NATIONAL GEOGRAPHIC

RESOURCE LIBRARY I ACTIVITY : 1 HR 15 MINS

Our Greenhouse

Students read to create an initial conceptual model of the greenhouse effect. They then collect temperature data from a physical demonstration simulating atmospheres with and without greenhouse gases and calculate and compare the mean, median, and range. Finally, they revise their model of the greenhouse effect using their data analysis and an interactive.

GRADES

6, 7, 8

SUBJECTS

Earth Science, Climatology

CONTENTS

1 Resource, 1 PDF

OVERVIEW

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For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/our-greenhouse/

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DIRECTIONS

This activity is part of the Climate Change Challenge unit.

1. Facilitate the design of an initial conceptual model of the greenhouse effect using a reading.

- Distribute the leveled article *Greenhouse Effect*. Assign students to read and annotate the first section of the article individually, highlighting or circling the following terms:
    - *Greenhouse gases*
    - *Atmosphere*
    - *Sunlight (sun's light)*
    - *Earth's surface*
    - *Heat*
- Have students Think-Pair-Share to assess the role each of these terms plays in the greenhouse effect.
    - Distribute the *Our Greenhouse Models* worksheet to students, and prompt students to use the reading and their notes to complete Part A. Their visual, conceptual model should contain each of the terms discussed previously, with these elements and their relationships clearly labeled.
- Connect students' models and initial ideas from the reading to the conclusions of the *Heating Up* activity, and explain that, today, they will collect their own data and use models to explain the processes responsible for global warming.

2. Demonstrate the greenhouse effect using a physical model and have students record and analyze resulting data.

- Introduce students to a physical model of the greenhouse effect.
    - See the *Setup* section for instructions on how to create this model prior to class.
    - Clearly emphasize the presence of carbon dioxide in the atmosphere within one bottle and its absence in the other.
- Have students Think-Pair-Share to relate this physical model to their visual, conceptual model with the following questions:
    - *How do the pieces of this model (lamp, bottles, bubbles, water, temperature) relate to your model of the greenhouse effect?* (The lamp models sunlight, the bottles model

the atmosphere. The bubbles are made of carbon dioxide. Water models the Earth's surface, and temperature measures the heat produced.)
    - *What is your hypothesis for how the temperature will compare between these two bottles after we measure them for 20 minutes?* (Student hypotheses may vary but should include a statement regarding the relative temperature in the two bottles, and a justification using prior knowledge.)

- Turn students' attention to Part B of *Our Greenhouse Models*. Ask students to record temperatures in each bottle every 15 minutes until all three readings are taken.
    - Use the intervening times to introduce the definitions of mean, median, and range, and practice calculating each.

- If students have prior knowledge of the terms *mean, median,* and *range*, solicit student definitions of these terms. Otherwise, introduce them, encouraging students to record definitions in their own words for their notes.
    - *Mean* (Also known as the average. Mean is calculated by adding a group of observations, and then dividing by the number of observations in the data).
    - *Median* (This is the 'middle' number in a set of observations put in order from smallest to largest. If there are an even number of observations, the median is the mean of the middle two.)
    - *Range* (The difference between the smallest and largest value in a set of numbers. It gives a sense of the amount of variation in the dataset.)
    - Model calculating mean, median, and range with hypothetical temperature data, in an I do, we do, you do format. For example: *68, 64, 68* (Rewrite numbers in order (64, 68, 68) and then calculate Mean: (64+68+68)/3 = 65.33; Median: 68; Range: 68-64 = 4.)

- Calculate mean, median, and range for the greenhouse effect data (extra carbon dioxide/seltzer) and the no greenhouse effect data (air/water). Discuss these statistics with the class by asking:
    - *How did these data change over time, from Reading 1 to Reading 3? Why?*
    - (Readings for both bottles likely increase with time, because the lamp heats the 'atmosphere' inside the bottles.)
    - *Which mean/median/range is higher? Why?*
    - (Mean and median for the greenhouse effect bottle will be higher, if the model has run for an extended period of time, such as 20 minutes. This is because the greenhouse

gas carbon dioxide is helping the atmosphere inside that bottle trap more heat. Range may or may not be different for the two.)
- *Was your temperature comparison hypothesis from before the experiment correct?*
- (Student responses will vary, but look for novel incorporation of information related to the greenhouse effect as students revise their understanding.)

3. Use an interactive to help students revise conceptual models of the greenhouse effect.

- Introduce students to the *Carbon Dioxide in the Atmosphere* online interactive by projecting it, explaining that this tool will help them to build on their growing knowledge of the greenhouse effect. Use the following elements to demonstrate how releasing more carbon dioxide causes an increase in temperature and track an energy packet through the environment:

    - The Key (identifies carbon dioxide, heat, and solar radiation – sunlight). Click "Show Key" in the top left-hand corner of the interactive.
    - The *Play* button (necessary to start the interactive).
    - The *Erupt* button (necessary to release carbon dioxide into the atmosphere).
    - The *Slow-Fast* switch (slowing the interactive down is necessary to see the details of the greenhouse effect).
    - The *Follow energy packet* and *Follow* CO_2 buttons (using these will make it much easier to see the details of the greenhouse effect).
    - The graphs (Air temperature and CO_2 graphs help students relate these two model components).

- Based on this model, assign students to revise their model of the greenhouse effect in Part C of the *Our Greenhouse Models* handout. Prompt students to incorporate the terms *greenhouse gases, atmosphere, sun's light (sunlight), Earth's surface,* and *heat* and their relationships, and using symbols such as arrows accompanied by + or - to show how one element might influence another. Regardless of the accuracy of their initial model, students can illustrate this effect again in a novel way.Ask for volunteers to share their revised models with the class, and use information from these models to update the class unit *Know and Need to Know* chart,regarding the greenhouse effect. Prompt all students to complete Part D of the *Our Greenhouse Models* handout explaining what they learned from data collection and the interactive that helped them revise their model, as a reflection on their learning in this activity.

    - Specifically, students might name general conclusions from data collection (the bottle with carbon dioxide heats more quickly under light than the bottle with air) or

particular actions of the model elements (greenhouse gases, atmosphere, sunlight, heat, and Earth's surface) that they witnessed in the interactive.

Tip

Step 1: It may help students to view a *simple diagram* of the greenhouse effect as they read. Additionally, you may wish to elicit prior understanding in a low-stakes way by having students create their initial explanatory models. Then, have them revisit the models to see and show how their thinking changes as they learn, demonstrating a growth mindset approach. To learn more about explanatory models, read about engaging students in modeling from the *STEM Teaching Tools* website. Explore different model structures to use (small group, whole group, and so on) from the *Ambitious Science Teaching* website.

Tip

Step 2: Setting up the physical model of the greenhouse effect prior to using it in the classroom and testing its results using your own equipment may help you time when to begin this demonstration and anticipate any challenges that might occur. You may note that if the light was turned on at the beginning of the class period or day, differences might already be evident by the start of each class period. The goal is less for students to witness this process from start to finish, and more for them to collect multiple data points from which to calculate the descriptive statistics' mean, median, and range.

Modification

Step 3: After students have revised their models, consider organizing a gallery walk to view their peers' ideas (and possibly engaging in a final round of individual model revision), before coming to consensus through discussion.

Informal Assessment

Informally assess students' initial and revised models of the greenhouse effect. Look for the incorporation of all elements and a visual expression of their relationships in the diagram. For example, the transfer of energy from sunlight to Earth's surface and its re-emergence as heat might be depicted with a shape for each term, and arrows to show movement.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Climatology

Learning Objectives

Students will:

- Collect data and calculate summary statistics to verify the role of carbon dioxide in the greenhouse effect.
- Draw conclusions from a simulation with a physical and digital demonstration of the greenhouse effect.
- Develop and revise an explanatory model of the greenhouse effect.

Teaching Approach

- Project-based learning

Teaching Methods

- Cooperative learning
- Demonstrations
- Reading

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving

    - Life and Career Skills
        - Social and Cross-Cultural Skills
- 21st Century Themes
    - Environmental Literacy
    - Global Awareness
- Critical Thinking Skills
    - Analyzing
    - Applying
    - Understanding
- Science and Engineering Practices
    - Analyzing and interpreting data
    - Developing and using models
    - Using mathematics and computational thinking

National Standards, Principles, and Practices

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 2: Cause and Effect:**
Cause and effect relationships may be used to predict phenomena in natural or designed systems.
• **MS. Earth and Human Activity:**
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
• **Science and Engineering Practice 2:**
Developing and using models

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- 2-liter plastic soda bottles
- Bright light[s]
- Carbonated water
- Rubber stoppers with holes for thermometers, or clay
- Water

- Thermometers

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per pair, Monitor/screen, Projector

PHYSICAL SPACE

- Classroom

SETUP

Step 2: To set up the physical model of the greenhouse effect, fill one 2-liter soda bottle halfway with fresh seltzer and another 2-liter soda bottle halfway with tap water. Immediately cap both, and allow them to reach room temperature. Place stoppers and/or clay with thermometers into the two bottles to measure the temperature of the air over the surface of the two liquids (see *The Greenhouse Gas Demo* (3:59) for visual reference). Shine the light (as bright as possible) at the two bottles, from an equal but close distance, and observe the temperature in the two bottles as it changes with energy input from the light over time. Depending on your specific setup, it may take more or less time for temperature differences between the two bottles to become evident. It will, therefore, help to turn on the light at or before the start of class. Turning the light on at the beginning of the day will result in progressively more dramatic temperature differences for a few hours, assuming that the bottles are well-sealed.

GROUPING

- Large-group instruction
- Large-group learning
- Small-group learning
- Small-group work

RESOURCES PROVIDED: HANDOUTS & WORKSHEETS

- Our Greenhouse Models

RESOURCES PROVIDED: REFERENCE

- Greenhouse Effect

RESOURCES PROVIDED: INTERACTIVES

- The Concord Consortium: Carbon Dioxide in the Atmosphere

BACKGROUND & VOCABULARY

Background Information

An increase in the greenhouse effect is responsible for the recent rapid pace of global warming. Carbon dioxide, methane, and nitrous oxide are all examples of greenhouse gases. They let the energy in sunlight pass through on its way towards Earth, but block the heat energy (created by sunlight striking the planet's surface) from leaving the atmosphere. This effect increases the average temperature on Earth.

Mean, median, and range are numbers used to summarize information about groups of observations; for this reason, they are called 'descriptive statistics.' To calculate the mean, divide the sum of all observations in a list by the number of observations. To find the median, choose the middle observation in an ordered list, or average the two middle observations if there are an even number of observations. To calculate the range, subtract the smallest observation in a list from the largest. These three descriptive statistics are useful for working with large amounts of data, in particular, to describe and compare the average observation or the spread of observations in two groups.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition

Term	Part of Speech	Definition
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
carbon dioxide	*noun*	greenhouse gas produced by animals during respiration and used by plants during photosynthesis. Carbon dioxide is also the byproduct of burning fossil fuels.
greenhouse gas	*noun*	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
heat	*noun*	energy that causes a rise in temperature.
mean	*noun*	mathematical value between the two extremes of a set of numbers. Also called the average.
median	*adjective*	situated in the middle.
range	*noun*	difference between the smallest and largest value in a set of numbers.
sunlight	*noun*	visible radiation from the sun.

For Further Exploration

Instructional Content

- National Geographic: Resource Library: Collection: Climate
- National Geographic: Resource Library: Collection: Climate Change