GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.

TEACHER GUIDE

INTRODUCTION TO CLIMATE CHANGE
GRADES 6-8

COMMON MISCONCEPTIONS

- **Climate is simply long-term weather and therefore can't be predicted.**
  There are significant differences between weather and climate processes and how they are studied and forecast. Weather is the atmospheric conditions at any given time or place. Climate is understood as the atmospheric conditions averaged over a long period of time and over a large area.

- **Climate has changed many times in the distant past, before humans began burning coal and oil, so the current warming cannot be caused by humans burning coal, oil, and natural gas.**
  There are several drivers that cause climate to change, and some of the key drivers have both natural and human sources. Recent increases in global temperatures result mostly from higher levels of heat-trapping gases in the atmosphere, which have been increasing because of human activities.

- **Global warming is caused by the ozone hole because the hole lets in more radiation.**
  Global warming is caused by increased greenhouse gases in the atmosphere. These gases include carbon dioxide and water vapor, which trap infrared radiation from the warmed surface of Earth. The ozone layer protects the planet from the sun's harmful radiation. A depletion of ozone allows more UV light to reach the surface but is not an important factor leading to increased temperature on Earth. Banning CFCs from spray cans has caused the ozone hole to stop growing.

WEATHER, CLIMATE, AND CLIMATE CHANGE

The difference between weather and climate is a matter of scale. Weather is the short-term (hours, days, weeks) conditions of the atmosphere described in terms of temperature, precipitation, humidity, wind, cloudiness, visibility, and air pressure. Weather is inherently variable, changing from day to day and season to season, with atmospheric conditions fluctuating naturally within a given range for a specific time and place.

Climate is the average of this variability in weather for a 30-year or longer time period. It is the "smoothing" of the variation in weather. While the "average" climate is most often talked about, long-term climate data also help us describe the range of expected conditions for a location, the frequency of extreme weather, and the likelihood of certain types of weather events. Climate data are essential for understanding patterns, trends, and changes in our long-term climate. Climate change is the statistically significant change in atmospheric conditions due to human activity.

EARTH'S CLIMATE SYSTEM

The atmosphere is not an isolated system. It interacts with other components of the Earth system – the oceans, for example. But it is also in contact with the cryosphere (ice and snow), the biosphere (animals and plants), the pedosphere (soil), and the lithosphere (rocks). All of these elements together compose the climate system, whose individual components and processes are connected and influence each other in diverse ways.

These components all react to change at different rates. The atmosphere adjusts to the conditions at Earth's surface such as ocean temperature or ice cover within a few hours to days. Currents in the deep sea require several centuries to react fully to changing boundary conditions such as variations in the North Atlantic oscillation, which cause changes in temperature and precipitation at the sea surface and thus drive motion at greater depths. A large continental ice mass such as the Antarctic ice sheet, as a result of climate change, presumably undergoes change over many millennia, and without counteractive measures it will gradually melt on this time scale. The predictability of climate is based on the interactions between the atmosphere and the more inert climate subsystems, particularly the oceans. Within this scheme, the various components of the climate system move at completely different rates.

GREENHOUSE EFFECT

Some of the gases in Earth's atmosphere, such as water vapor and carbon dioxide, play an important role in influencing Earth's average temperature. These gases are referred to as greenhouse gases (GHG), because they act like the glass on a greenhouse. They allow solar radiation in through the atmosphere but prevent the escape of some of the reflected radiation back out into space. These greenhouse gases absorb reflected radiation and emit it back toward Earth, causing a warming of the lower atmosphere.

This naturally occurring process is an important part of the planet's ability to support life on Earth as we know it. Without this process, Earth's average temperature would be approximately –18°C. Instead, the average temperature is approximately 15°C today. Greenhouse gases are naturally emitted by the oceans and land in an annual cycle. CO_2 is drawn into plants as they grow and sprout leaves. CO_2 is released as dead vegetation rots. Volcanoes produce GHG. Animals release CO_2 as they breathe. There is methane in manure and from swamps. What is not natural is the rate humans are adding greenhouse gases to the atmosphere. This process is referred to as the Enhanced Greenhouse Effect and is responsible for triggering and enhancing the current warming trend. As more greenhouse gases are produced, they accumulate in the atmosphere and absorb long wave reflected radiation (i.e., infra-red). More radiation is then radiated back towards Earth, causing enhanced warming.

TEACHER TIPS

Remind students that a scientific model includes the most important components with respect to the phenomenon, labels those components, and shows relationships/interactions between those components. We use the convention of a zoom-in lens to model what might be happening at the microscopic level (air in the car, air outside the car). Help students identify the most important components of the car/Sun system (inputs: sunlight; processes: energy transfers, transformations, and conservation; outputs: ask students what we use as an indicator of transfer of heat [temperature changes]). Ask students how we can indicate interactions between components in the system (ex. arrows, different size arrows to indicate quantity, squiggly lines to indicate vibratory motion).

These questions may be useful for facilitating the consensus discussion during the Explain phase:

- Could someone restate our question (or our charge)? What are we building consensus about?
- What are some things we think we can say at this point about our anchoring phenomenon?
- What is our evidence for those ideas (those explanations)?
- How should we represent it? Are we Ok with that?
- Do we all agree with that?
- How are these explanations similar? How are they different?

If the class hasn't generated criteria for sound experimental design, lead them in a quick discussion to create a list of criteria each group can use. The quality of the experimental design affects how valid and reliable the data generated are.

- Use the class's brainstormed list of variables that might affect the air temperature inside the car. These will be the independent variables (IV). Have each student group investigate one of the identified IVs.
- Ask: what should they measure to determine if the IV has an effect? Students should suggest measuring the temperature inside the container and outside the container.
- Ask: what variables need to stay the same/be controlled? This will vary based on the variable being tested. Basically, each group will control for all the other variables brainstormed except for the one they are testing.
- Ask: are there procedures that every group should do the same way? Distance from light if not outside, amount of time to collect data.
- Ask: How many trials are needed to feel confident in their data? Time and materials will limit the number of trials each group can do. If possible, students will want to run their tests at least three times. If that is not possible, they should include the lack of multiple trials lessens their confidence in the reliability of their data.

ABOUT THIS LESSON

This lesson was created by the National Science Teaching Association (NSTA) to pair with the Generation Genius video and support *NGSS*.

They have requested we provide the following background with this lesson:

The Next Generation Science Standards (NGSS) are the national standards on how students learn science, and they are based on contemporary research presented in *A Framework for K–12 Science Education (the Framework).* The shift in science teaching and learning required by the Framework is summarized in this infographic: A New Vision for Science Education.

At the start of each Generation Genius lesson, students are presented with a phenomenon, then they try to explain it. Students will notice they have gaps in their knowledge and ask questions, which motivates them to build ownership of science ideas they need in order to explain how or why the phenomenon occurred. The way students build ownership of science and engineering ideas is through active engagement in the science and engineering practices (SEPs). This process of sensemaking, or doing science to figure out how the world works, is one of the major shifts the *Framework* encourages.

To engage in the SEPs, students should be part of a learning community that allows them to share their ideas, evaluate competing ideas, give and receive critiques, and reach consensus. Students can start by sharing ideas with a partner, then with a small group, and finally, with the whole class. This strategy creates opportunities for all students to be heard, build confidence, and have something to contribute to whole-class discussions. Each Generation Genius lesson provides conversational supports to facilitate such productive student discussions to contribute to sensemaking.

Excited to continue your shift toward the new vision for science education? Check out the Generation Genius Teacher Guide page on the NSTA website for resources and strategies to engage every student in your classroom in **doing** science.

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