Back to the Future: Climate Edition

Lesson Set 3 of 5

CLIMATE CHANGE

NCSE
National Center for Science Education

Teacher Prep

Age Levels: 9th-12th grade

Time Commitment: 6-8 days
(if all activities completed)

Key Vocabulary/Concepts:
climate, meandering, oxbow, ocean currents, fossils, volcanoes, Paleocene-Eocene Thermal Maximum, stratigraphic columns, dendrochronology, tree-rings, proxy, ice core, correlation, causation

Materials:

- Laptops or other computer access
- Internet access
- Post-it Notes *(in-person)* or Google Jamboard *(remote)*
- 3” x 5” notecards *(in-person)* or Google Jamboard *(remote)*
- Student-Facing Printouts for each lesson
- Ice Core Investigation
  - 20 small pieces of paper—1 for each container
  - Marker to label each container
  - 25-white ½” pom-poms per individual container (100 for the group of 4 students)
  - 69 5-mm green pom-poms
  - 116 5-mm purple pom-poms
  - 97 5-mm orange pom-poms
  - 20 clear containers

Continued on next page.

Introduction

This lesson set explores how proxies, or stand-ins, are used to gather evidence for past climate events. A climate proxy is a variable preserved within the geologic record that can serve in place of direct climate data because it correlates with climate conditions. Examples of climate proxies are tree rings, ice cores, sediments, and even diary records. Students investigate a variety of proxies in order to understand past climate events and forecast future climate events.

Teacher Goals

1) Provide structured opportunities for students to ask questions that drive the learning process.
2) Develop students’ ability to synthesize multiple sources of data to build paleoclimatological understanding.
3) Facilitate student use of scientific tools or simulations necessary for paleoclimatological data collection and analysis.

Student Learning Goals

1) Generate questions in order to clarify the relationship between tree rings, ice cores, and other proxies for historical carbon emissions and global temperature.
2) Obtain and communicate information in order to explain how natural processes affect climate.
3) 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.

Climate Change Lesson Set Series

https://ncse.ngo/supporting-teachers/classroom-resources

CLIMATE CHANGE

Teacher Prep (continued)

Apps and Software:

- Google Jamboard or Google Drawings
- National Institutes of Health's ImageJ pre-loaded onto student laptops

The King's Centre for Visualization in Science's Historic Climate Trends Applet

Background

Teacher Knowledge

Nature of Science

We recommend that students work through the NCSE Nature of Science lesson sets at some point during the year. However, if this is not possible, be sure to introduce students to FLICC, a framework for understanding science denial, prior to presenting this lesson set. Part E: The Characteristics of Science Denial in Nature of Science Lesson Set 1: Science is a Way of Knowing is especially valuable. It takes students through several examples of FLICC in action while dismantling common misconceptions about the COVID-19 pandemic. Learn more about FLICC.

Scientific Concepts:

This lesson set focuses on the study of ancient climates using proxies. The study of past climates helps us to understand current climate trends and forecast future climates. To complete this lesson set, a basic knowledge of paleoclimatology is needed. If a refresher on past climates is necessary, consider checking out the Paleontological Research Institute's Teacher-Friendly Guide to Climate Change or Jeffrey Bennett's online Global Warming Primer before introducing this curriculum to your students.

Discussion Points

a) How do scientists know what happened in the past at times when no one was alive to record data?
b) What climate evidence does the fossil record show us?
c) In what ways do volcanoes affect climate?
d) How are tree rings used to understand past climate events?
e) How are ice cores used to understand past climate events?
f) What does historic climate data tell us about current climate trends?
g) What does historic climate data tell us about future climate trends?

Prerequisite Student Knowledge

Students should have a basic understanding of convection currents, which will help them to understand the anchor activity. Additionally, students should have a general understanding of the geologic time scale and how it is used to organize Earth's history.

FALLACY FACT

Core Misconceptions

✗ **MISCONCEPTION:** ***Natural climate change in the past implies current climate change is also natural.***

✓ **FACT: Modern climate change is abrupt and driven by human activity, distinguishing it from past climate change.**

✗ **MISCONCEPTION:** ***Past climate change was more extreme.***

✓ **FACT: Our understanding of past climate change allows us to create projections for future climate based on current trends. The climate crisis we are experiencing now will result in similar extreme climates to what Earth has experienced in the past.**

Teacher Instructions

Anchoring Phenomenon

Anchor: Time is Like a River

- Project or share the slide set for the Anchor activity. Start the class by allowing students to observe the slide containing a satellite photo of the Juruá River. Ask them to complete a "See, Think, Wonder". Prompt students to notice the oxbows and ask them what they think is happening there. Questions to consider:
  - *What do you think is causing the river to change course?* Erosion—this process is called **meandering**. The flow of the water erodes one section, then deposits it in another.
  - *How do scientists determine where the river used to flow (**oxbows**)?* Highlight that even if no one was there to observe it, we can still determine where a river used to flow because the process of meandering is the same now as it was in the past. Scientists apply this same idea, that natural laws operate today as they did in the past, to other aspects of the natural world, which helps them to understand how Earth looked in the past. The same is true for climate, the average weather conditions of a place.
- Pass out the *Time is Like a River* student handout. Remind students that the text in Part A is taken directly from the online interactive and they should not need to make inferences. Part B requires them to make inferences about what the text is attempting to convey. Preview the true-false statements and reiterate that if the statement is false, they must correct it. In Part C, students are asked to apply their understanding of the text. They must also cite evidence from the online interactive to support their evaluation. Actively monitor the students. The following questions are suggestions to prompt thinking:
  - *What is the connection between the ocean currents and the river we saw in the first part of the activity?*
  - *Why is the water warmer at the equator and cooler at the poles?*
  - *Where is the "cold blob" coming from?*

Storyline Activities

Part A: Past vs. Present

- From the Do Now/Bellringer folder in the above link, project the three images of the fossilized organisms. Ask students to consider the following:
  - *The year is 13802. You are a planetary geologist collecting data on a newly discovered planet. This planet is covered in sand, has extremely high temperatures, no surface water, and is home to very little life. However, you have discovered fossils. You collect some of the fossils seen here. What was this planet like in the past? What questions could help us understand the planet or these fossils more?*
* Introduce the concept of **paleoclimatology**. To begin, ask students how we gather data on climate today. Students may respond with the following: thermometers, barometers, anemometers, satellites, and weather balloons. Explain that these tools didn't exist before humans invented them, and so our picture of past climates is incomplete. In order to understand past climate history, we need to use **proxies**, or stand-ins, for that historical data.
* Prior to class, set up the four stations listed below. Establish expectations for students (self-guided stations or timed stations), then release students to complete the stations.
  - **Station 1: Past vs. Present:** Match the descriptions to their correlating map, then place the maps in order. *How has our climate changed and what impact has that had?*
  - **Station 2: Paleocene-Eocene Thermal Maximum:** Read the text found in the teacher resource folder. *What do scientists understand about this period of rapid warming?*
  - **Station 3: A Year Without Summer:** Watch the video The Colossal Consequences of Supervolcanoes (4:51). *What caused this climate event? How long did it last?*
  - **Station 4: Cretaceous Kansas:** Analyze the stratigraphic column found in the teacher resource folder. *What did this land-locked state look like in the past?*
- At the end of the activity, ask students:
  - *Which type of **volcano** has short-term climate impacts?* Describe the specific cause and effect on the climate.
  - *Which type of volcano has long-term climate impacts? Describe the specific cause and effect on the climate.*
  - *What methods do scientists use in order to understand events in Earth's history?*
- **Teacher Tip:** Diaries, art, and creative writing can all be used as proxies for anecdotal climate data as well. Provide an opportunity for students to go back into their local history to see if there is a record of the Year Without a Summer.
- **Anchor to Activity – Tying it All Together:** Guide the discussion back to what they had covered in the anchor, *Time is Like a River*. Briefly mention that although we are collecting much of this data today, such as fossils, the data can help us to understand the past. Ask students to explain how spikes of mercury in marine deposits help us to understand past volcanism and how fossils help us to understand past biomes.

Storyline Activities (continued)

Part B: Looking at Layers

- **Activity 1: What Can We Learn from a Tree?**
  - **Prior to Class:** Load the ImageJ program onto laptops for students and also load the high-resolution core samples from the teacher resource folder onto the computers. Familiarize yourself with the ImageJ program.
  - Before starting the lesson, provide students with the *3-2-1 Bridge* handout. Show them a picture of **tree rings** and ask them to complete it. The key is to only give them a short time for completion so that they put their first thoughts down.
  - Show students the video Tree Stories: How Tree Rings Reveal Extreme Weather Cycles (2:27). This will introduce them to **dendrochronology** and using tree rings as a climate proxy.
  - Introduce students to the ImageJ program. Direct students to the tree cores and the marks, or cross-dates.
  - Break students into groups, provide laptops with the ImageJ program, and direct students to follow the instructions on the *What Can We Learn from a Tree?* student handout to collect their data.
  - As students complete their data collection, provide the master chronology for their site. Then direct them to the interactive graph.
  - At the end of class, direct students back to the 3-2-1-Bridge handout. Ask them to complete the 3-2-1 for a second time, then to write their "bridge" on the back of their paper.
  - **Teacher Tip:** The opening video gives a brief lesson on how to identify drought years using tree rings. Ask students to take pictures of any tree stumps they may come across and see if the rings match up with your local climate history. If not, discuss the factors that may be involved in preventing a tree from suffering the effects of drought.
  - **Acknowledgement:** "What Can We Learn from a Tree?" was developed using resources created by Nichole Davi. The original resources can be found at TREX - Tree-Ring Expeditions.

- **Activity 2: Ice Core Investigation**
  - **Prior to Class:** Create the "model ice cores" using the plastic containers and pom-poms following the directions in *Ice Core Investigations_Teacher Instructions*.
  - Prior to the activity, show students the video Scientists Scramble to Harvest Ice Cores as Glaciers Melt (3:20). After watching, discuss why ice cores are important archives of information (they help us understand past climates) and why scientists are racing to collect samples (they are currently melting). Press students by asking why we do not have samples of glaciers from previous ice ages. Elicit that those glaciers have since melted.
  - Hand out *Ice Core Investigations_Student Handout*. Read the background information with students. Review other proxies they have learned about: mercury for volcanoes and tree rings for climate. Explain that they will be learning how scientists use carbon dioxide level to infer past temperature.

Storyline Activities (continued)

Part B: Looking at Layers (continued)

- Release students to complete the investigation following the directions in the student handout found in the teacher resource folder. Gather student data on the *Ice Core Investigations_Graphing Spreadsheet* and project the resulting graph so that students can complete the analysis questions.
- Direct students to the Historic Climate Trends visualization tool and student handout. Remind students that these graphs were collected using data from ice cores. Students will be comparing the slopes from different points in time for temperature to determine if current warming is happening at a faster or slower rate than past climate change.
- Students should conclude that the rate of temperature change is happening at a faster rate now than before.
- **Acknowledgement:** "Ice Core Investigations" was developed using resources created by Ashley Malone. The original resources can be found here.

- **Activity 3: Carbon Emission Query**
  - Provide students with the *Is There a Relationship?* double-line graph that shows the Apple stock price on January 1 juxtaposed with the precipitation of Barry County, Missouri from 2005 to 2009. Ask students to complete an I^2 of the graph, making identifying statements, then inferences based on those identifying statements. Ask students to create classroom definitions of **correlation** and **causation**.
  - Review from other lessons the driving question and what has been learned over the past lessons. Tell students that they will be looking at graphs that show historical atmospheric carbon trends based on proxy data as well as current atmospheric carbon trends. They will also be looking at some data about sources of atmospheric carbon.
  - Provide *Carbon Emission Cards* to groups of students and prompt them to follow the I^2 strategy in order to create captions for their graphs.
  - Pass out sticky notes to students and provide instructions for a gallery walk. Students should walk from table to table silently, identify the graph with the least feedback and provide feedback on their sticky note responding to the prompts "I like …, I wonder … , Next steps …."
  - After the gallery walk is complete, allow groups time to review their feedback and revise their captions. Share findings.
  - Ask students to answer the formative assessment questions individually:
    - *How do current trends of atmospheric carbon compare to historical atmospheric carbon trends?*
    - *Which source of carbon emissions is the likely cause of the current trend of atmospheric carbon?*
  - **Anchor to Activity – Tying it All Together:** Look back at the anchor, *Time is Like a River*, and ask students to review how they are able to determine what the river has looked like in the past. Ask students to make metaphors, comparing what tree rings or ice cores tell us about climate to what oxbow lakes tell us about a river's path.

Storyline Activities (continued)

Part C: Postcards from Future Destinations

- Display the Juruá River from the Anchor activity and ask students to make predictions about the future path of this river. Ask students to consider the following questions:
  - *What do we think may happen?*
  - *What evidence do we have for that?*
  - *What effect might that have on the local population?*
  - *What could we do to prevent this from happening?*
- Project Global Land-Ocean Temperature Index or pass out the Average Global Land and Sea Temperature Anomaly Graph and as a class, complete an I^2 of it. Pass out the carbon emissions graphs from the previous day, along with the sunspots graph. Provide students time to think about these graphs, then discuss which is best correlated. What does that correlation mean?
- Provide students with some background regarding global warming and highlight that global warming will have different impacts depending on location. Students will be conducting research into a specific region and determining what impacts global warming will have there and why. Students will forecast what the future of this location will look like and create a postcard from that future destination, including an illustration on the front and a message on the back.
- After the projects are completed, display them around the room and provide an opportunity for students to complete a gallery walk. At the end of the gallery walk, ask students to share a fact that excites them, a fact that worries them, a fact we need to know, and a stance or suggestion they have for moving forward.

Extension Activities

Deeper Dive

- Tree-Ring Expeditions
- Vostok Ice Core: Excel
- Paleoclimate Reconstruction Lab

Online Resources

- » New York Times article: In the Atlantic Ocean, Subtle Shifts Hint at Dramatic Dangers
- » Ted-Ed video: The Colossal Consequences of Super Volcanoes (4:51)
- » MinuteEarth video: These tiny shells know how much ice there is on Earth (2:50)
- » Brigham Young University video: Tree Stories: How Tree Rings Reveal Extreme Weather Cycles (2:26)
- » Reuters video: Scientists Scramble to Harvest Ice Cores as Glaciers Melt (3:20)

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