



Air and Atmosphere

Middle School Grades

Lesson Summary

Students will learn about the greenhouse gas CO₂ and about sources of this gas. They will collect different samples of air and test them for CO₂ content.

Prior Knowledge & Skills

- Data collection skills
- Knowledge of the greenhouse effect
- Following scientific procedure skills

AAAS Science Benchmarks

The Physical Setting

Processes that Shape the Earth

Common Themes

Models

NSES Science Standards

Unifying Concepts and Processes

Systems, Order, and Organisms

Evidence, Models, and Explanation

Change, Constancy, and Measurement

Form and Function

Science as Inquiry

Abilities Necessary to Do Scientific Inquiry

Understandings About Scientific Inquiry

Science in Personal and Social Perspectives

Personal Health

Risks and Benefits

Editor's Note: During step #10, advise students to hold their breath as long as possible before blowing up the balloon.

Teaching Time: 45 – 60 minutes

Materials

Per Group:

- 2 pairs of goggles
- 3 twist ties
- 3 straws
- 4 4oz. paper cups
- 1 empty wine bottle
- 3 different colored balloons
- 1 small piece of paper that can be rolled into a funnel

Per Person:

- 1 copy of datasheet
- Student journals
- Pencils

Per Classroom:

- 2 plastic shoeboxes
- 2 desk lamps
- 1 small bag of topsoil
- 2 thermometers
- Plastic wrap
- 2 large, rubber bands
- 1 box of baking soda
- 1 gallon of vinegar
- 1 red cabbage (or phenolphthalein)
- 1 air pump (for inflating balloons)
- 2L bottle to hold cabbage juice solution

Advanced Planning

Preparation Time: ~30 minutes

1. Gather the necessary supplies.
2. Boil cabbage and save dark purple liquid (phenolphthalein can be used as a substitute for the cabbage juice)
3. Put 4 teaspoon baking soda into plastic bags for each group

Recommended Reading: (attached)

- Background Information

The Chicago Academy of Science and its Peggy Notebaert Nature Museum

<http://www.caosclub.org/totalcaos/members/caosho33.html>



Air and Atmosphere


Lesson Introduction

Global warming is a term often heard these days, but just what is it? In this lesson, students will learn about global warming and the role humans may be playing in increasing the global temperature on the earth. Global warming can be defined as a change or increase in the average global temperature. This increase in temperature is directly related to the concentration of particular gases that can be found in the atmosphere. These gases are sometimes called greenhouse gases.

In this lesson, the students will explore the phenomena of global warming through the process called the greenhouse effect which is the means, or mechanism, by which global warming occurs.

Age Appropriateness:

In order to make Total CAoS! relevant to as many grades (K-8) as possible, activities have been written at a middle grade level. Teachers in very early elementary or middle school classrooms may need to adapt portions of the Total CAoS! lesson to meet the needs of their grade level.

Look for the  symbol for the math connection in this lesson.

This activity meets many of the National Science Standards for Grades 5-8. Click below to find this activity according to the standards it addresses:



[National Science
Content Standards](#)



[Links to State
Learning Standard Pages](#)

Time Allotment

45-60 minute class period

Materials

Per Group:

- 2 pairs of goggles
- 3 twist ties
- 3 straws
- 4 4oz. paper cups
- 1 empty wine bottle
- 3 balloons (make sure they are 3 different colors)
- 1 small piece of paper that can be rolled into a funnel per group

Per Person

- copy of datasheet
- student journals
- pencils

Per Classroom

- 2 plastic shoeboxes
- 2 desk lamps
- 1 small bag of topsoil
- 2 thermometers
- plastic wrap
- 2 large, rubber bands
- 1 box of baking soda
- 1 gallon of vinegar
- 1 red cabbage
- 1 air pump per class (for inflating balloons)
- 2L bottle to hold cabbage juice solution

Advanced Preparation

- Boil the cabbage in water until the water becomes a dark purple. Store the liquid in the refrigerator until ready for use.
- Put 4 heaping teaspoonfuls of baking soda into plastic baggies (one per group).
- Collect enough wine bottles (or similarly shaped glass bottles) to distribute one per group. Label three paper cups per group CO₂, CLASS AIR, and LUNGS.

Lesson Assessment

One method of assessing whether or not students understand material is to have them teach it to another classroom or other group of students or adults. For example, have your students prepare a book, poster, presentation or some other method that would teach a younger classroom about global warming and the greenhouse effect.

Divide the students into groups based on the method they wish to use to share the information. If necessary, assist them in determining the various ways they could teach what they have learned. For example, students who wish to write and perform a song could work together. Students who wish to make a poster display could work with a partner or individually.

When evaluating students, look at how clearly they were able to express their knowledge of the learning outcomes. Did they define both global warming and the greenhouse effect? Were they able to distinguish the difference between the two in an understandable way? Did they identify greenhouse gases? If so, how many?

You might also look at such aspects as the creativity of their presentation, the information they included from the lesson, and how effectively they worked together, if applicable.

Procedure

Tap Prior Knowledge

1. Ask students if they have ever seen a greenhouse. What are greenhouses used for? Why are they used for the purpose of growing plants? Discuss the fact that greenhouses have an "invisible" ceiling which traps the heat inside. Ask the students if they have ever heard of the greenhouse effect. The "invisible ceiling" in our atmosphere is caused by specific gases known as the greenhouse gases (CO₂, O₂, H₂O, SO₂, and CH₄). These gases trap the sun's heat inside our atmosphere causing an increase in the average global temperature.
2. How do you think we could model the greenhouse effect? Show students the materials for building a greenhouse model to guide them to the correct response. Ask them what changes could be made to the model to better show actual conditions here on Earth. Set up two greenhouse models for the students to examine. In one, place nothing but a thermometer in the plastic shoebox. Cover the shoebox with plastic wrap and secure it in place with a rubber band. Aim the light source directly into the plastic shoebox and record the initial temperature on the board and label it Box 1. In the second box, place a thin layer of soil to simulate the earth and set up the rest the same as the first box. Record the initial temperature of Box 2 on the board.

At the end of the lesson, come back to the boxes and record their final temperatures on the board next to their initial temperatures. Explain to the students that the boxes simulated the earth's atmosphere, the plastic wrap simulated the greenhouse gases, and the light simulated the sun. The temperature in the boxes increased in much the same way as global temperatures increase due to

an increased concentration of greenhouse gases in the atmosphere.

Engage Students in a Hands-On Activity

3. Distribute the following materials to each group:

- 1 wine bottle
- 3 balloons of different colors
- 4 4oz. paper cups (fill one most of the way full of vinegar. The other three will be filled half full of cabbage juice later on in the experiment)
- 3 twist ties
- 3 straws
- baggie of baking soda
- copies of data sheet
- paper for funnel


4. Decide on group roles for the experiment such as:

1. wine bottle holder (This person must wear goggles)
2. balloon holder (This person must also wear goggles)
3. twist tie-er
4. bottle filler (This person will fill the bottle with both the vinegar and the baking soda)
5. air pumper
6. balloon inflater (This person could also be the twist tie-er if there are not enough students in the group)

5. Explain to the students that they are about to conduct an experiment that will test for carbon dioxide levels in a sample of air. The students will be testing three different samples of air: pure carbon dioxide gas, air from the classroom, and air from their bodies. First, they will collect the sample of pure carbon dioxide gas.

Note: While the students are working on the next part of the experiment, the instructor should go around and fill the remaining three paper cups for each group with the cabbage juice.

6. Have the "bottle filler" add the vinegar to the wine bottle. Next, have them roll the small piece of paper into a funnel and place it in the neck of the bottle. Carefully add the baking soda from the baggie to the wine bottle.
7. IMMEDIATELY have the balloon holder stretch the neck of the balloon over the wine bottle while the "bottle holder" keeps it firmly in place. (These students should already have their goggles in place at the start of the experiment). Leave the balloon in place for a few seconds so that it can fill up with the escaping carbon dioxide gas. (The balloon should inflate to about 4 inches in diameter).

8. Pinch the neck of the balloon and carefully remove it from the bottle without allowing any of the trapped gas to escape. With one person pinching the neck of the balloon, have another person tie a twist tie around the end of the balloon being careful not to puncture the balloon with the metal in the twist tie. Set this balloon aside and record its color on the data sheet.
9. Instruct the "air pumper" to take a second balloon and pump it full of air using the air pump.  Make sure the diameter of the second balloon matches that of the first. Set this balloon aside and record its color on the data sheet also.
10. Finally, have the "balloon inflator" take the third balloon and blow it up with air from his/her lungs. Set this balloon aside and record its color on the data sheet.

Note: If the students fail to collect their sample of carbon dioxide or it escapes from their balloon, add another small paper cup full of vinegar to their bottles. There should be enough baking soda left over to refill their balloons with carbon dioxide gas several more times.

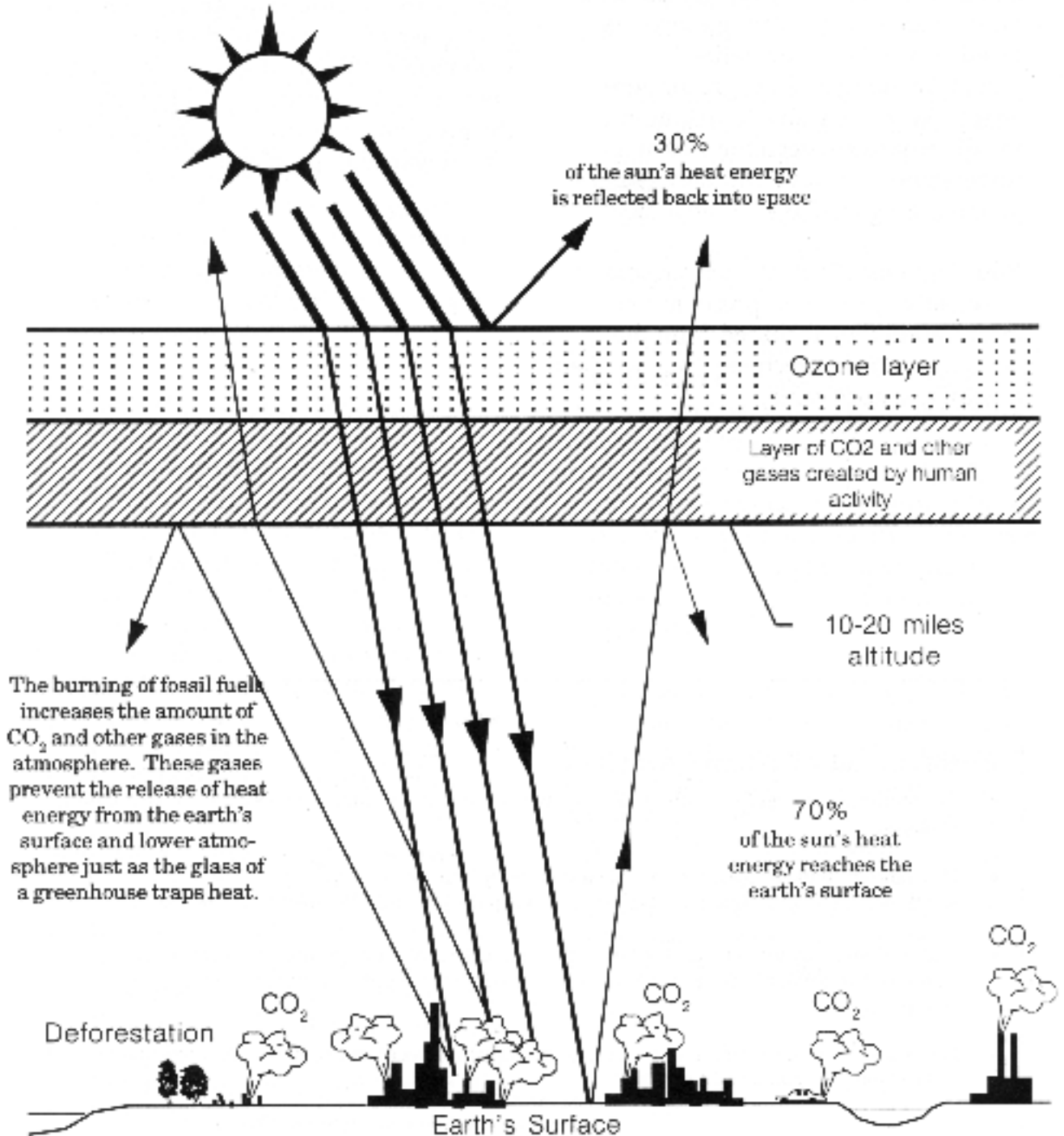
11. After the students have filled all three balloons, explain how they will test each one for the presence of carbon dioxide. It is very important in this next part not to loose any gas from the balloons as this will just complicate the experiment and take up too much time.
12. Have each group carefully place the end of a straw into the lip of their balloon filled with carbon dioxide gas. Pinch the neck of the balloon so that you are holding the straw at the same time. SLOWLY undo the twist tie without letting any gas escape. Next, insert the opposite end of the straw into the cabbage juice and slowly loosen your grip on the lip of the balloon and the straw. As the gas bubbles into the cabbage juice, have the students observe the changes that occur and record them on their data sheets. Continue with the rest of the balloons until all three have been tested.

Introduce Scientific Principle

13. When carbon dioxide combines with water, carbonic acid is produced. The cabbage juice is an acid base indicator which changes from purple to dark red or violet in the presence of an acid. It would turn green in the presence of a base. The degree of change will indicate the concentration of carbon dioxide in each sample.

Students can now measure the difference in carbon dioxide concentrations in the air from the room versus pure carbon dioxide gas to see how an increased level of CO₂ is much more acidic. Not only does CO₂ act as a greenhouse gas trapping the sun's radiation in our atmosphere, it is also a factor in the production of acid rain. Acid rain causes erosion of limestone statues, corrosion of bridges and other structures, and poor plant growth.

Diagram #1: The Greenhouse Effect and Global Warming



14. Make sure that the students leave with a firm grasp of the concept that the greenhouse effect and global warming are not the same thing, but rather, that, the greenhouse effect contributes to the global warming problem!

Relate Activity and Concept

15. For comparison, you may want to test the levels of CO₂ in car exhaust or other sources of pollution. The practices learned in this lesson can then be related to the students' everyday life in

terms of how much CO₂ they consume while riding the bus to and from school.

Language Arts Connection

16. Using what they have learned about CO₂ and the greenhouse effect, have the students design an oral presentation that would inform their school community about the issue and ways they could reduce their own impact on the environment (carpooling, walking to school, etc.). After they have practiced, have the students present their speech to the principle, parents, or other community groups.

Background Information

The air around us is made of different elements and compounds, the most common of which are nitrogen, oxygen, argon, and carbon dioxide. Other elements and compounds found in trace amounts include ozone, water vapor, hydrogen, helium, xenon, neon, and krypton. All of these substances are not only naturally found in the air we breathe, they are, in fact, necessary. These substances only become harmful when they reach toxic levels in the atmosphere. When this occurs, we say the air is polluted.

Global warming can be defined as a change or increase in the average global temperature. This increase in temperature is directly related to the concentration of particular gases that can be found in the atmosphere. These gases are sometimes called greenhouse gases. Many of the greenhouse gases such as Carbon dioxide (CO₂), Methane (CH₄), or Ozone (O₃) are found naturally in the atmosphere. But when the concentrations of these gases are increased in the atmosphere, (mainly due to our burning of fossil fuels such as oil, natural gas, or coal) they create a chemical blanket around the earth, therefore decreasing heat loss and increasing the global temperature.

Some scientists believe that an increase in the levels of CO₂ alone will cause an increase in the average global temperature due to the fact that the atmospheric CO₂ helps to trap UV light from the sun in the atmosphere. This happens because the light from the sun enters the atmosphere as short wave radiation. When it enters the atmosphere, it is converted into long wave radiation and is trapped as it tries to escape by the various greenhouse gases. Other scientists believe that an increase in global temperature produces more frequent forest fires which cause plant death and decay thus releasing more carbon dioxide into the atmosphere. It is still being debated which theory is correct.

Ozone is often mentioned when talking about the greenhouse effect. We hear a lot about the "ozone layer", but what exactly is ozone? Ozone is an often misunderstood gas that is vital to life here on planet Earth. Ozone is actually a form of oxygen. One molecule of ozone is made up of three atoms of oxygen. There are two basic types of ozone, depending on where it is found in the atmosphere:

1. **Stratospheric Ozone:** This is ozone that is in the right place. This type of ozone is concentrated 15-25 miles up in the earth's atmosphere. This very thin layer acts as an invisible shield, letting light and heat from the sun through, but absorbing/filtering out ultraviolet (UV) radiation, which is harmful to life on

the earth's surface. High levels of UV radiation can cause damage to plant tissues and severely affect aquatic life, including plankton, the foundation of most aquatic food chains. Increased exposure to UV radiation also has been linked to increased occurrences of various forms of cancer, especially skin cancer.

2. Ground-Level Ozone: This is ozone that is out-of-place. This type of ozone is trapped very low in the atmosphere, close to the surface of the earth. This "layer" of ozone is not natural, does not absorb/filter out UV radiation, and can cause serious health problems to human life.

CFCs (or chlorofluorocarbons) are stable, nontoxic, human-made chemicals used for a variety of products, such as aerosol sprays, coolants, and plastic foam. CFCs, as the students will soon find out, have had and are continuing to have a tremendous effect on the ozone layer.

The depletion of the ozone layer is having some dramatic effects on Earth systems. There is very strong scientific evidence that the chemicals that humans create are destroying ozone. In some cases, this depletion may be even more severe, such as over Antarctica and the Arctic, where holes in the ozone layer seem to be occurring. Only time and further research will show the true effects human activities are having on this very important atmospheric layer.

Name _____

Date _____

Predict

Which sample of air contains the most carbon dioxide (CO₂)? The least?
Rank from 1= most, to 3= least.

Sample #1 - pure CO₂ _____

Sample #2 - air from the room _____

Sample #3 - air from your body _____

Observe

Draw and describe the color change that occurs in each sample.



Sample #1



Sample #2



Sample #3

Conclusion

Which sample actually contained the most carbon dioxide (CO₂). Why?

