas with your fingers and place the bottom end of the straw into the BTB.

11. Loosening your grip, slowly bubble the gas through the BTB. Squeeze the balloon to release all of the gas.

12. Observe the color of the liquid. When the students conduct the experiment, they are to make careful observations and record their observations on a data sheet.

13. Safety Reminder: Point out that while none of these chemicals is dangerous, it is good to practice safe scientific methods. In this experiment, leave all BTB samples on the trays in case they spill. Don't splash any chemicals around. If available, wear safety goggles.

14. Have the groups conduct the test with their own balloons and BTB.

15. When all of the groups have finished, ask, "How does BTB react in the presence of almost pure carbon dioxide?" (It turns yellow.) Tell the students that BTB stands for "bromothymol blue solution," which can be used to test for presence of carbon dioxide gas. It changes color from blue to blue-green (a little carbon dioxide) to green (some carbon dioxide) to greenish-yellow (a lot of carbon dioxide). Draw this color scale on the board. This drawing will help the students realize that green is

an intermediary color between blue and yellow and that there are other shades of color between blue and bright yellow.

16. Have the students record their results on their data sheets and then write a sentence or two to describe their results.

17. Ask the students to compare how the two samples of gas affected the BTB. Did the room air affect the BTB at all? If so, how many groups observed a color change? (The results of the experiment depend on the exact concentration of BTB and on the ventilation in the room. In most cases, the room air changes the color of BTB very little if at all.)

18. Ask the students what this means in terms of the concentration of carbon dioxide in air. (The amount of carbon dioxide is near the limit of the sensitivity of the BTB test. In fact, carbon dioxide makes up only 0.0369% of the atmosphere.)

Part 3:

1. Remind the class of the links between carbon dioxide levels in the atmosphere and the global temperature which they learned about in previous sessions. Ask if they can name some sources of carbon dioxide in the atmosphere. List these on the board. Explain to the class that among the sources of carbon dioxide in the atmosphere, are car exhaust and the breath of humans and animals. The students will compare the concentration of carbon dioxide from a car's exhaust with the other samples.

2. Tell the students that the class will be going out to a car to collect examples of exhaust which they will analyze using the BTB method.

3. Organize the class into groups and issue each group one twist-tie and one balloon. (Bring several extra balloons and twist-ties in case you have some breakage. You will also bring the funnel, as well as an extra funnel, folder, scissors, and tape).

4. Have the students stay in groups and follow you to the car. One group at a time will hand you their balloon for filling. As soon as you fill their balloons, they are to work together to tightly tie off the neck of the balloon with the twist-tie. One student should hold the balloon closed while the other student twists the neck of the balloon to prevent gas from escaping and puts on the twist-tie. Collect one sample per group and two extra samples. Return to the classroom.

5. When the students are settled in their groups, tell them that they will be testing two additional gas samples (car exhaust and human breath) and comparing them to the other test samples (air from this room and carbon dioxide from vinegar and baking soda).

6. Have the students collect the human breath sample by blowing up a balloon. The groups need to adjust the sample sizes so that each balloon passes through the hole of a roll of masking tape.

7. The students test the car exhaust and human breath samples using the previous testing procedures. The students need to record the results on a data sheet.

8. When all the groups have finished, ask the students which gas sample had the highest carbon dioxide content? Using the color scale on the board, record the results. Fill in the names of the other samples the same way. When there are conflicting results, list each gas sample and write the number of groups that had each result.

9. After observing all the group data, the students should be able to state which equal volume sample of gas had the most carbon dioxide. (Most groups should find that the order from least to most carbon dioxide is: air, human breath, car exhaust, and almost pure carbon dioxide from the baking soda and vinegar reaction.)

10. Ask the class if the results confirmed their expectations or if they were surprised at the outcome.

11. Ask the students what additional information they would need to determine the relative amounts of carbon dioxide contributed to the atmosphere by humans breathing and humans driving cars. (They would need to know the number of humans versus the number of cars, how much time the cars are driven on average, the volume per minute of the gas exhaled by humans, and the volume per minute of the gas “exhausted” by cars.)

12. Ask the class to suggest which of the sources of carbon dioxide (either car exhaust or human breath) could be reduced? How might this be done?

13. Remind the students that some carbon dioxide is needed in the atmosphere or the Earth would freeze. The problem is one of balance. Many researchers think that too much carbon dioxide is being added to the atmosphere from burning fossil fuels such as gasoline, natural gas, coal, and oil. These fuels are formed by the decay of plants and animals that lived long ago. Each year people burn fossil fuels that require about one million years to form. There is no quick way to recapture the carbon dioxide from the atmosphere and to replace those fuels. Scientists who have measured the amount of carbon dioxide from different sources found that carbon dioxide released in the United States comes from the following sources:

Cars and other transportation.....8%
Homes and businesses.....15%
Industry.....28%
Electrical power plants.....49%
(Note: Electrical power plants provide energy to homes and industries.)

## Extensions

1. The students can investigate the following questions using some of the same materials and the same testing procedure from this lesson.

*Do older cars produce a higher concentration of carbon dioxide? in their exhaust than newer cars?

*Do cars with pollution control equipment produce less carbon dioxide than cars that do not have such equipment?

*Do diesel engines produce more or less carbon dioxide than gasoline engines?

2. Have students use a plastic garbage bag to collect a volume of gas exhausted by a car in a certain time period. Have them record the time it takes to fill the bag with that volume, estimate the volume of gas collected, and estimate the amount of time an average car would run each day. From that data, the total estimated amount of exhaust gas that a car generates in a year can be calculated. Students could go on to estimate the volume of human exhaust (breath) exhaled by one person in a year. Ask them to figure out how to estimate this. Finally, students could compare their estimates of the volume of exhaust contributed by a car in one year to that contributed by a person in one year. The reasoning used and conclusions could provide the basis for an excellent discussion of the significance of these estimates when considering possible solutions.

## Sources

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