Solar Education for NY
SchoolPower...Naturally

The Greenhouse Effect

SPN LESSON #22

TEACHER INFORMATION

LEARNING OUTCOME

After participating in a greenhouse simulation and plotting carbon dioxide levels representing over 250 years, students are able to cite evidence of the increase of that gas and suggest ways that levels might be decreased.

LESSON OVERVIEW

Students address ways carbon dioxide levels might be decreased. One option investigated is use of alternative energy sources such as photovoltaic systems. The photovoltaic panel monitor provides data regarding the amount of carbon dioxide that would have been put into the atmosphere if fossil fuels had been used to generate the same amount of electricity.

GRADE-LEVEL APPROPRIATENESS: This Level II environmental considerations lesson is intended for students in grades 5-8.

MATERIALS

In addition to copies of the student handout for the lesson, each team of two students will need:

2 thermometers

1 10-mL graduated cylinder

2 sealable sandwich bags

1 glass jar large enough to enclose the bag of ice and thermometer

a light source (the Sun or an electric lamp having a 75- to 100-watt bulb)

SAFETY

If an electric lamp is used as a source of light in the ice cube activity, caution students that the bulb and possibly the shade will be hot.

Students should keep water away from the lamp and the electrical outlet.

TEACHING THE LESSON

Ask students why it is dangerous to leave a family pet in a closed car during the summer. They will likely respond that the car will get too hot inside and that the pet will suffer and possibly die. Ask them to explain why the car gets hot sometimes when it is not very hot outside. This would

be a good way to lead them into a discussion of how the glass of a greenhouse plus the gases inside trap heat and prevent it from radiating out. Students will now be ready to relate this discussion to the issue of global warming. These examples will help students understand why global warming is often referred to as "the greenhouse effect."

If you do not have a refrigerator in your classroom, a cooler of ice cubes will be adequate for keeping enough ice on hand for students to use each day. Try to give teams of students ice cubes of approximately the same size. Also be sure that students are clear about what they are doing before giving them the ice. That way there will be less melting prior to starting the investigation. As usual, you will want to try the activity yourself prior to doing it with students. Different light sources and setups give slightly different results. To avoid instances of very little or too much melting, check the protocol with your equipment and make adjustments as needed.

Inexpensive thermometers mounted in metal work well and are safer to use than long, glass thermometers. Another option is the plastic strip thermometers typically used in aquaria or to take a person's temperature. If you can find some having the appropriate scale, they are inexpensive and do not break.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

Part A - Analysis

1. On the basis of your measurements, what do you conclude?

   The temperature reading and amount of melting inside the jar were greater because of the heat energy trapped by the glass.

Part B - Analysis

1. As you look at the data table and your graph, it is easy to see the trend that indicates carbon dioxide levels are increasing.

   (a) During which 50-year period is the increase the greatest?

   The last 50 years: 1953 to present.

   (b) If no changes are made in our output of carbon dioxide, what will the level most likely be in 2050?

   The level will be approximately 700 ppm.

2. Atmospheric carbon dioxide levels can be reduced in a number of different ways.

   (a) One is to use alternative energy sources to generate electricity. Check the photovoltaic monitor and determine how much carbon dioxide was saved over the past week as a result of using electricity from the panel on your school roof.

   Answers will vary.

(b) Another suggestion is to stop deforestation and cultivate more trees and other green plants. Explain how allowing more plants to live and grow can reduce atmospheric carbon dioxide levels.

Plants remove carbon dioxide from the atmosphere during the process of photosynthesis. Additional green plants would mean more carbon dioxide being removed and temporarily taken out of circulation. Plants such as trees that store carbon on a long-term basis work best.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

- The source for data on atmospheric carbon dioxide levels is the Indiana Department of Education, Energy, Environment, and Economics.
- *Science I: Essential Interactions*, Centre Pointe Learning, Inc., of Cincinnati, Ohio, is the source that provided the idea for the ice cube activity.

BACKGROUND INFORMATION

Photosynthesis and respiration/combustion are the two main processes that cycle carbon through an ecosystem. Carbon bonds carry and store the energy needed by living things. Energy is lost in the form of heat at every transfer in a food chain. Accordingly, light energy must be captured and stored, on a continuing basis, through the process of photosynthesis. This replenishment of energy helps to maintain the living systems in green plants.

During photosynthesis, light energy absorbed by chlorophyll is used to split water molecules. The oxygen is released out of the cells to the atmosphere. Then carbon and oxygen, from the carbon dioxide that has entered the plant, react with hydrogen from the split water molecules. From these small carbon-hydrogen-oxygen units, larger organic molecules such as glucose are synthesized.

Respiration and combustion are processes that release energy from carbon bonds. Large organic molecules such as starches and cellulose can be broken down by combustion. This process releases the carbon by combining it with oxygen, forming carbon dioxide. Burning wood and fossil fuels are good examples of how we use the process when the benefit we want is available energy. Typically we want the heat energy released from the carbon bonds.

The carbon dioxide in our atmosphere serves a second purpose. In addition to being a raw material necessary for the production of organic compounds, carbon dioxide reflects escaping radiant heat energy back to Earth. However, as levels of carbon dioxide in the atmosphere increase, more heat is retained and temperatures rise. According to researchers, the increasing levels of carbon dioxide in Earth's atmosphere have contributed to changing weather patterns, ice ages, and fluctuations in sea level. If the increase in carbon dioxide levels now taking place continues, dire consequences for Earth are predicted.

REFERENCES FOR BACKGROUND INFORMATION

http://exploratorium.edu/climate/global-effects/index.html

http://exploratorium.edu/climate/biosphere/data2.html

Ask Dr. Global Change. "Dr. Global Change" is a reference service that assists researchers, students, educators, resource managers, decision makers, and the general public in finding information and data relevant to global environmental change. Answers are prepared by GCRIO staff along with staff from U.S. government agencies. Dr. Global Change can be reached at: http://gcrio.custhelp.com/cgi-bin/gcrio.cfg/php/enduser/home.php

Miller, Kenneth and Joseph Levine. *Biology.* Pearson Education, Inc., Upper Saddle River, NJ, 2003.

Smith, Leo. *Ecology and Field Biology*. 4th edition. HarperCollins Publisher, New York, 1990.

Wright, Richard T. and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future*. Pearson Education, Inc., Upper Saddle River, NJ, 2002.

EXTENDED ACTIVITIES

1. Discuss with students the impact of increasing temperatures on Earth. Have students research some specific topics such as "the effect of global warming on the … [polar regions, aquatic life, agriculture, rain forests, animal migration, weather patterns]."
2. Relate Earth to Venus in relationship to Venus's runaway global warming.
3. Have students design an investigation using the same basic setup as this investigation—sealable sandwich bags, ice cubes, inverted jar, and thermometers. Ask them to create a design that would determine if an increased amount of carbon dioxide in the jar would increase the temperature and therefore the amount of melting. A good design might have two jars, both with bags of ice. The difference between the two setups would be that one also contained carbon dioxide. This could be done in a number of ways. Students could use an antacid tablet, or vinegar and baking soda, to generate the carbon dioxide. They could also exhale into the jar. Students would determine and measure the "responding" variable.

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA

Standard 1—Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Math Key Idea 1: Abstraction and symbolic representation are used to communicate mathematically.

M1.1: Extend mathematical notation and symbolism to include variables and algebraic expressions in order to describe and compare quantities and express mathematical relationships.

M1.1a: Identify independent and dependent variables.

M1.1b: Identify relationships among variables including: direct, indirect, cyclic, constant; identify non-related material.

Science Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

S1.1: Formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.

S1.1a: Formulate questions about natural phenomena.

S1.1b: Identify appropriate references to investigate a question.

S1.1c: Refine and clarify questions so that they are subject to scientific investigation.

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

S2.1: Use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.

S2.1a: Demonstrate appropriate safety techniques.

S2.1b: Conduct an experiment designed by others.

S2.1c: Design and conduct an experiment to test a hypothesis.

S2.1d: Use appropriate tools and conventional techniques to solve problems about the natural world, including: measuring, observing, describing, classifying, sequencing.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

S3.1: Design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.

S3.1a: Organize results, using appropriate graphs, diagrams, data tables, and other models to show relationships.

S3.1b: Generate and use scales, create legends, and appropriately label axes.

S3.2: Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.

S3.2a: Accurately describe the procedures used and the data gathered.

S3.2b: Identify sources of error and the limitations of data collected.

Process Skills Based on Standard 4

General Skills

1. Follow safety procedures in the classroom and laboratory.
2. Safely and accurately use the following measurement tools: metric ruler, balance, stopwatch, graduated cylinder, thermometer, spring scale, voltmeter.
3. Use appropriate units for measured or calculated values.
4. Recognize and analyze patterns and trends.

Standard 4

Living Environment

Key Idea 6: Plants and animals depend on each other and their physical environment.

6.1: Describe the flow of energy and matter through food chains and food webs.

6.1c: Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of

substances cycled between the living and nonliving environment.

6.2: Provide evidence that green plants make food and explain the significance of this process to other organisms.

6.2a: Photosynthesis is carried on by green plants and other organisms containing chlorophyll. In this process, the Sun's energy is converted into and stored as chemical energy in the form of a sugar. The quantity of sugar molecules increases in green plants during photosynthesis in the presence of sunlight.

6.2b: The major source of atmospheric oxygen is photosynthesis. Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

7.1: Describe how living things, including humans, depend upon the living and nonliving environment for their survival.

7.1c: In all environments, organisms interact with one another in many ways. Relationships among organisms may be competitive, harmful, or beneficial. Some species have adapted to be dependent upon each other with the result that neither could survive without the other.

7.2: Describe the effects of environmental changes on humans and other populations.

7.2a: In ecosystems, balance is the result of interactions between community members and their environment.

7.2d: Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources.

Physical Setting

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.1: Explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.

2.1a: Nearly all the atmosphere is confined to a thin shell surrounding Earth. The atmosphere is a mixture of gases, including nitrogen and oxygen with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere.

2.2: Describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.

2.2r: Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane, and water vapor. These substances can affect weather, climate, and living things.

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www.nyserda.org

Should you have questions about this activity or suggestions for improvement, please contact Bill Peruzzi at billperuz@aol.com

(STUDENT HANDOUT SECTION FOLLOWS)

Name _____

Date _____

The Greenhouse Effect

Introduction

The atmosphere in the past has interacted with Earth's bodies of water and solid surface in ways that have kept the temperature within a range suitable for life. Think of Earth's atmosphere as a very large blanket. Without this blanket of gases, it is likely that Earth's average temperature would fall from 15 ^{O}C to –18 ^{O}C. This is not warm enough for life as we know it to exist.

Carbon dioxide, methane, water vapor, and a few other atmospheric gases trap heat energy in much the same way that the glass used in greenhouses does. The properties of glass allow radiant energy in the form of light from the Sun to enter the greenhouse, but do not let out the radiant energy given off by warm objects.

When radiant (light) energy from the Sun enters Earth's atmosphere, the oceans, lakes, rivers, soil, plants, and other objects absorb much of it and are warmed by it. They then emit radiant energy in a different form. The emitted energy, which cannot pass through the atmosphere, helps to maintain Earth's temperature range.

The greenhouse gases are currently receiving a lot of attention. Many scientists are concerned because the amount of carbon dioxide in Earth's atmosphere is increasing. Factories, cars, homes, and power plants churn out carbon dioxide as we burn fossil fuels and wood. More carbon dioxide in the atmosphere means that Earth's average temperature will increase. These increased levels will likely result in major alterations to the world's climate.

Materials per Group

2 thermometers

1 10-mL graduated cylinder

2 sealable sandwich bags

1 glass jar large enough to enclose the bag of ice and thermometer

1 light source (the Sun or an electric lamp having a 75- to 100-watt bulb)

Develop your understanding

Part A

1) Record the temperature shown on the two thermometers.

   Thermometer #1 _____ ^{O}C Thermometer #2 _____ ^{O}C

2) Place an identical ice cube in each of the two plastic bags.

3) Place one of the bags and thermometer #1 inside the glass jar. Note: The jar should be upside down so that the bag is resting on the tabletop—not against the glass of the jar.

4) Position both the bag in the jar and the bag with thermometer #2 in a sunny place or under a strong light. The thermometers should be the same distance from the bag of ice and the light source in both setups.

5) Wait for 15 minutes. While waiting, go on to Part B.

6) Record the temperature in both setups.

   Thermometer #1 (with bag ***inside*** jar): _____ ^{O}C

   Thermometer #2 (with bag ***outside*** jar): _____ ^{O}C

7) Use the graduated cylinder to determine the amount of melting that occurred in each bag.

   Volume of meltwater in the bag ***inside*** jar: _____ mL

   Volume of meltwater in the bag ***outside*** jar: _____ mL

Analysis

1. On the basis of your measurements, what do you conclude?

Part B

Develop your understanding

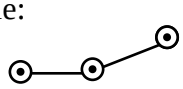
More than 100 years ago, Earth's atmosphere contained approximately 280 parts per million (ppm) of carbon dioxide. By 1990 the level of carbon dioxide was 350 ppm. The data table below, Atmospheric Concentrations of Carbon Dioxide, shows how levels have changed from 1750 to 1993.

Table: Atmospheric Concentrations of Carbon Dioxide

Year	**CO_2 Concentration (parts per million – ppm)**
1750	282
1800	283
1850	290
1900	297
1950	312
1980	335
1990	350
1993	355

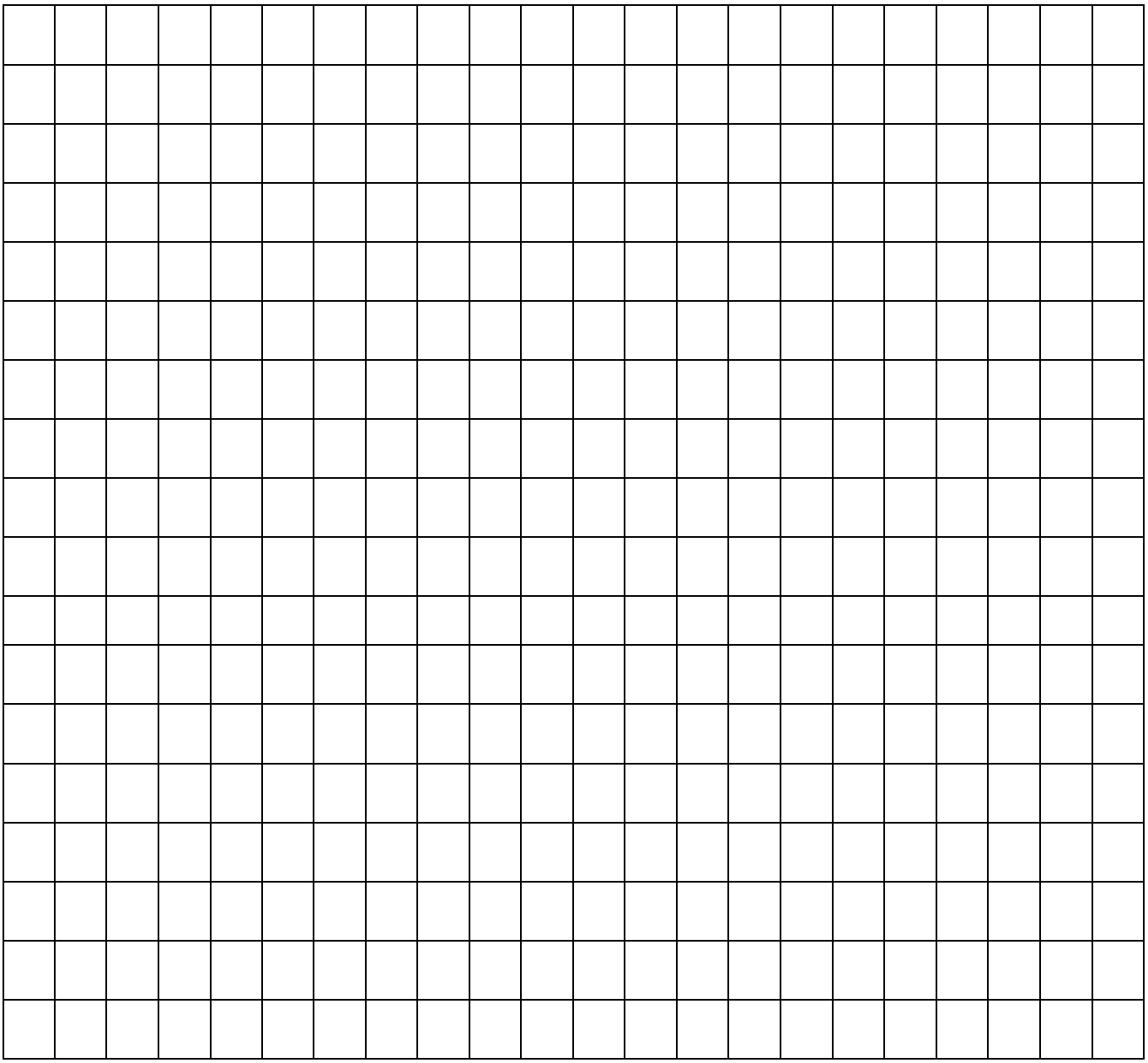
Using the information in the data table, and following the directions below, construct a line graph on the grid provided:

- Label the horizontal axis "Year."
- Label the vertical axis "Carbon Dioxide Concentration in ppm."
- Mark an appropriate scale on each axis.
- Plot the data on the grid. Surround each point with a small circle and connect the points. Example:



- Provide an appropriate title for the graph that follows.

Graph Title: _____



Analysis

1. As you look at the data table and your graph, it is easy to see the trend that indicates carbon dioxide levels are increasing.

   (a) During which 50-year period is the increase the greatest?

   (b) If no changes are made in our output of carbon dioxide, what will the level most likely be in 2050?

2. Atmospheric carbon dioxide levels can be reduced in a number of different ways.

   (a) One is to use alternative energy sources to generate electricity. Check the photovoltaic monitor and determine how much carbon dioxide was saved over the past week as a result of using the electricity from the panel on your school roof.

   (b) Another suggestion is to stop deforestation and cultivate more trees and other green plants. Explain how allowing more plants to live and grow can reduce atmospheric carbon dioxide levels.