

Modern Extinction — The Warming Planet

Lesson Overview:

In this lesson, students explore the evidence for climate change and global warming. The lesson emphasizes data-driven exploration. The exploration begins with indications of past ice ages and warming periods and the role of climate change in mass extinctions. Students watch *Racing Extinction* video clips to enhance their perspective and insight. Activities in this lesson include listing keywords associated with climate change and creating a concept map of hypothesized causes for climate change. Students develop a basic model of the greenhouse effect, including the role of the carbon cycle, atmospheric carbon dioxide and other greenhouse gasses. The positive feedback model provides students with a conceptual framework to understand the causes and consequences of “runaway” climate change. In a class activity, students debate the motion: “The evidence for human-caused climate change justifies taking action.”

***Racing Extinction* Video Clips:**

- **Video Clip 1: The Hidden Carbon Dioxide World**

This clip provides an innovative technology to visualize how human activities result in carbon emissions. Using cameras equipped with special infrared filters, filmmakers reveal the invisible carbon dioxide emissions resulting from everyday actions.

- **Video Clip 2: The Methane Problem**

In this clip, scientists discuss evidence to support the prediction that mass quantities of methane released by the melting polar ice caps will contribute to runaway climate change. Students will also see why scientists believe that methane is to blame for the Permian-Triassic extinction event.

- **Video Clip 3: Plankton Decline**

This clip shows how human activities can have global impact by exploring how our impact on Earth's oceans is resulting in a decline in phytoplankton production.

Lesson Duration: Two 45-minute sessions

Essential Questions:

- What is climate change?
- How are anthropogenic changes to the atmosphere and oceans destabilizing climate?
- What are the mechanisms by which changes in atmospheric gases impact global climate?
- What is the scientific evidence for climate change?

Objectives:

Students will:

- Define climate change and global warming.
- Analyze hypotheses that explain how human activities are destabilizing climate.
- Describe the mechanisms of climate change on Earth's systems and the principle of positive feedback.
- Cite evidence for climate change in the past and in modern times.

Standards:

- *Next Generation Science Standards*
 - HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
 - HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
 - HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
 - HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
 - HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
 - HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

- **Common Core State Standards**
 - RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
 - RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
 - RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
 - RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
 - WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
 - WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
 - WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
 - SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Materials Needed:

- Computer or mobile device with Internet access
- Graphics software (optional)

Teacher Preparation:

- Watch *Racing Extinction* video clips, or the entire documentary if possible
- Review online resources provided in lesson
- Consider strategies for ELL, struggling, and accelerated students

Background Information (for the Teacher):

In recent years, scientists have demonstrated clear evidence for two global trends: climate change and rising rates of extinction. While some uncertainty remains about minor aspects of the specific mechanisms, scientists have reached increasing consensus that human activities are the cause of these trends. The documentary *Racing Extinction* highlights the connection between the two—the fact that climate change is contributing to species extinctions. Scientists are also increasingly concerned that loss of Earth’s biota will limit the planet’s ability to mitigate climate change.

In this lesson, students explore the concept of climate change, which encompasses past and present variation in global and regional climate patterns. Climate change today is often referenced in terms of the present increase in global temperature (“global warming”), attributed to increasing levels of atmospheric carbon dioxide due to the use of fossil fuels. To develop a scientific perspective, students investigate scientific evidence for climate change and global warming. To find such evidence, scientists analyze ice cores and the pollen record, as well as geological events such as past glaciation and global sea levels. These data provide evidence of past climate change events such as ice ages and warming periods.

To put current climate change into context, students explore how anthropogenic changes to the atmosphere and oceans destabilize the climate. For example, fossil use adds carbon dioxide to the atmosphere. Carbon dioxide and other greenhouse molecules, notably methane, absorb and re-emit infrared radiation that warms Earth’s surface. The net effect of adding greenhouse molecules to the atmosphere is, therefore, to cause increases in global temperature. Changes in global temperature have a cascade effect on climate. Hence, global warming leads to climate change. The extent of climate change effects varies from region to region. Although there may be some local benefits, such as increased rainfall in some areas, the net costs are expected to rise due to more severe weather events.

Key learning points for this lesson:

- Scientists are confident that with the next 100 years, global temperatures will rise at least 2.5 degrees Fahrenheit, perhaps as much as 10 degrees.
- According to the Intergovernmental Panel on Climate Change, “...net damage costs of climate change are likely to be significant and to increase over time.”
- Since the 1880, global temperatures have increased an average of 1.4°F and since 1975 temperatures have increased at 0.15 to 0.20°C per decade.
- Carbon emissions have jumped since the Industrial Revolution. Current CO₂ concentration is 390 parts per million (ppm) compared with the pre-Industrial Revolution level of 280 ppm.

- A small change in global temperature is significant because of the vast amount of energy needed to change ocean and atmospheric temperatures. The last ice age, causing extensive glaciation 20,000 years ago, resulted from a five-degree drop in global temperature.
- Well-documented observable effects of climate change include:
 - Sea level rise (due to thermal expansion and glacial melting)
 - Loss of polar sea ice in both the Arctic and Antarctic
 - Reduction in size of mountain glaciers
 - Shifts of plant and animal species' ranges and migration patterns
 - Earlier onset of spring weather and later onset of fall weather
- Positive feedback in climate change models may result in “runaway” global warming. For example, increased temperatures are causing melting of permafrost resulting in the release of methane, a greenhouse gas. Higher levels of methane increase temperatures, melting more permafrost, releasing yet more methane and so on.
- Earth’s climate is highly complex, so precise predictions are not possible. However, sophisticated climate models have predicted changes that are mostly supported by observable changes.

Procedure:

ENGAGE

1. In their notebooks, students write down a list of activities they enjoy outside.
2. Students choose one of these activities as their favorite and write a sentence describing why they enjoy this activity.
3. Students write a short passage to describe how their enjoyment of their favorite activity changes if the day is very hot or very cold. Encourage students to include a reference to actual temperatures based on their experience.
4. Working in small groups, students discuss the terms “climate change” and “global warming”.
5. Students write in their notebooks how they think that climate change or global warming could impact their favorite activity. For example, students could write a short passage titled: “How climate change will affect the things I like to do.”
6. From prior knowledge, students create a list of keywords that they have heard related to global warming and climate change.
7. Explain to students that they will explore the evidence for climate change and global warming, beginning with prehistoric events such as ice ages.

EXPLORE

1. Working in small groups, students research online resources to learn about past ice ages and warming periods. Example websites include:
 - a. NASA: [Earth's Fidgeting Climate](#)
 - b. Geological Society of America: [Evolution of Earth's climatic system: Evidence from ice ages, isotopes, and impacts](#)
 - c. Proceedings of the National Academy of Sciences: [Ice-core evidence of abrupt climate changes](#)
 - d. NASA Earth Observatory: Paleoclimatology: [The Ice Core Record](#)
2. Each group creates a table of various tools and methods that scientists use to recreate paleoclimates. Ensure the table includes how each tool or method can provide evidence for specific climate patterns (e.g., use of ice cores to determine past temperatures). For a list of methods:
 - a. U.S. Department of Energy: [Exploring Clues to Our Past](#)
 - b. NOAA: [What Are “Proxy” Data?](#)

3. Working individually, students choose one method and write in their notebooks a passage about how that method has contributed to scientific knowledge about climate change in the past.
4. Students add to their list of climate change keywords as they encounter new words and phrases.
5. Returning to group work, students research online resources to review the scientific evidence for climate change in historic times. Example websites:
 - a. NASA Earth Observatory: [Global Temperatures](#)
 - b. NASA Global Climate Change: [Climate change: How do we know?](#)
 - c. American Physical Society: [The Discovery of Global Warming \(Timeline\)](#)
 - d. *Behavioral Analysis*: [Climate Change: The Evidence and Our Options](#)
6. Each group lists hypotheses scientists have proposed to account for climate change. Students can review the following websites to develop summaries of the various hypotheses:
 - a. EPA: [Causes of Climate Change](#)
 - b. American Chemical Society: [What are the greenhouse gas changes since the Industrial Revolution?](#)
 - c. *Philosophical Transactions of the Royal Society*: [Climate change and trace gases](#)
 - d. How Stuff Works: [How the Ice Age Worked](#)

EXPLAIN

1. Each group creates a concept map of hypothesized causes for climate change. Encourage groups to include non-anthropogenic causes that scientists have hypothesized. Ensure the concept map includes a basic model of the greenhouse effect.
2. Students watch Video Clip 1 *The Hidden Carbon Dioxide World*.
3. Based on their concept map, each group creates an infographic to illustrate the greenhouse effect, including the role of the carbon cycle, atmospheric carbon dioxide and other greenhouse gasses. Ensure that the infographics include the role of human activities in the carbon cycle.
4. Groups share their infographic with other groups, explaining how their model describes the greenhouse effect as a driver of climate change.
5. Working individually, students write a short passage explaining how human use of fossil fuels contributes to climate change.

ELABORATE

1. Working in small groups, students explore the concept of positive feedback. If necessary guide students from familiar concepts of negative feedback (such as a thermostat) and encourage them to think of examples of positive feedback such as blood clot formation.
2. Students watch Video Clip 2 *The Methane Problem*.
3. In their groups, students discuss the role of methane in the Permian-Triassic extinction event and how methane may be part of a global warming positive feedback mechanism.
4. Students watch Video Clip 3 *Plankton Decline*.
5. Groups discuss how human activities could exacerbate positive feedback by limiting the capacity of Earth's systems to mitigate changes in global temperature. (These human activities, such as pollution, agriculture or overfishing, need not necessarily be directly related to climate change.)
6. Each group researches online to develop a positive feedback model for climate change, citing examples in addition to methane. Examples of positive feedback climate loops:
 - a. NOAA National Climatic Data Center: [What are positive feedbacks?](#)
 - b. UK Met Office: [Climate feedbacks](#)
7. Groups choose a specific example, such as methane release due to the melting of permafrost and the albedo effect due to ice melting.
8. Groups elaborate on their example, researching evidence to support their example and relating their example to extinctions today.
9. Groups create a short presentation to articulate a position for or against action to address their particular example.
10. Divide the class into two groups.
11. In a class activity, students debate the motion: "The evidence for human-caused climate change justifies taking action." Encourage students to argue in favor of a particular position, even though they may not agree with that position.

EVALUATE

1. For a pop quiz, students can take the NASA quiz "Warm Up" about the impact of about global temperature change on Earth's climate.
 - a. NASA: Warm Up: [Global Temperature Quiz](#)
2. Working individually students complete four of the five following constructed responses.
 - Write a short passage describing the role of global warming in climate change.
 - Write a list of three ways in which humans are changing the atmosphere and oceans.

- Describe one example of a positive feedback mechanism that can destabilize the climate.
- Write one sentence to explain how the greenhouse effect warms Earth's atmosphere.
- List three types of scientific evidence that demonstrate the increase in global temperatures since the 19th century.