



# The Greenhouse Experiment

Grades 3-5

## Lesson Summary

Students will create imaginary towns and analyze their greenhouse gas emissions. Then they will participate in a greenhouse experimental demonstration and finally demonstrate their knowledge of the greenhouse effect using a puzzle (Appendix A Diagram).

## Prior Knowledge & Skills

- Introductory knowledge of the greenhouse effect
- Data gathering skills
- Ability to follow experimental procedure

## AAAS Science Benchmarks

### **The Nature of Science**

*Scientific Inquiry*

### **The Physical Setting**

*Energy Transformations*

### **The Mathematical World**

*Numbers*

### **Habits of Mind**

*Communication Skills*

## NSES Science Standards

### **Science as Inquiry**

*Abilities Necessary to Do Scientific Inquiry*

### **Physical Science**

*Transfer of Energy*

### **Life Science**

*Regulation and Behavior*

### **Science and Technology**

*Understandings About Science and Technology*

### **Science in Personal and Social Perspectives**

*Risks and Benefits*

## NCGE Geography Standards

### **Environment and Society**

*Standard 14*

**Teaching Time:** Three 45 – 60 minute periods

## Materials

- 8 sets of crayons or markers (1 per group)
- Tape for displaying created towns
- Scissors
- Butcher paper or end roll of newspaper
- 10 two-liter clear plastic bottles
- 20 thermometers
- 5 rolls of masking tape (2 groups can share one roll)
- 10 rubber bands (one per group)
- 2 boxes of clear plastic wrap
- Index cards or other small piece of card stock
- Soil
- 10 Dixie cups
- 10 copies of Student Data Table
- 30 copies of Too Cool for School – Student Sheet
- 1 copy of Too Cool for School – Teacher Sheet
- White paper
- Glue
- Rulers
- Appendix A Diagram

## Advanced Planning

**Preparation Time:** ~10 minutes

1. Review the instructions
2. Gather the necessary supplies.

## Recommended Reading: (attached)

- Greenhouse Gas Explanation Sheet
- Student Background Sheets

The National Energy Technology Laboratory

The Keystone Center – Climate Status Investigations: Too Cool for School

[http://www.keystonecurriculum.org/html/too\\_cool\\_for\\_school.html](http://www.keystonecurriculum.org/html/too_cool_for_school.html)



[Curriculum Grid](#)-navigate by day or discipline

You are in the Science discipline

- [Special Delivery-Opinion](#)
- [Too Cool for School](#)
- [Parts Per Million](#)
- [Acting Out Energy](#)
- [Totally Cubular](#)

### DAY 1

**Goal:** To understand the definition, types and origins of the major greenhouse gases.



**Objective:** Students will...

- Create a town with all the elements to sustain human life.
- Discuss how the activities of the people in the town may create greenhouse gases.
- Make a connection between small unrelated activities and their cumulative affects on emissions of greenhouse gases.

Links on this page: GHG Explanation Sheet | [Data Table](#) | [Teacher Sheet](#)  
[Extension Activity](#) | [Student Sheet](#) | [Extension Activity-Student Sheet](#) |

Too  for School-

### The Greenhouse Experiment

#### Materials (For a class of 32):

- 8 sets of crayons or markers (1 per group)
- Tape for displaying created towns
- Scissors
- Butcher paper or end roll of newspaper

**Time Required:** 45-60 minute period

**Standards Met:** S2, S3, S4, S7, G4, G5, LA4, LA5, LA12

#### Procedure:

- Draw 8 very simple ecosystems with a mountainous area, small stream and larger river on roll of butcher paper. (about 4 feet per group)
- Arrange these sections around the room on separate tables with markers at each station.
- Instruct the students that they are owners of this land. They have unlimited supplies and resources to create their ultimate town. The only requirements are that the town must have a way of providing food and shelter and energy for its people.
- Tell students to think of all the things they like to have in their life and make sure that it will be

provided for them within their town.

- Explain to the students that they have 20 minutes to create their ultimate town.
- Tape the towns to the walls around the classroom so that the whole group can see. Have each group explain their town.
- Hand out the Too Cool for School GHG Explanation Sheet.
- Read over the gas definitions.
- Ask students to now go back to their town and identify where and what type of GHGs their town may be emitting.
- Have each town present their findings.
- Lead a discussion about which of the GHGs are anthropogenic (caused by humans) and which are natural.

## DAY 2

**Goal:** Using their knowledge of GHGs and their potential sources, students use a model to collect temperatures and investigate the greenhouse effect.

**Objective:** Students will...

- Increase understanding of the GHGs and how they impact the greenhouse effect
- Be able to explain the usefulness of models in understanding the phenomena

### Materials

(For a class of 30):

- 10 2-liter plastic bottles -- cut the tops of the bottles off at the point where the neck begins to narrow.
- 20 thermometers (2 per student group)
- 5 rolls of masking tape (2 groups can share one roll)
- 10 rubber bands (one per student group)
- 2 boxes of clear plastic wrap
- index cards or other small pieces of card stock
- soil
- 10 dixie cups
- 10 copies of Student Data Table
- 30 copies of Too Cool for School – Student Sheet
- 1 copy of Too Cool for School – Teacher Sheet

**Time Required:** Two 45-60 minute periods

**Standards Met:** M1, M4, M6, M14, S1, S2, S3, LA5, LA7, LA12

### Procedure:

PREP

- Set out ten workstations with the materials listed above.
- Read teacher sheet to determine if you would prefer to use sunlight or a light bulb to produce heat for this lab.

### PART ONE

- Begin by discussing different types of models with students.
- Ask students to share their ideas of what a model is. Solicit examples of models they have seen or heard about.
- Explain that scientists use models to help them understand things that are difficult to test in a lab setting.

- Ask students how they think scientists might test what is happening in the atmosphere. Because it is so large, a model can be used to see what is happening on a smaller scale.
- Explain to students that models are not perfect replicas of the real thing, but can be helpful in understanding the ideas involved.

## PART TWO:

- Optional: (You might want students to complete the lab and reach their own conclusions about what the bottles model).
  - Explain that students will be using a model to learn more about the greenhouse effect. They will build a small greenhouse and investigate temperatures.
  - Hand out a student sheet to each student.
  - Using the student sheet, review the concept of a greenhouse with students. How do they stay warm even during cool weather? How are they typically designed? Remind students that greenhouses typically have clear walls and ceilings that allow the sun's energy to enter.
  - Divide students into groups of three and assign each group to a different workstation.
  - Hand out and review the Student Sheet-Greenhouse Experiment.
  - Review student directions on an overhead.
  - Using the materials at their station, students should create a greenhouse and complete the lab.
  - When students have completed the Questions for Thought, review the experiment and data with the entire class.
  - Explain that this is an example of a model used to look at the large scale idea of the earth as a greenhouse.
- \*You can add a third variable to this experiment by having students complete one station with wet soil to see if it changes the results!

## Home/Community Connection:

- Challenge students to discover how the temperature varies in a car exposed to the sunlight with its windows left open, compared to a car with its windows closed? Ask students to design and conduct an experiment to find the answer to this question. Encourage them to make a list of the variables they controlled in their experiment. They should summarize what they did and what they discovered.
- Ask students who they could contact to discover the average temperature for a particular month over the past 20 years? Once they get this data, ask them to prepare a bar graph displaying the results.
- Encourage students to watch the evening news or read the local newspaper to find out how temperature and cloud cover is related.
- Arrange a fieldtrip to a local greenhouse.

## Extensions:

- You might want to continue the study of the greenhouse effect with The Greenhouse Experiment-Extension Activity.
- 70.8% of the Earth's surface is covered with water. Ask students if they would expect their greenhouse model to give similar results if water were used in the model rather than soil? Encourage students to test their hypotheses.
- Why do greenhouses sometimes whitewash their windows? During what seasons does the whitewashing occur?

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## Green House Gas (GHG) explanation sheet

To many people, the term "greenhouse effect" conjures up dire images of Earth's future. Yet without it, Earth would be a frigid planet, with average temperature around zero degrees Fahrenheit instead of the 60 degrees it is today.

The natural greenhouse effect keeps our planet warm. As the sun's energy reaches Earth's surface, some of it is reflected back and some absorbed. The absorbed energy warms the earth, which in turn radiates heat back towards space as infrared energy. Water vapor, carbon dioxide and other gasses in the atmosphere absorb some of the outgoing infrared energy, which heats them. These molecules then radiate the energy in all directions, including back to Earth. In effect, some of the energy remains trapped in our atmosphere, warming the planet.

GHGs that are created or emitted by human actions are called anthropogenic.

**Carbon dioxide** is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned. Carbon Dioxide accounts for 9% – 36 % of greenhouse gases.

**Methane** is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock. Methane is also given off from agriculture such as growing rice.

**Nitrous oxide** is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

**Chlorofluorocarbons (CFC)** are emitted from refrigeration systems, aerosol cans and some manufacturing processes.

**Water Vapor** is naturally occurring and accounts for 36%-70% of the greenhouse effect. Water vapor is vital to the greenhouse effect which sustains life on earth but, if the atmosphere warms with added carbon dioxide, this can increase the natural amount of water vapor in the air because more water vapor can evaporate into warm air than into cold air.

## Too Cool for School - Student Sheet

### Background:

People have been using greenhouses to help plants flourish for a long time. Light enters the greenhouse through the glass. The objects within the greenhouse absorb the light and heat energy from the sun. While light easily passes into and out of the glass, heat does not. A greenhouse has also been called a "hot house" because the heat becomes trapped inside the glass room. The greenhouse effect is the name given to the role the atmosphere plays in warming the Earth. It is a known scientific fact that certain gases (GHGs) in the atmosphere trap heat in the air. If too many of these gases build up in the atmosphere, this could lead to a gradual "warming up" of the Earth. In this activity, your job is to develop and test a model that will illustrate what happens to the temperature of the air around the Earth when heat is trapped within the Earth's atmosphere.

Your job is to discover the answer to the following question:

**How does the air temperature in an open container compare to that of a closed container, both of which are exposed to direct light from the sun?**

Experiment Directions:

1. Check to be sure you have all of the materials needed. Refer to the materials list below.

**Materials you will need (these should be at your station):**

Two 2 liter plastic bottles with the tops cut off

soil

2 thermometers with card stock squares

plastic wrap & 1 rubber band

masking tape

1 Dixie cup

2. Measure 6 full Dixie cups of soil and pour them into one of the plastic bottles.
3. Repeat the process with the other plastic bottle.
4. Cover the bulb of each thermometer with a small square of card stock. Simply tape a small square of card stock onto the back of the thermometer, near the region of the bulb. This prevents unusual temperature readings that result from the metal parts of the thermometers absorbing more heat than would the rest of the contents of each bottle.
5. Adjust thermometers to be the same temperature.
6. Place the thermometers in similar locations and directions in each bottle's soil.
7. Place plastic wrap over one of the bottle's open top. Secure with tape.
8. Put both bottles in a sunny location.
9. Record temperature data of each thermometer every minute. Be sure to record the same thermometer's temperature first.
10. Record data for a period of 10 minutes.
11. Complete Questions for Thought.

**NOTE:** As is the case with any good experiment, you must be very careful to control variables. Here are some of the things you will need to think about in your model.

- amount of soil in each container
- placement of the thermometer in each container
- placement of each of the bottles
- height of the sides of each bottle
- time each container is to be left in the sun
- comparison of the two thermometers to each other (What will you do if the starting temperatures of the two thermometers are different?)

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### Too Cool for School – Data Table

Time	Temperature Bottle 1 (open top)	Temperature Bottle 2 (closed top)	Observations


**Questions for Thought:**

1. Make a drawing of your experiment. Be sure to label all of the parts. Design a data table in which to record your data. Be sure to place labels on any numbers you record.

Drawing

2. Diagram and/or describe why the containers heat up.

3. Explain why the final temperatures of the two bottles were different.

4. The plastic bottles in your experiment were acting as a model of the greenhouse effect. Good models try to use things that behave similarly to the "real thing." In this case, the real thing is the Earth's atmosphere and the sun. List those parts of your model that were the same for the real greenhouse effect and those parts that only represented what might be happening in the actual atmosphere.

Same as the 'real thing':

Representation of the 'real thing':

5.

A second grader asks you to explain how a greenhouse works. How would you go about answering her question? Remember, you are talking to a second grader! (You may include drawings in your explanation and should also try to tie in some everyday experiences the second grader might have had with the greenhouse effect.)

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### Too Cool for School-Teacher Sheet

Important Notes:

- In order to get the best possible results, students should set their experiments up in direct sunlight on a cool day.
- Outside temperatures less than 72 degrees F are best, with cold temperatures working very well.
- The experiment may be set up either outdoors or on an indoor windowsill or counter.
- The maximum temperature is likely to be reached within a maximum of 15 minutes.
- If your classroom does not receive direct sunlight, and you cannot wait for a sunny day to go outdoors, a light bulb may be substituted for the sun.
- If you do use light bulbs, give students safety pointers on handling hot bulbs.
- Students should experiment with different arrangements of the bulb.
- You will need only one bulb per student group, as one bottle may be set on each side of the light bulb. Distances of only a few centimeters between the light bulb and the bottles work best.
- Check to see that the thermometers are oriented in the same position relative to the light bulb.
- Students should read the thermometers every 1 minute and always read the same thermometer first.
- It works best to cover the bulb of the thermometer with a small square of card stock. This prevents unusual temperature readings that result from the metal parts of the thermometers absorbing more heat than would the rest of the contents of each bottle.
- When setting up the experiment, simply tape a small square of card stock onto the back of the thermometer, near the region of the bulb.

In order to answer "Questions for Thought" question 3, students will need some knowledge of the greenhouse effect. Rather than providing this information prior to the lab, allow students to collect their data and to answer "Questions for Thought" questions 1 and 2 first. The closed container helps to illustrate how heat is trapped by the CO<sub>2</sub> lid on our atmosphere. This "lid" prevents heat from escaping into outer space.

This causes the air inside the bottle to become warmer faster than in the "control", which has no lid. Emphasize to students that this is a model of what may be happening to our global temperature.

Sample Answers to Questions for Thought:

1. Why did the temperature in each bottle go up?

Both light and heat energy from the sun passed through the plastic and warmed the air and soil inside the bottle.

2. Explain why the final temperatures of the two bottles were different?  
The air inside each of the bottles is heated up. The air in the open container can mix with the cooler air in the room, so it has a chance to stay cooler. The air in the closed container is trapped, so the warm air stays warm.
3. The plastic bottles in your experiment were acting as a model of the greenhouse effect. Good models try to use things that behave similarly to the "real thing". In this case, the real thing is the Earth's atmosphere and the sun. List those parts of your model that were the same for the real greenhouse effect and those parts that only represented what might be happening in the actual atmosphere.

**Parts that were the same**

both are exposed to direct sunlight

both involve air heating up

both have soil present

Both have moisture in the air

**Parts that were different**

plastic bottles represent the Earth & its atmosphere

plastic wrap was used to represent CO<sub>2</sub> gas trapping in the heat

the Earth's surface is not covered with soil everywhere

the temperature of the Earth varies at different times of the year

the Earth's atmosphere does not have a physical barrier, like plastic wrap. Instead, it is held down by gravity

the real atmosphere is much larger than the layer of air trapped in the bottle.

4. Imagine a second grader asks you to explain how a greenhouse works. How would you go about answering her question?

Student answers will vary to this question.

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### Too Cool For School-Extension Activity

**Goal:** Students will design a physical representation of the greenhouse effect



**Objectives:** Students will...

- . Illustrate, in a diagram form, how the greenhouse effect works

**Materials** (For a class of 30):

- . clean sheet of white paper
- . glue
- . scissors
- . rulers
- . Appendix A Diagram

**Time:** 45 minutes



**Standards Met:** S3, S7, S8, LA4, LA12



**Procedure:**

- . Hand out student sheets and ask students to read the background information.

- Explain that students will be creating a 'puzzle' showing the greenhouse effect. They need to be sure they have the required materials and can then begin the activity following the directions on the student sheet.
- Students will be cutting out pieces of the greenhouse effect diagram and then organizing those pieces to illustrate how all of the parts fit together.
- Emphasize to students that there is no one right answer. The class may end up with 20 different diagrams, each of which "makes sense". That is the key.
- Diagrams are used to make complex relationships easier to understand. If their diagrams are confusing and disorganized, then they have not achieved the goal of succinctly illustrating the concepts involved in the greenhouse effect.
- Remind students that only the "basics" are provided for their diagram.
- Give each student group a copy of the Diagram on the student sheet. Encourage them to make additions that will add color and understanding to their diagram.
- If some students would rather use larger sheets of paper for their diagrams, this would be acceptable. The cutouts are designed to fit on an 8x10 sheet of paper, which has been turned side-ways. If students use larger sheets of paper, they will have more room to add explanations and arrows to their drawings.
- Ask for student volunteers to share their diagrams with the class and to explain the important parts.

### **Home/Community Connections:**

- The Climate Challenge is a voluntary program between the U.S. Department of Energy and the electric utility industry. The plan is part of the U.S. response to the 1992 Rio Energy Treaty mandating international stabilization of greenhouse emissions. As part of the plan, utility companies keep track of decreases in their emissions of greenhouse gases. Start your own climate challenge in your classroom. Encourage your students to get their parents to switch to energy saving measures around the house.
- Ask various businesses if you can display your posters in their waiting room.

### **Extensions:**

- Make a real global climate change puzzle. First draw and color your picture. Add labels and explanations. Cut out the picture to make interesting shaped puzzle pieces. Challenge one of your classmates or someone at home to put your puzzle together.

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### **Too Cool for School-Extension Activity - Student Sheet**

Name: \_\_\_\_\_ Date: \_\_\_\_\_

**Directions:** Review the information below and create a diagram of the greenhouse effect.

#### **Background:**

The atmosphere is divided into layers according to major changes in its temperature. The layers of air that surround the Earth are held close to it by the force of gravity. The layer of the atmosphere closest to Earth is the troposphere. Almost all of the Earth's weather occurs in the troposphere. The height of the troposphere varies, but averages around 8-17 kilometers.

As heat energy from sunlight travels through the atmosphere, only a small amount of the heat energy is trapped by the atmosphere. Most of the heat energy is absorbed by the ground. The ground then warms the air above it.

The next layer of the atmosphere is called the stratosphere. The stratosphere contains winds called the jet stream. This layer also contains the ozone layer. Most of the ozone layer is located between 16 and 60 kilometers above the Earth's surface. Ozone acts as a shield for the Earth's surface, absorbing most of

the ultraviolet radiation from the sun. Overexposure of the skin to ultraviolet radiation has been linked to skin cancer.

Above the stratosphere is the mesosphere, the layer in which most meteoroids burn up as they enter Earth's atmosphere. Above this layer, there is one more layer, the thermosphere. This layer has no well-defined outer limit. The air in this layer is extremely thin and the air pressure is only about one-millionth as great as it is on Earth's surface.

**Problem:**

Develop a diagram illustrating the greenhouse effect, using the materials provided.

**Materials:**

- clean sheet of white paper
- page containing cutouts of greenhouse components
- scissors
- glue
- ruler
- markers or colored pencils

**Let's Investigate:**

- In previous activities, you picked up bits and pieces of the global climate change puzzle. You will now attempt to pull your ideas together to construct a diagram showing how the greenhouse effect works. Your teacher will provide you with a page of drawings, labels, and pictures. Cut each of these out and arrange them on a sheet of paper in order to illustrate the greenhouse effect. Once you have arranged all of the cutouts on a blank sheet of paper, glue them down.

**Summing Up:**

- Add arrows to your drawing showing heat from the sun hitting the Earth's surface.
- While most of the sun's energy reaches the Earth, about 30% of this energy is reflected back into space. Add more arrows showing energy being reflected just inside the ozone layer back into space.
- The greenhouse gases form a "blanket" which traps heat energy inside the Earth's atmosphere. Add arrows showing heat energy being trapped and reflected around the atmosphere and back to Earth.  
(Adapted from a module developed by Nesbit Laboratory School – [http://www.earth.uni.edu/EECP/mid/mod5\\_app.html](http://www.earth.uni.edu/EECP/mid/mod5_app.html))
- See the diagram on this page to help you get started.

DIAGRAM: (attached)



SPACE  
OZONE LAYER

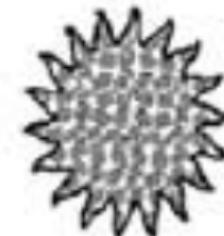
ATMOSPHERE  
EARTH



REFRIGERATORS

McRae

Natural Gas



$CO_2$

CFCs



# Earth Space Atmosphere Ozone Layer

