Activity 2
Change Is in the Air

FORCES OF CHANGE

Atmosphere

CHANGE IS IN THE AIR

Smithsonian
National Museum of Natural History

ACTIVITY 2

Change Is in the Air

The Early Devonian Period
(416 – 397 million years ago)

Illustration by Mary Parrish © Smithsonian Institution

Overview

Students compare the composition and temperature of the atmosphere since Earth began with the atmosphere's composition and temperature in the past two centuries.

Suggested Grade Level

7 – 10

National Standards Alignment

National Science Education Standards
Earth and Space Science, Content Standard D, Grades 9 – 12: The Origin and Evolution of the Earth System: The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago. The early earth was very different from the planet we live on today. Grades 5 – 8: Earth's History: The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred

Time

One class period (30 – 60 minutes)

Vocabulary

EOCENE EPOCH—period of Earth history 57 to 38 million years ago
EVOLUTION—changes in living and non-living systems over time
FOSSIL FUELS—fuels such as oil and coal that come from the remains of plants and animals buried millions of years ago
PALEOCLIMATOLOGIST—scientist who studies ancient climates

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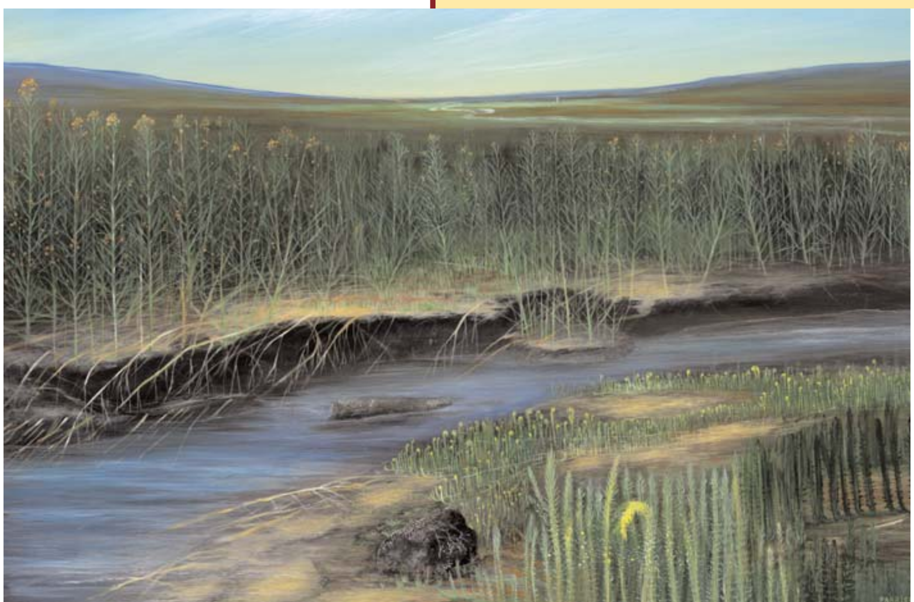
OBJECTIVES

Students will be able to:

1. Explain what has caused climate changes hundreds of thousands of years ago.
2. Describe how climate changes occurring today are the same or different from past changes to Earth's climate.
3. Describe how scientists perform research on past climates.



The Archean Eon
(Four to 2.5 billion years ago)
Illustration by Peter Sawyer, modified by Mary Parrish © Smithsonian Institution

Background

In the 4.6 billion years of Earth's history, the composition of the atmosphere has changed from a hazy, unfamiliar mix to today's mostly blue skies. As the atmosphere developed, life began and evolved. The evolution of living things changed the atmosphere, and those changes in turn altered life.

To deduce what the atmosphere has been like for billions of years, paleontologists, geologists, and paleoclimatologists study rocks, ancient soils, and fossils. With every new find, they improve and refine their understanding of ancient atmospheres.

Three billion years ago, the sun was only about 70 percent as bright as it is today. Earth should have frozen over, but it didn't. Why not? Because greenhouse gases in the atmosphere, mainly methane and carbon dioxide, retained enough of the sun's heat to keep temperatures above freezing.

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The Late Carboniferous Period (Pennsylvanian) (318 – 299 million years ago)

Illustration by Mary Parrish © Smithsonian Institution

During most of the past 290 million years, Earth was much warmer than it is now. Between 200 and 45 million years ago polar ice caps were small or absent, and winters were warmer around the globe. Many scientists think that high levels of CO_2 in the atmosphere contributed to keeping the climate warm. High-latitude forests may also have raised temperatures by absorbing heat from the sun. Regardless of the cause, warm climates enabled many types of plants and animals to live in the Polar Regions.

Decreases in atmospheric CO_2 have been linked to ice ages over the past million years, when ice sheets periodically blanketed much of the Northern Hemisphere. Scientists studying air bubbles trapped in cores of ancient ice from Greenland and Antarctica found that continental ice sheets advanced while CO_2 in the atmosphere decreased. As the ice sheets advanced and retreated and the climate changed, many species vastly changed their geographic ranges.

At the start of the Eocene Epoch, about 55.5 million years ago, Earth experienced perhaps the most sudden and extreme warming at any time in its history. This planetary heat wave is called the Paleocene-Eocene Thermal Maximum, or PETM. Scientists have found evidence that the PETM was associated with a major release of CO_2 into the environment, much as is happening with burning fossil fuels today. What we learn from studying the PETM may help us understand our own future.

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Activity

1. Explain the activity and provide background information on the Earth's changing atmosphere.

2. If the classroom has enough computers for students to work independently, assign each student to a computer. If the classroom does not have enough computers for individual work, divide the class up into groups.

3. Provide students with the following list of web sites that contain historical atmospheric data and have students spend up to fifteen minutes reviewing the sites.

   The Mauna Loa curve (atmospheric carbon dioxide measurements since 1958) http://maps.grida.no/go/graphic/co2_concentration_in_the_atmosphere_mauna_loa_curve

   Vostok ice cores (carbon dioxide and temperature data from ice cores for the past 460,000 years)
   http://gcmd.nasa.gov/records/GCMD_CDIAC_CO2_VOSTOK_ICECORE.html

   Temperature changes over the past 1,000 years
   http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewclimate.htm

Questions

Students should write down answers to the following questions:

1. Is a correlation between Earth's average temperature and carbon dioxide levels? What is the correlation?

2. How rapidly did carbon dioxide and temperature fluctuate hundreds of thousands of years ago. How rapidly have they fluctuated in the past 1,000 years?

3. What causes the fluctuations?

4. Are the fluctuations in the past 1,000 years in keeping with natural variation or not?

5. What do you noticed about changes in the fluctuations since the 19th century when the Industrial Revolution increased emissions of carbon dioxide into the atmosphere?

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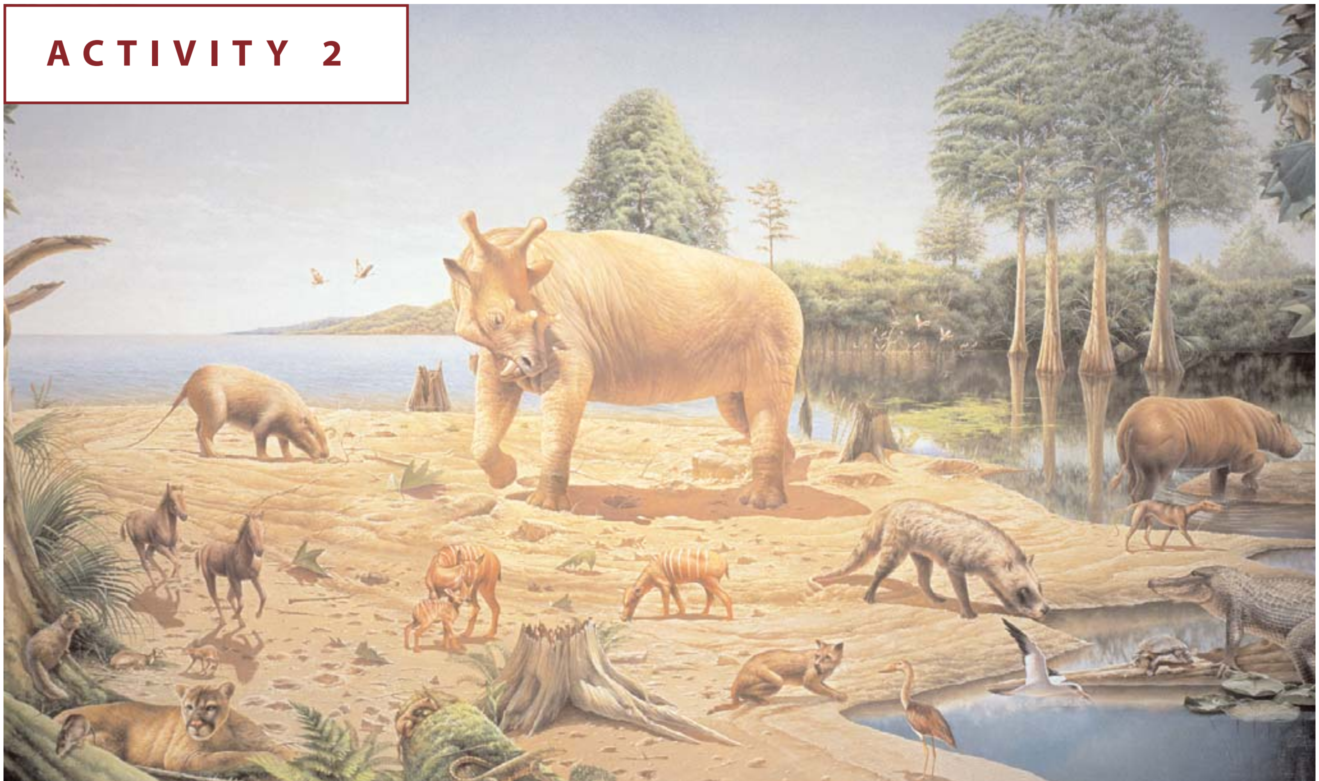

The Eocene Epoch
(55.8–33.9 million years ago)

Illustration by Bob Hynes © Smithsonian Institution

Extension

Introduction to Paleoclimatology

Background

The Eocene Epoch was the warmest part of the past 65 million years. During the early Eocene, palm trees grew as far north as Canada, and forests of dawn redwoods covered Ellesmere Island near the North Pole. The Arctic Ocean was not permanently frozen, alligator relatives swam in the swamps on Ellesmere Island, and mammals related to flying lemurs climbed in the dawn redwood trees. Since the Eocene is so recent (geologically speaking), many clues remain to tell scientists about the atmosphere and climate, and how these affected life on Earth.

Eocene fossils from near the poles tell us that the yearly average temperature at high latitudes was as much as 25°C (45°F) warmer than it is today. If the whole planet had been that much warmer, the average temperature at the equator would have been close to 50°C (122°F)—too hot for many kinds of animals and plants to survive. Instead, scientists think that in the Eocene the tropics were about the same temperature they are today, and that Earth's warmth was more evenly distributed from the equator to the poles.

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Fossil Ginkgo leaf, 58 million years ago, North Dakota

Photo by James DiLoreto © Smithsonian Institution

Background (continued)

High levels of CO_2 in the atmosphere cause temperatures to rise globally. But during the Eocene, temperature differences between the poles and the tropics were smaller than they are today. This pattern suggests that factors in addition to CO_2 in the atmosphere might have been at work. Paleoclimatologists (scientists who study ancient climate) like the Smithsonian's Scott Wing want to know how much CO_2 was in the atmosphere during the Eocene. How do they find out?

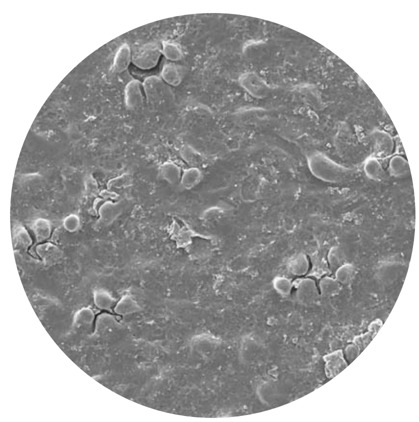
Ginkgo trees that grew during the Eocene Epoch were almost identical to those that grow today. A team of paleoclimatologists including Dr. Wing has used Ginkgo fossils to estimate the amount of CO_2 in the atmosphere.

Tiny pores, or stomata, on Ginkgo leaves act like little mouths to let in CO_2 used in photosynthesis. As the amount of CO_2 in the atmosphere increases, leaves can take in the same amount of CO_2 with fewer pores. Careful counting under a microscope shows that the density of pores on fossil Ginkgo leaves is about the same as the density of pores on leaves of living *Ginkgo* trees. This finding suggests that the amount of CO_2 in the Eocene atmosphere was not very different from present, and some factor other than atmospheric CO_2 was responsible for warm Eocene climates.

Some paleoclimatologists think that warmth at the poles was the result of higher atmospheric levels of water vapor or methane, which, like CO_2, are greenhouse gases. Methane may have created clouds of ice crystals that held in heat over the poles like a planetary ski cap.

Activity

Obtain leaves from a Ginkgo tree. Dry them carefully. Look at the pores, or stomata, in the leaves under a microscope. Compare them with the pores in this fossil Ginkgo leaf from 55 million years ago. Is the number of pores approximately the same?



Fossil Ginkgo leaf, 55 million years ago, Wyoming, magnified to show pores

Scott Wing © Smithsonian Institution