EDC Earth Science

TEACHER EDITION

LAB-AIDS
Experiencing Science

The following pages are select samples from

EDC Earth Science

Included in this packet are sections from the *Teacher Edition* to be used in conjunction with the provided sample equipment and *Student Book* pages. We encourage the use of all provided sample materials in or out of a classroom to properly understand the seamless integration between equipment, student materials, and teacher resources.

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CHAPTER SIX

The Longest Experiment: Climate Change in Earth's History

Overview

Scientists use sophisticated computer models to simulate the complex interactions between components of Earth's climate system. These models are critical to predictions about climate change that will happen in the coming decades. However, small changes in the assumptions that underlie these models can have a significant influence on what these models predict. How do scientists know how Earth will actually behave?

Earth's climate system has been operating for billions of years, and as it turns out, the climate has changed dramatically in the past. Earth's geologic record—in the form of ice, sediments, rocks, and fossils—is a treasure trove of information about climate change that has happened in the past and how these changes have affected the planet. Earth's climate system is very complex, and although scientists continue to improve their understanding of the different factors and feedbacks operating on different time and spatial scales, the information presented in this chapter is necessarily quite simplified. There are so many feedbacks within Earth's climate system that the absolute causes of climate change are uncertain. However, the data from the study of Earth's climate history are invaluable in improving the accuracy of global climate models and making better predictions about the future.

In this chapter, students explore climate change that has happened in Earth's past and think about its relevance to climate change happening now. They study data about changes currently happening related to Earth's climate and examine the forecasts of climate models about Earth's future. In addition to building on their foundation of knowledge about Earth's atmosphere and hydrosphere from previous chapters, this study connects them to many of the concepts covered later in the course, relating to plate tectonics and the rock cycle.

Goals for Student Understanding

This table shows alignment of *Framework for K–12 Science Education* (the *Framework*) content, practices of science and engineering, and crosscutting concepts with chapter learning objectives. This is not intended to be used as a checklist, but it shows how students' learning experiences in *EDC Earth Science* map to the *Framework* goals.

Learning Objective	Framework Content, Practices, and Crosscutting Concepts	Where Taught
Students understand that Earth's climate has changed dramatically in the past.	ESS2.D.4 Asking questions Developing and using models Constructing explanations Patterns Cause and effect Systems and system models Scale, proportion, and quantity Energy and matter Stability and change	*What's the Story?*—"Journey to a Different Time" *Activity 3*—"Investigating How Orbital Changes Have Affected Past Climate" *Reading*—"The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age" "How Fast Can the Climate Change?
Students know that scientists investigate Earth's climate history by studying records of past climates stored in tree rings, coral, rocks, sediment, and ice, as well as more recent human records of weather data.	ESS2.D.2 Analyzing and interpreting data Using mathematics Constructing Explanations Engaging in Argument from Evidence Patterns Cause and effect Stability and change	*Activity 2*—"Using Climate Proxies" *Activity 4*—"What's Happening Now and What's Predicted for the Future?" *Reading*—"Evidence of Earth's Past"
Students know that periodic changes in the tilt of Earth as well as its orbit have caused changes in the distribution of solar input, which has affected global climate in the past.	ESS2.D.2 Developing and using models Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Activity 3*—"How Orbital Changes have Affected Past Climate"
Students know that historical fluctuations in global average temperature have corresponded with fluctuations in atmospheric CO_2 levels, related to factors such as the movement of tectonic plates over millions of years.	ESS2.D.1, ESS2.D.3, ESS2.D.4 Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Readings*— "The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age" "How Fast Can the Climate Change?" "Sorting Out Natural and Human-induced Climate Change"
Global climate models predict that temperatures will continue to rise, and that the amount of temperature change predicted is related to future CO_2 emissions. These temperature increases are already causing sea level rise, the melting of glacial and polar ice, and changes in precipitation and ocean acidity. Students know that CO_2 increases over the past 100 years are largely attributable to human activities.	ESS2.D.5, ESS2.D.6 Analyzing and interpreting data Using mathematics Using Models Engaging in Argument from Evidence Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Activity 4*—"What's happening now and what's projected for the future?" *Reading*—"What's Happening Now and What's Predicted for the Future?"

Possible Misconceptions and Barriers to Learning

- The concepts covered in this chapter are sophisticated and will challenge students to use all the skills they have acquired during this course. Many students are likely to still have difficulties with visualizing Earth's processes in three dimensions and understanding that small, incremental changes over millions of years can have dramatic effects. They also are likely to continue to struggle with conceptualizing complex, dynamic systems involving multiple interacting factors. Be aware of these challenges as you listen to students during class discussions and review their work.
- Many people have the idea that during the Pleistocene the temperatures were constantly below freezing and don't understand that there were periods during which the climate was as warm as today. The Ice Age was actually a period of climate instability with dramatic fluctuations in temperature. The Pleistocene has included about 20 glacial intervals and 20 interglacial intervals. Scientists think that Earth's climate is in an interglacial interval today.

Assessment Outcomes

Students should be able to

1. give examples of how Earth's climate has changed in the past.
2. describe how climate proxies are used by scientists to investigate Earth's climate history.
3. model how periodic changes in Earth's orbit, called Milankovitch cycles, triggered the advance and retreat of continental ice sheets during the Pleistocene.
4. explain and give an example of how increased rates of volcanism associated with plate tectonic movements may have caused increased levels of atmospheric CO_2 and global warming in the past.
5. explain and give an example of how mountain-building associated with collisions between two plates can decrease atmospheric CO_2 levels and cause global cooling.
6. describe how certain changes in Earth's systems such as sudden changes in ocean circulation, can cause more rapid climate change.
7. relate the predictions of global climate models to CO_2 emissions, and to data regarding changes in precipitation, ocean acidity, arctic ice extent, glacier volume, and sea-level rise.
8. describe evidence that human activities have increased CO_2 concentrations in the atmosphere and caused the increased global temperatures measured over the last century.

Assessment Strategies

Students have a number of opportunities in this chapter to express their initial and developing understanding of concepts related to the processes that cause Earth's climate to change. By taking note of the answers given by students completing group work or working individually, you can determine pacing, identify which concepts need more or less emphasis, and gauge students' understanding of the content at the end of the chapter. The following table summarizes the formative and summative assessment opportunities.

The table also provides an alignment between the student assessment outcomes and the assessment items at the end of the chapter. You should determine ahead of time which of these assessment opportunities you will evaluate formally (assign a grade) and which you will evaluate more informally. In general, the *Consider* and *Investigate* sections provide opportunities for formative assessment, and the *Process* section provides opportunities for summative assessment.

Opportunities	Information Gathered
Consider	
Brainstorming	Students' prior understandings of Earth's history and initial ideas about what could have caused climate to be different in the past
What's the Story—"Journey to a Different Time"	Students' initial understandings of the types of evidence used to reconstruct Earth's climate history, and review of how changes in Earth's energy balance can affect global temperature Assessment Outcome 1 (Assessment items 7, 8)
Investigate	
Activity 1—"Looking for Clues to the Past"	Assessment Outcome 2 (Assessment items 1–3)
Reading—"Evidence of Earth's Past"	Assessment Outcome 2 (Assessment items 1–3)
Activity 2—"Using Climate Proxies"	Assessment Outcome 2 (Assessment items 1–3)
Activity 3—"Investigating How Orbital Changes Have Affected Past Climate"	Assessment Outcome 3 (Assessment items 4, 5)
Reading—"The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age"	Assessment Outcomes 4, 5 (Assessment item 6)
Reading—"How Fast Can the Climate Change?"	Assessment Outcome 6 (Assessment item 9)
Activity 4—"What's Happening Now and What's Projected for the Future?"	Assessment Outcome 7 (Procedure Part A, Steps 2, 3; Part B, Steps 1–3; Analysis Questions 1–5)
Reading—"Sorting Out Natural and Human-induced Climate Change"	Assessment Outcome 8 (Assessment item 7)
Address the Challenge	Students' abilities to synthesize what they have learned from their study of Earth's climate history and teach it to others through a museum exhibit
Process	
Share	Students' understandings of the key concepts covered in this chapter
Discuss	Students' ideas about how their thoughts about climate have changed since the beginning of this unit, and their abilities to synthesize what they have learned, relating phrases and terms used in this chapter to the concept of climate change
Assessment	Students' understandings of the range of concepts presented throughout the chapter; these questions can be used in class, for homework, or as a quiz at the end of the chapter.

Scope and Sequence

The following is provided to help with your lesson planning. Adjust it according to the needs and interests of your classroom, and whether you assign readings as homework or complete them in class.

WEEK			DAY		PREVIEW
1	**Consider**		1	Introduce chapter and discuss *Brainstorming* questions	Students brainstorm what they know about Earth's history—in particular, the Cretaceous Period in which dinosaurs lived and the Pleistocene Ice Age. They think about how climate could have been so much colder during the Pleistocene and about ways that studying climate change in Earth's history could help humans better understand climate change that is happening now.
			2	Read/discuss *What's the Story*—"Journey to a Different Time" Introduce *Challenge*	Students read a story about a very warm point in Earth's history when no polar ice caps existed and a very cold point in Earth's history when ice covered much of North America. They think about what might have caused Earth's climate to change so dramatically in the past and what might cause the climate to change now and in the future.
	Investigate	Gather Knowledge	3	*Activity 1*—"Looking for Clues to the Past"	Students practice looking for evidence of events that have happened in the past by looking for clues around the classroom.
			4	*Reading*— "Evidence of Earth's Past"	Students read about climate proxies—tools used by scientists to investigate Earth's climate history. They summarize what they have learned and think about the importance of collecting climate proxy data from different locations around Earth.
			5	*Activity 2*—"Using Climate Proxies"	Students use simulated proxy data from sediment cores to determine past ocean temperatures.
2			6	*Activity 3*—"Investigating How Orbital Changes Have Affected Past Climate"	Students use a model Earth and Sun to demonstrate the Milankovitch cycles and think about how these orbital cycles affect the intensity of Earth's seasons and in turn the advance and retreat of ice sheets during the Pleistocene.
			7	*Reading*—"The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Cretaceous"	Students read about how plate tectonic movements occurring over very long periods of time have led to warm and cool periods in Earth's history. They think about how climate change in the past is relevant to Earth's future.
			8	*Reading*—"How Fast Can the Climate Change?"	Students read about abrupt climate change events that have occurred in Earth's history and the potential causes of these events.
			9	*Activity 4*—"What's Happening Now and What's Projected for the Future," Part A	Students study the predictions of global climate models and relate them to observed changes in global temperature, sea-level rise, ice measurements, ocean acidification and precipitation.
			10	*Activity 4*—"What's Happening Now and What's Projected for the Future," Part B	
3		Address the Challenge	11	*Reading*—"Sorting Out Natural and Human-Induced Climate Change	Students read about how scientists use their understanding of Earth's climate history to assess whether climate change happening now is due to natural processes or human activities. They summarize evidence that human activities are contributing to the current warming trend.
			12	*Address the Challenge:* Create Museum Exhibit	Students prepare museum exhibits that explain the key concepts they studied in this chapter.
	Process		13	*Share* exhibits	Students share their museum exhibits and review the major concepts covered in this chapter.
			14	*Discuss* concept mapping	Students discuss how their ideas about climate have changed since the beginning of the unit and review the complex factors that can bring about climate change by creating a concept map that relates the various terms and phrases used in this chapter.
	Review		15	Review	
	Assessment		16	Summative Assessment	

Materials and Preparation

Note: All reproducible pages (Student Sheets, Literacy Supplements, and Resource Supplements) and many images from the student book can be found in the Teacher Resources as PDFs or slide presentations.

You may choose to use the following optional Literacy Supplements:

- Literacy Supplement 6.1: *Anticipation Guide* for "Journey to a Different Time"
- Literacy Supplement 6.2: *Three-Level Reading Guide* for "Evidence of Earth's Past"
- Literacy Supplement 6.3: *Three-Level Reading Guide* for "The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age"
- Literacy Supplement 6.4: *Science Fact Triangle* for "How Fast Can the Climate Change?"
- Literacy Supplement 6.5: *Science Fact Triangle* for "Sorting Out Natural and Human-Induced Climate Change"

You may want to place a poster with a geologic timeline on the wall to refer to during this chapter.

Prior to *Activity* 2—"Using Climate Proxies"

1. Gather the materials listed below.

   FOR THE TEACHER
   - gravel, "foram" sheets, and 16 plastic "sediment core" tubes (*see* Step 2 below)

   FOR EACH TEAM OF STUDENTS
   - 1 "sediment core" (containing gravel and "forams") (*see* Step 2 below)
   - 1 tray (for sorting contents of "sediment core")
   - 1 calculator*

   FOR EACH STUDENT
   - (optional) ruler
   - graph paper*

   *not included in LAB-AIDS equipment package

Foram Counts for Activity 2

AGE (YBP=years before present)	FORAM COLOR	FORAM TYPE		
		RIGHT COILING	LEFT COILING	OTHER
0 ybp (today)	dark blue	42	8	25
30,000 ybp	yellow	10	40	25
60,000 ybp	gray	16	34	25
90,000 ybp	green	41	9	25
120,000 ybp	orange	44	6	25
150,000 ybp	light blue	11	39	25
180,000 ybp	brown	13	37	25
210,000 ybp	pink	23	27	25

2. Check the number of "forams" in each plastic "sediment core" tube (see Foram Counts table). There should be one striped set and one solid set for each age. Sort them if they are mixed. For first-time use, remove forams from sheets and place each set in one tube, along with about 200 cm^3 of gravel.

3. Create a class data table similar to the Foram Counts table. Post it so teams can record their data.

Prior to *Activity* 3—"Investigating How Orbital Changes Have Affected Past Climate"

1. Gather the materials listed below.

   FOR EACH TEAM OF STUDENTS
   - 1 plastic "planet" with wooden axis (*see* Step 2 below)
   - access to a light source*
   - marker

   *not included in LAB-AIDS equipment package

2. If needed, assemble the "plastic planets" by connecting the two halves and inserting a wooden dowel for the axis.

Prior to *Activity* 4—"What's Happening Now and What's Projected for the Future"

1. Gather the materials listed below.

   PART A—FOR EACH STUDENT
   - (optional) ruler
   - graph paper*

   PART B—FOR THE CLASS
   - 2 sets Expert Group 1 Data Cards (Figs. 6.20, 6.21 in student book)
   - 2 sets Expert Group 2 Data Cards (Figs 6.22, 6.23 in student book)
   - 2 Expert Group 3 Data Cards (Fig. 6.24 in student book)
   - 2 sets Expert Group 4 Data Cards (Figs. 6.25, 6.26 in student book)
   - means of projecting Expert Group Data Cards* (see Step 2 below)

   *not included in LAB-AIDS equipment package

2. Projectable Expert Group Data Card images are in the Chapter 6 slide presentation in Teacher Resources.

Prior to *Address the Challenge*

1. Gather materials for students to use to create visuals for their museum exhibits.

Prior to *Process*

1. Optional Resource Supplement 6.1: *Climate Change Concept Map* is available in Teacher Resources or the Chapter 6 slide presentation.

2. You may want to invite another class or community members to view students' museum exhibits.

less complete records show processes that affect climate over longer periods, and indicate how much climate has changed.

LITERACY SUPPLEMENT 6.2
Responses to *Three-Level Reading Guide* for "Evidence of Earth's Past"

1. *Are these statements correct? Mark Y or N for each statement. For statements marked "N," rewrite them so they are correct.*
   - Y a. Natural records of past climate, such as tree rings and coral growth, can tell us what it was like hundreds and even thousands of years ago.
   - N b. ~~Tree rings can be used to tell what the climate was like hundreds of thousands of years ago.~~ *Tree rings can be used to tell what the climate was like for the past few hundred years. Some long-lived species (e.g., redwoods) can provide information for one or two thousand years but are unreliable past that.*
   - Y c. Bubbles of trapped air in ice can be analyzed to tell us concentrations of greenhouse gases in the atmosphere at the time the ice formed.

2. *Do you think these statements agree with the reading? Mark Y or N for each statement. For statements marked "N," rewrite them so they are correct.*
   - Y a. It is possible to determine what the climate was like in the past, although the further back in time we go, the more uncertain we are of our determinations.
   - Y b. If data obtained from different methods agree, for example ice core and tree ring data, then we feel more confident in our determination of what the climate was like in years past.

3. *Do you agree with these statements and can you find evidence—in the reading or elsewhere—to support your position? Mark Y or N for each statement. For statements marked "N," rewrite them so they are correct.*
   - Y a. Although data from analysis of rocks is less detailed than that from tree rings, it is nevertheless valuable in determining what Earth's climate was like in the past.
   - Y b. Climate proxies, such as tree rings and ice cores are more reliable than human written records in general because people can make mistakes.

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2. Each of the climate proxies discussed in the reading yields information about climate in a particular area of Earth—land or sea, tropical, temperate, or arctic areas. Why would it be important to have data from all these different areas?
3. Some climate records, such as tree rings, give more detailed and continuous information about past climate, but only date back hundreds or thousands of years. Other climate records, such as those in continental rocks, go back much farther but are less complete or detailed. How might scientists use each of these types of information to learn about how Earth's climate system works?

ACTIVITY 2
Using Climate Proxies

Setting the Stage: Using Forams as Clues to Ocean Temperature

As you learned in the reading *Evidence of Earth's Past,* scientists are able to use various clues preserved in ocean sediment to learn about Earth's climate history. The microscopic foraminifera *Neogloboquadrina pachyderma* (*N. pachyderma*) serves as a particularly useful indicator of ocean temperature. These foraminifera (Figure 6.10) are found in two forms. When the ocean water is relatively warm, this organism tends to grow into a right-coiling form. When the water is relatively cold, *N. pachyderma* grows into a left-coiling form. When these organisms die, they settle to the ocean bottom and their skeletons are incorporated into the accumulating layers of sediment, preserving a record of the ocean temperature at the time each organism was alive.

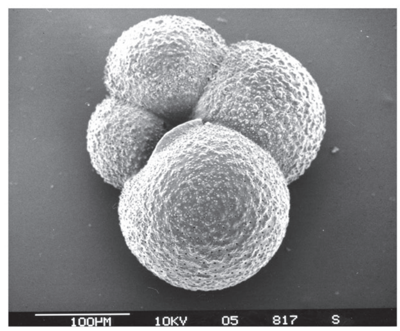

FIGURE 6.10 Neogloboquadrina pachyderma *is a microscopic organism that provides valuable clues about past ocean temperature.*

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ACTIVITY 2
Using Climate Proxies

In this activity, students simulate using evidence from ocean sediment cores to determine past climates.

Facilitating *Activity 2*—"Using Climate Proxies"

Prior to class:

- Post a table at the front of the classroom for students to use when recording their group's data. (See the Materials and Preparations section for the setup of this table.)

During class:

- Have students work with a partner on this activity.
- Review the procedures with the students and discuss what the sample bags represent. Remind them that in real life these foraminifera are so small that they would need to do the counting under a microscope. Also remind them that in actual sediment cores, there would likely be a number of different types of organisms other than *Neogloboquadrina pachyderma*.

- Make sure all teams record their data on the class chart, and then copy the class data into their notebook, filling in student Table 6.2.
- Have students answer the Analysis questions and prepare for a discussion.

Responses to *Analysis* for *Activity 2*—"Using Climate Proxies"

1. Describe your results:
   a. During what time periods was the ocean water relatively warm according to the simulated foraminifera data? *The water was relatively warm between 75,000 and 125,000 years ago and for the last 10,000 years.*
   b. During what time periods was the ocean water relatively cold according to the simulated foraminifera data? *The ocean water was relatively cold between 20,000 and 60,000 years ago and 140,000 and 200,000 years ago.*

Scientists study the record preserved in the sediment layers by drilling into the ocean bottom using a variety of coring devices. They obtain undisturbed sediment cores using hollow tubes, such as the one shown in Figure 6.11. The sediment cores are then brought to the surface and analyzed. The age of the layers is determined using radioisotopic dating techniques, and each layer is carefully studied.

In this activity, you will simulate counting and analyzing the number of right-coiling versus left-coiling *N. pachyderma* in the layers of a sediment core. You will use these data to determine past ocean temperatures.

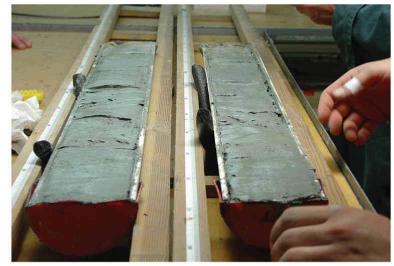


FIGURE 6.11
This sediment core from the ocean floor near New Zealand contains microscopic organisms, such as foraminifera, that can be used to determine past ocean temperatures. The core halves have been swiped with a spatula so that sedimentary features in the core can be seen.

Procedure

Record all observations and answers in your notebook as you work.

1. Carefully pour the contents of your core onto your desk or lab bench, being careful not to lose any pieces (this could cause errors in your measurements). Notice that there are three different fossil foraminifera (forams) as shown in Figure 6.12 below: left-coiling *N. pachyderma*, right-coiling *N. pachyderma*, and *Globigerinoides sacculifer (G. sacculifer):*[3]

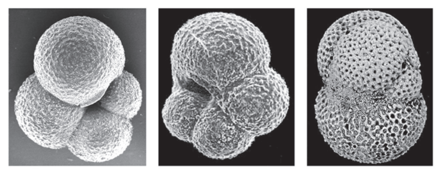


FIGURE 6.12
(left to right) Left-coiling N. pachyderma, *Right-coiling* N. pachyderma, G. sacculifer

2. Count and record the number of each of the different types of forams found in your sediment core.
3. Note the age of your core sample (printed on your core tube) then record the number of right-coiling and left-coiling *N. pachyderma* in the row of the class chart that corresponds to the age of your core.
4. Make a table in your notebook similar to Table 6.2. Copy the class data into it.

Materials

FOR EACH TEAM OF STUDENTS
- "sediment core" containing "forams"
- tray
- calculator

FOR EACH STUDENT
- ruler (optional)
- graph paper

2. Relate the ocean water temperature recorded in these sediment samples to past global climate. What does it tell you? What does it not tell you about global climate at the time these layers formed? *Students may say that these data tell you what ocean temperatures were like at the location where the sediment accumulated, and this is likely to correlate with atmospheric temperatures in that region as well. The data do not necessarily tell you what ocean and atmospheric temperatures were in other parts of the world. Additional data from different regions would need to be collected to develop a more global picture. These data also do not tell us about other aspects of the climate, such as precipitation.*

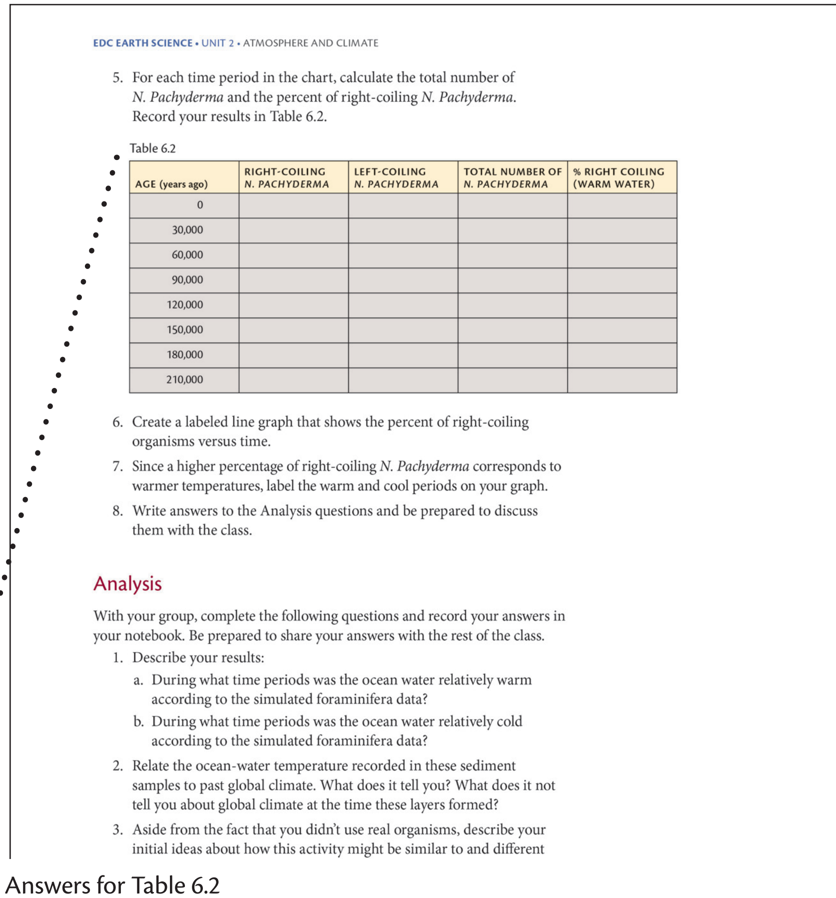
Teaching Strategies

The radio-isotopic dating techniques referred to in the introduction to this activity are covered in Chapter 8. However, you could spend some time teaching about dating techniques at this point as well.

Teaching Strategies

To abbreviate this activity, you could simply pass out the data to students (number of right-coiling and left-coiling foraminifera at each age interval) and have them complete the table and graph.

3. Aside from the fact that you didn't use real organisms, describe your initial ideas about how this activity might be similar to and different from the real processes scientists follow to analyze sediment cores. *Answers will vary. Students may say that the actual foraminifera samples would be much smaller and would need to be counted under a microscope, there probably wouldn't be the same number in each core sample, and/or that there are likely to be other organisms and materials within the sample as well. They might realize that it would be more difficult to distinguish differences in the coiling direction of two similar foraminifera than it was for them to sort the images (and that it would have to be done very carefully to avoid errors in measurements). Students may propose that in an actual sample, some foraminifera would be broken into pieces, making it more difficult to count the individuals. They may also have found that counting the foraminifera was somewhat tedious. It is not the intention of this activity to convince students that scientific work is boring; however, they should realize this type of careful work is very much a part of science and provides the basic data necessary for discoveries.*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5. For each time period in the chart, calculate the total number of *N. Pachyderma* and the percent of right-coiling *N. Pachyderma*. Record your results in Table 6.2.

Table 6.2

AGE (years ago)	RIGHT-COILING *N. PACHYDERMA*	LEFT-COILING *N. PACHYDERMA*	TOTAL NUMBER OF *N. PACHYDERMA*	% RIGHT COILING (WARM WATER)
0				
30,000				
60,000				
90,000				
120,000				
150,000				
180,000				
210,000				

6. Create a labeled line graph that shows the percent of right-coiling organisms versus time.
7. Since a higher percentage of right-coiling *N. Pachyderma* corresponds to warmer temperatures, label the warm and cool periods on your graph.
8. Write answers to the Analysis questions and be prepared to discuss them with the class.

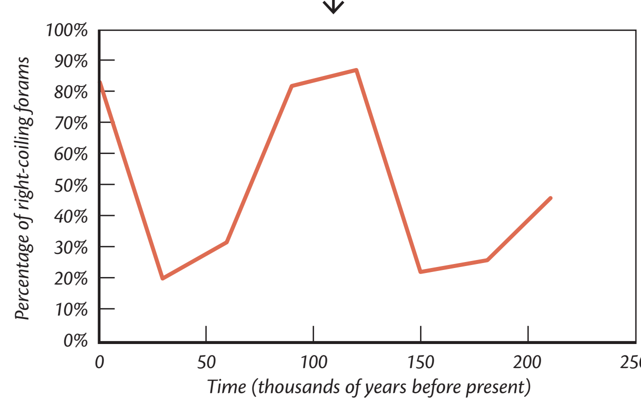
Analysis

With your group, complete the following questions and record your answers in your notebook. Be prepared to share your answers with the rest of the class.

1. Describe your results:
   a. During what time periods was the ocean water relatively warm according to the simulated foraminifera data?
   b. During what time periods was the ocean water relatively cold according to the simulated foraminifera data?
2. Relate the ocean-water temperature recorded in these sediment samples to past global climate. What does it tell you? What does it not tell you about global climate at the time these layers formed?
3. Aside from the fact that you didn't use real organisms, describe your initial ideas about how this activity might be similar to and different

Student Answers for Table 6.2

AGE (YEARS AGO)	RIGHT-COILING N. PACHYDERMA	LEFT-COILING N. PACHYDERMA	TOTAL N. PACHYDERMA	% RIGHT-COILING N. PACHYDERMA
0	42	8	50	84%
30,000	10	40	50	20%
60,000	16	34	50	32%
90,000	41	9	50	82%
120,000	44	6	50	88%
150,000	11	39	50	22%
180,000	13	37	50	26%
210,000	23	27	50	46%



EDC EARTH SCIENCE SEMESTER 1

The first semester introduces students to Earth's systems and focuses on the hydrosphere and atmosphere. Students explore the sources of freshwater on the continents and the effects of currents in the world's oceans. They delve into the science of climate and climate change, exploring the factors that affect climate locally and globally and investigating the causes of climate change in Earth's past.

CHAPTER	SCIENCE CONCEPTS	LEARNING ACTIVITIES
INTRODUCING EARTH SCIENCE		
Chapter 1 Comparing Earth to Other Worlds	Introduction to Earth's systems; basic requirements for sustaining life	Students read an excerpt from a science fiction story about Mars colonists and analyze the resources necessary to sustain human populations on this neighboring planet.
UNIT 1: HYDROSPHERE: WATER IN EARTH'S SYSTEMS		
Chapter 2 Life's Blood: Seeking Water from Earth	Water cycle; surface water, groundwater, assessing and protecting water supplies	Students learn about droughts in Texas and Tennessee, and consider how access to plentiful and clean water is critical to human survival. They build their knowledge about how water is obtained by reviewing the water cycle and learning the science behind surface and groundwater supplies. After researching case studies from communities around the world, they get up close and personal, evaluating where their water comes from and whether their supply could be threatened in the future.
Chapter 3 Rivers of the Sea: Ocean Currents	Global patterns of ocean circulation; how wind and density differences drive ocean currents; global conveyor belt; El Niño	Students read a true story about Thor Heyerdahl, the explorer who set sail across the Pacific in the primitive raft Kon-Tiki to prove a theory. Drifting on an ocean current, he sought to show that people from South America could have migrated to Polynesia over 1,000 years ago without the benefit of developed seafaring vessels. Students gather knowledge about the science of ocean currents to decide whether his idea was crazy or had a chance of success.
UNIT 2: ATMOSPHERE AND CLIMATE		
Chapter 4 Local Connections: Regional Climate	Climate and weather; influence of latitude, atmospheric circulation, proximity to ocean, elevation, land features, and prevailing winds on regional climate	Students start their exploration of climate close to home, learning about the climate in their local area and comparing it to a chosen travel destination. Students learn how climate is measured and how it affects the flora and fauna of a landscape. They investigate key factors that cause climate to vary so much around the world.
Chapter 5 The Bigger Picture: Global Climate	Energy balance, albedo effect, greenhouse effect, carbon cycle, positive and negative feedback loops	Students read about a community in Alaska that is threatened by global warming and research the factors that influence global climate and can cause it to change. Based on what they've learned, they consider whether members of the Alaskan community should move or stay, and prepare recommendations to share at a public meeting.
Chapter 6 The Longest Experiment: Climate Change in Earth's History	Paleoclimatology, climate proxies, climate change in Earth's past, Milankovitch cycles, tectonic processes that influence climate, human impact on climate	Students explore two time periods in Earth's past when climate was very different from today—the warm Cretaceous and a glacial interval of the Pleistocene. Students study evidence—recorded in sediments, rocks, and ice—that climate has varied through Earth's history, and explore the factors that have contributed to these changes. They look at evidence that Earth's climate is changing now and how human activity and natural factors contribute to this change.
MID-YEAR CHALLENGE		
Chapter 7 Broadcast from the Future	Synthesis of concepts learned in the first part of the course	Students use the knowledge they have gained during the first semester of this course to make predictions about what Earth will be like in the year 2100. They communicate their predictions in a news broadcast from the future.

EDC EARTH SCIENCE SEMESTER 2

During the second semester of *EDC Earth Science,* students gain a deeper understanding of Earth's systems by exploring Earth's place in the universe and the workings of the geosphere. They study how solar systems form as part of the life cycle of stars and investigate how Earth's interior and surface are moving and changing. They examine evidence of tectonic plate movement as they investigate volcanic eruptions and earthquakes that have occurred in the western United States. They explore rock cycle processes and use clues in rocks to determine events that have happened in Earth's past. After gaining a greater appreciation of Earth's geosphere, students revisit the solid Earth from a human perspective. They explore how the geosphere provides critical natural resources, and how human's use of these resources has affected the balance of Earth's systems.

CHAPTER	SCIENCE CONCEPTS	LEARNING ACTIVITIES
UNIT 3: EARTH'S PLACE IN THE UNIVERSE		
Chapter 8 Stars, Planets, and Everything in Between: Solar System Origins	Solar system formation, Kepler's Laws, radioactive dating, life cycle of stars, spectroscopy	Students explore Earth's place in the universe by investigating how planets and solar systems form as part of the life cycles of stars. They gather evidence for the solar nebular theory from the observable patterns of motion in the solar system. They learn about methods for dating the age of Earth and other solar system objects. They investigate planets, asteroids, comets, and other solar system neighbors, and compare different models that account for the birth of the solar system and the life and death of stars. They learn about Kepler's Laws of Motion and investigate the geometry of movement of orbits. They conduct a mock trial to examine evidence for the solar nebular condensation theory, and examine line spectra used by astronomers to investigate the composition of objects located many light years from Earth.
Chapter 9 Journey to the Center of the Earth: Exploring Earth's Interior	Earth's interior structure and composition, internal sources of heat energy, seismic waves, introduction to plate tectonic theory, driving forces of plate movement	Students begin their exploration of the geosphere by looking down at their feet and wondering what lies below them. If they could dig through the floor, through the foundation of their building, through the soil and rocks, and keep going and going, what would they see? They explore Earth's internal structure, as well as the movements and changes that occur within the planet that have a profound effect on Earth's surface. Ultimately, students synthesize their understanding of Earth's interior by creating a "journey" into the earth, communicating scientific information about what they would encounter along the way.
UNIT 4: PLATE TECTONICS		
Chapter 10 On Shaky Ground: Earthquakes and Transform Boundaries	Transform-fault boundaries, earthquakes, physical and computer models, earthquake forecasting	Students read about the 1906 San Francisco earthquake and study the relationship of this event to the transform-fault boundary along the west coast of California. They use global-positioning-system (GPS) data to track plate motions, build a physical model to understand movements along the fault, and study computer models scientists use to forecast when and where earthquakes will occur.
Chapter 11 Sleeping Dragons? Subduction-Zone Volcanoes	Subduction zones, volcanoes and types of volcanic eruptions, technologies for volcano monitoring, data analyses	Students examine the relationship of the Cascade volcanoes in Washington, Oregon, and California to the subduction zone along the Northwest coast. They plot earthquake data to delineate a subduction zone and learn how scientists monitor changes beneath a volcano that may signal an imminent eruption. Ultimately, students apply information about the eruptive histories of the Cascade volcanoes, combined with current monitoring data, to assess the risk associated with living near volcanoes such as Mount Rainier.
Chapter 12 Clues on the Ocean Floor: Divergent Boundaries	Seafloor spreading, paleomagnetism, plate tectonics summary, landforms associated with plate boundaries	Students explore the process of seafloor spreading occurring along the Mid-Atlantic Ridge, looking for patterns in maps of earthquake distribution, seafloor topography, ocean crust age, and paleomagnetic data. They pull together what they've learned about plate tectonic processes that occur along divergent, convergent, and transform-plate boundaries.

requires students to synthesize their learning throughout the semester. The units within the two semesters are as follows:

EDC Earth Science Semester 1

Unit 1: Hydrosphere: Water in Earth's Systems
Unit 2: Atmosphere and Climate
Mid-Year Challenge

EDC Earth Science Semester 2

Unit 3: Earth's Place in the Universe
Unit 4: Plate Tectonics
Unit 5: The Rock Cycle
Unit 6: Earth Resources
Final Challenge

You will find more information regarding the content of this course at the beginning of each chapter in the teacher edition, along with information about the crosscutting concepts and scientific practices embedded in the chapter activities and readings.

NGSF ALIGNMENT

The following table shows the correlation between the concepts addressed in *EDC Earth Science* and *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012).

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
ESS1 EARTH'S PLACE IN THE UNIVERSE		
ESS1.A: THE UNIVERSE AND ITS STARS		
The star called the Sun is changing and will burn out over a life span of approximately 10 billion years.	3: Earth's Place in the Universe	8
The sun is just one of a myriad of stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe.	3: Earth's Place in the Universe	8
The study of stars' light spectra and brightnesses is used to identify compositional elements of stars, their movements, and their distances from Earth.	3: Earth's Place in the Universe	8
ESS1.B: THE EARTH AND THE SOLAR SYSTEM		
Kepler's Laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun.	3: Earth's Place in the Universe	8
Orbits may change due to the gravitational effects from, or collisions with, other bodies.	3: Earth's Place in the Universe	8
Gradual changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.	2: Atmosphere and Climate	6
ESS1.C: THE HISTORY OF PLANET EARTH		
Radioactive-decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time.	3: Earth's Place in the Universe 5: The Rock Cycle	8 14
The continents' rocks (some as old as 4 billion years or more) are much older than rocks on the ocean floor (less than 200 million years), where tectonic processes continually generate new rocks and remove old ones.	3: Earth's Place in the Universe 4: Plate Tectonics 5: The Rock Cycle	9 10–12 14
Although active geological processes, such as plate tectonics (link to ESS2.B) and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	3: Earth's Place in the Universe 4: Plate Tectonics 5: The Rock Cycle	8. 9 10–12 13, 14
ESS2: EARTH'S SYSTEMS		
ESS2.A: EARTH MATERIALS AND SYSTEMS		
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep knowledge of how feedbacks work within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts.	1: Hydrosphere: Water in Earth's Systems 2: Atmosphere and Climate 4: Plate Tectonics	2, 3 4–6 10, 11
Evidence from deep probes and seismic waves, reconstructions of historical changes in the earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid but plastic mantle, and a solid surface crust.	3: Earth's Place in the Universe	9

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
The top part of the mantle, along with the crust, forms structures known as tectonic plates. Motions of the mantle and its plates are driven by convection (i.e., the flow of matter due to the energy transfer from the interior outward and the gravitational movement of denser materials toward the interior).	3: Earth's Place in the Universe 4: Plate Tectonics	9 10–12
The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities.	2: Atmosphere and Climate	4–6
These changes can occur on a variety of time scales from sudden (e.g., volcanic dust clouds) to intermediate (ice ages) to very-long-term tectonic cycles.	2: Atmosphere and Climate	4–6
ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS		
The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle. This energy moves through and out of the planet's interior, primarily by mantle convection.	3: Earth's Place in the Universe 4: Plate Tectonics	9 10
Plate tectonics can be viewed as the surface expression of mantle convection.	3: Earth's Place in the Universe 4: Plate Tectonics	9 10–12
ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES		
The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics	2, 3 11
These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.	1: Hydrosphere: Water in Earth's Systems 2: Atmosphere and Climate 4: Plate Tectonics 5: The Rock Cycle 6: Earth Resources	2, 3 4–6 11 13, 14 15
ESS2.D: WEATHER AND CLIMATE		
Global climate is a dynamic balance on many different time scales among energy from the sun falling on Earth; the energy's reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems; and the energy's re-radiation into space.	2: Atmosphere and Climate	4–6
Climate change can occur if any part of Earth's systems is altered. Geological evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer term changes (e.g., ice ages) due to variations in solar output, Earth's orbit, or the tilt of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen.	2: Atmosphere and Climate	4–6
The time scales of these changes varied from a few to millions of years. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	2: Atmosphere and Climate	4–6
Global climate models incorporate scientists' best knowledge of physical and chemical processes and of the interactions of relevant systems. They are tested by their ability to fit past climate variations.	2: Atmosphere and Climate	6
Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise.	2: Atmosphere and Climate	6
The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and the biosphere. Hence the outcomes depend on human behaviors as well as on natural factors that involve complex feedbacks among Earth's systems.	2: Atmosphere and Climate	6
ESS2.E: BIOGEOLOGY		
The many dynamic and delicate feedbacks between the biosphere and other earth systems cause a continual coevolution of Earth's surface and the life that exists on it.	2: Atmosphere and Climate 3: Earth's Place in the Universe	4, 6 8

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
ESS3: EARTH AND HUMAN ACTIVITY		
ESS3.A: NATURAL RESOURCES		
Resource availability has guided the development of human society. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks, as well as benefits.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
New technology and regulation can change the balance of these factors.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
ESS3.B: NATURAL HAZARDS		
Natural hazards and other geological events have shaped the course of human history by destroying buildings and cities, eroding land, changing the course of rivers, and reducing the amount of arable land.	4: Plate Tectonics 5: The Rock Cycle	10, 11 12, 13
These events have significantly altered the sizes of human populations and have driven human migrations.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics 5: The Rock Cycle	2 10, 11 13
Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics 5: The Rock Cycle	2 10–12 13
ESS3.C: HUMAN IMPACTS ON EARTH SYSTEMS		
The sustainability of human societies and of the biodiversity that supports them require responsible management of natural resources not only to reduce existing adverse impacts but also to get things right in the first place.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
Scientists and engineers can make major contributions—for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
When the source of a problem is understood and international agreement can be reached, it has been possible to regulate activities to reverse or avoid some global impacts (e.g., acid rain, the ozone hole).	2: Atmosphere and Climate 6: Earth Resources	6 16
ESS3.D: GLOBAL CLIMATE CHANGE		
Because global climate changes usually happen too slowly for individuals to recognize them directly, scientific and engineering research—much of it based on studying and modeling past climate patterns—is essential.	2: Atmosphere and Climate	5, 6
The current situation is novel, not only because the magnitudes of humans' impacts are significant on a global scale but also because humans' abilities to model, predict, and manage future impacts are greater than ever before.	2: Atmosphere and Climate	5, 6
Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities, as well as to changes in human activities. Thus science and engineering will be essential both to understanding the possible impacts of global climate change and to informing decisions about how to slow its rate and consequences—for humanity as well as for the rest of the planet.	2: Atmosphere and Climate	5, 6