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CK-12 Earth Science For High School Teacher's Edition



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CHAPTER

1

HS TE What is Earth Science?

Chapter Outline

- 1.1 CHAPTER 1: WHAT IS EARTH SCIENCE?
 - 1.2 LESSON 1.1: THE NATURE OF SCIENCE
 - 1.3 LESSON 1.2: EARTH SCIENCE AND ITS BRANCHES
-

1.1 Chapter 1: What Is Earth Science?

Chapter Overview

This chapter outlines the scientific method and the use of models. It also delineates the field of Earth science and describes several of its branches.

Online Resources

See the following Web sites for appropriate laboratory activities:

In this lab, students will learn the steps of the scientific method by identifying and applying each step to a fun activity that compares variables between two types of bubble gum. Students will be asked to form a hypothesis, collect and organize data, use scientific measurements, and differentiate between qualitative and quantitative data.

- <http://serc.carleton.edu/sp/mnstep/activities/27600.html>

In this inquiry lab, students will use the scientific method to solve a problem. They will develop and test a hypothesis to answer the question: Does the number of times a pendulum swings depend on the weight attached to it or to the length of the string? The URL below is the teacher page for the activity. It has links to a student guide and handout.

- <http://www.biologycorner.com/worksheets/pendulum.html>

These Web sites may also be helpful:

You can go the URL below for information on common student misconceptions about science and the scientific endeavor.

- <http://undsci.berkeley.edu/teaching/misconceptions.php>

These URLs provide tips, strategies, and background for teaching high school students about the nature and process of science.

- <http://undsci.berkeley.edu/teaching/tips.php>
- http://undsci.berkeley.edu/teaching/912_implications2.php

At this URL, you can find links to downloadable scientific method flowcharts that portray science inquiry as a dynamic process.

- <http://undsci.berkeley.edu/teaching/teachingtools.php>

Pacing the Lessons

TABLE 1.1: short caption

Lesson	Class Period(s) (60 min)
1.1 The Nature of Science	1.5
1.2 Earth Science and Its Branches	1.0

1.2 Lesson 1.1: The Nature of Science

Key Concepts

- Scientific method
- Scientific models
- Importance of community in science
- Safety in science

Lesson Objectives

- Identify the goal of science.
- Explain the importance of asking questions.
- Describe how scientists study the natural world.
- Explain how and why scientists collect data.
- Describe the three major types of scientific models.
- Explain how a scientific theory differs from a hypothesis.
- Describe appropriate safety precautions inside and outside the science laboratory.

Lesson Vocabulary

- **conceptual model:** abstract, mental representation of an object or system
- **control:** factor that is kept constant in an experiment so that only the independent variable changes
- **dependent variable:** variable in an experiment that is measured to see how it is affected by changes in the independent variable
- **hypothesis:** testable, plausible explanation for a scientific question or problem
- **independent variable:** variable in an experiment that is changed by the researcher in order to test its effect on the dependent variable
- **mathematical model:** set of equations that represents a real-world process or simulates a natural system
- **model:** representation of an object or system that is simpler than reality and easier to manipulate and study
- **physical model:** physical representation of an object or system
- **scientific method:** series of steps for investigating a testable question using empirical information gathered from experimentation, experience, or observation
- **theory:** broad scientific explanation that has been repeatedly tested and supported by evidence

Teaching Strategies

Introducing the Lesson

Use a projector to show the class the world map of volcanoes at the following URL: <http://www.cccarto.com/volcanofinder.html>.

Question: What do you observe about volcanoes from this map?

Sample answer: Volcanoes are concentrated in certain locations. For example, a ring of many volcanoes surrounds the Pacific Ocean.

Question: What questions do the observations raise?

Sample answer: Why do so many volcanoes occur around the Pacific? What causes volcanoes?

Point out that most scientific investigations begin with questions that arise because of observations such as these. Tell students they will learn more about scientific investigations when they read this lesson.

Discussion

Lead the class in a discussion of the importance of falsification as a criterion of a scientific hypothesis. Discuss how a falsifiable, or testable, hypothesis can be proven wrong if it is indeed wrong because observations or measurements can be made to test it. Ask students to brainstorm hypotheses that can and cannot be falsified.

Building Science Skills

Use the worksheets in the PDF document below to give students practice identifying dependent and independent variables and controls in scientific experiments. Students may work alone or in groups on the activity, which could also be assigned as homework.

http://www.lessonplansinc.com/lessonplans/identifying_variables_ws.pdf

Differentiated Instruction

Ask students to think about how a hypothesis might gain the status of a theory. Then pair any ELL students or less proficient readers with other students, and have them work together to discuss and answer the question.

Enrichment

Have students who need extra challenges collaborate on making a science safety video to share with the rest of the class. Make sure the students include safety rules that you know will be especially important for Earth science class.

Science Inquiry

The scientific method is applied to myths and legends in the Discovery Channel's Mythbusters show. Video clips from the show are available at the first URL below. Have students use the PDF worksheet at the second URL below to analyze how the scientific method was applied in each video. After students view one or more videos, challenge small groups of students to develop their own investigation to test one of the myths or legends from the show.

<https://www.google.com/search?q=mythbusters%20videos&hl=en&source=ig&tbm=vid> (video clips from show)

<http://sciencespot.net/Media/mythbusterswkst.pdf> (student worksheet)

Overcoming Misconceptions

Several terms introduced in this lesson are often confused, leading to serious misconceptions about the nature of science and scientific investigation. The terms include hypothesis, scientific law, and theory. Have students go the following URL and under “Vocabulary Mix-ups,” click on each of the terms to read about them in detail.

<http://undsci.berkeley.edu/teaching/misconceptions.php>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 1.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 1.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students’ mastery of the lesson with Lesson 1.1 Quiz in *CK-12 Earth Science For High School Quizzes and Tests*.

Points to Consider

What types of models have you had experience with? What did you learn from them?

What situations are both necessary and dangerous for scientists to study? What precautions do you think they should use when they study them?

How does the scientific meaning of the word theory differ from the common usage? Can you find an example in the media of where the word was used incorrectly in a scientific story? The misuse of the word theory is rampant in the media and in daily life.

1.3 Lesson 1.2: Earth Science and Its Branches

Key Concepts

- Overview of Earth science
- Major branches of Earth science

Lesson Objectives

- Define and describe Earth science.
- Identify the field of geology.
- Describe oceanography.
- Define meteorology.
- Understand what astronomy studies.
- List other branches of Earth science, and explain how they relate to the study of Earth.

Lesson Vocabulary

No new vocabulary terms are introduced in this lesson.

Teaching Strategies

Introducing the Lesson

Most students will have studied Earth science in middle school. Ask students to recall what they remember about the focus of this science. Call on one student after another to state a topic that they think they will learn about in high school Earth science based on their prior experience. List all the relevant topics they identify on the board and add any major topics they fail to mention. Tell the class they will learn more about the scope of Earth science when they read this lesson.

Discussion

Assign the article on Earth's four spheres (lithosphere, hydrosphere, atmosphere, and biosphere) at the URL below. You may want to have students read the article as a homework assignment. After students have read the article, discuss how the branches of Earth science relate to the four spheres.

<http://www.cotf.edu/ete/ess/ESSspheres.html>

Activity

Students can learn more about Earth's spheres with the interactive animations, text, and thought questions at the following URL. They will gain a deeper understanding of how the spheres interact and why studying Earth as a system must involve scientists who specialize in different branches of Earth science.

http://www.classzone.com/books/earth_science/terc/content/investigations/es0103/es0103page01.cfm

Cooperative Learning

Divide the class into groups and have each group choose one of the branches of Earth science described in the lesson. Make sure all of the major branches of Earth science are covered. Then tell students to learn more about their assigned branch, including some possible careers in that branch. Ask a volunteer in each group to share with the class what they learned about their branch of Earth science.

Differentiated Instruction

Post several pieces of poster board on the walls around the classroom. On each poster, write the name of one of the major branches of Earth science (e.g., geology, oceanography, climatology, meteorology, environmental science). Divide the class into groups, incorporating any special needs students with other students who can assist them, and give each group a different colored marker. Then have groups circulate from one poster to another, working as a group to write everything they know about each branch of Earth science and commenting on what other groups have written. When all the groups have finished, use their most relevant writings and comments to summarize their knowledge of the branches of Earth science.

Enrichment

Ask one or more interested students to interview a local Earth scientist (e.g., meteorologist, geologist, oceanographer). They should prepare for the interview by making a list of questions they have about the scientist's specialty and how it relates to other specialties in Earth science. Invite the students to share what they learn from the interview with the rest of the class.

Science Inquiry

Work with students to brainstorm a research question pertaining to one of the branches of Earth science described in the lesson. Guide students in generating a testable hypothesis and identifying data they would need to test it. Discuss as a class how the research relates to other branches of Earth science.

Chemistry Connection

Show students how Earth science relates to chemistry by describing specific examples, such as the formation of chemical rocks. Point out how chemistry is necessary to explain this and many other Earth processes.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 1.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 1.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 1.2 Quiz in *CK-12 Earth Science For High School Quizzes and Tests*.

Points to Consider

Why is Earth science important?

Which branch of Earth science would you most like to explore?

What is the biggest problem that humans face today? Which Earth scientists may help us to solve the problem?

How do the other branches of science impact Earth science?

CHAPTER **2**

HS TE Studying Earth's Surface

Chapter Outline

- 2.1 CHAPTER 2: STUDYING EARTH'S SURFACE
 - 2.2 LESSON 2.1: EARTH'S SURFACE
 - 2.3 LESSON 2.2: WHERE IN THE WORLD ARE YOU?
 - 2.4 LESSON 2.3: MODELING EARTH'S SURFACE
 - 2.5 LESSON 2.4: TOPOGRAPHIC MAPS
 - 2.6 LESSON 2.5: USING SATELLITES AND COMPUTERS
-

2.1 Chapter 2: Studying Earth's Surface

Chapter Overview

In this chapter, students are introduced to Earth's surface features. They also learn about map projections, including topographic maps, and how computers and satellites are used to study and understand Earth's surface.

Online Resources

See the following Web sites for appropriate laboratory activities:

This interactive online activity has students consider the different types of map projections and the most appropriate projections for various uses. After reading about, seeing graphics of, and taking notes on a variety of map projections, students will assume they are cartographers and will specify which types of map projections would be the most valuable for their clients.

- http://education.nationalgeographic.com/archive/xpeditions/lessons/01/g912/projections.html?ar_a=1

In this lab, students will learn how different map projections are used to view Earth. They will use an online map-generator tool to discover how well the commonly used Mercator projection represents high- and low-latitude areas. They will also see a different type of map projection, called a Mollweide Projection, which is used by many scientists.

- <http://www.bigelow.org/virtual/handson/maps.html>

These Web sites may also be helpful:

To learn about ways to use Google Earth as an educational tool for Earth science, go the URL below. The URL provides links to many activities that are relevant to this chapter.

- http://serc.carleton.edu/NAGTWorkshops/visualize04/tool_examples/google_earth.html

You can review map projections and how different projections compare at the following URL.

- <http://www.learnnc.org/lp/editions/mapping/6433>

Visit this URL to find a plethora of resources for teaching students about maps. Resources include teaching ideas, activities, and many more educator resources.

- <http://education.usgs.gov/secondary.html>

This is a great resource for educators looking for ways to use GPS technology to enhance their classroom lessons. Visit the GPS area for ideas for geocaching, lesson plans, and more.

- <http://gis2gps.com/>

At the following URL, you can access materials that explain how to teach Earth science concepts and skills using GPS and GIS.

- <http://edcommunity.esri.com/arclessons/lesson.cfm?id=296>

Pacing the Lessons

TABLE 2.1: short caption

Lesson	Class Period(s) (60 min)
2.1 Earth's Surface	1.0
2.2 Where in the World Are You?	1.0
2.3 Modeling Earth's Surface	1.5
2.4 Topographic Maps	2.0
2.5 Using Satellites and Computers	1.5

2.2 Lesson 2.1: Earth's Surface

Key Concepts

- Continents and landforms
- Ocean basins and their features
- Constructive and destructive forces and how they change Earth's surface

Lesson Objectives

- Briefly identify different features of continents and ocean basins.
- Define constructive forces and give a few examples.
- Define destructive forces and give a few examples.

Lesson Vocabulary

- **constructive force:** force that causes landforms to grow
- **continent:** large land mass that lies above sea level
- **continental margin:** edge of continental crust that lies beneath ocean water, where continental crust gives way to oceanic crust
- **destructive force:** force that wears away or destroys landforms
- **landform:** physical feature of Earth's surface such as a hill or peninsula
- **mid-ocean ridge:** large mountain range that runs through an ocean basin
- **ocean basin:** entire area covered by the water of an ocean
- **ocean trench:** deep valley on the ocean floor

Teaching Strategies

Introducing the Lesson

Introduce Earth's surface landforms in a familiar context. Call on students to identify and describe examples of landforms such as mountains, hills, plains, and valleys in their local area. If there are any variations in landforms close to the school, you could take students on a walk to identify them. Tell students they will learn in this lesson more about the landforms that cover Earth's surface and the forces that created them.

Demonstration

Use the 1980 massive explosive eruption of Mount St. Helens in Washington State to demonstrate forces that shape Earth's surface. It shows how a volcanic eruption can be both a destructive and constructive force. The Nova video at the URL below shows amazing footage of the event that will be sure to leave an impression on students.

<http://www.youtube.com/watch?v=iqG4Vi-eu5U>

Activity

Have students play the AAAS "Shape It Up" game at the URL below. Students will learn which forces of erosion create specific landforms and how long it takes them to do the job. The activity will help students understand the destructive forces that continuously shape Earth's surface features and the long time spans they typically require.

<http://powermylearning.com/content/shape-it-aaas?playlist=152478>

Using Visuals

Call students' attention to the figure in the text that shows major features of the world's ocean basins. Have them find and describe specific features, including the mid-ocean ridge system, continental margins, trenches, chains of volcanoes, and abyssal plains. Point out how the mid-ocean ridge is nearly continuous throughout Earth's oceans. Tell students they will learn in later chapters how these landforms were created.

Differentiated Instruction

Before students read the lesson, have them make a three-column KWL chart, with column headings of Know (K), Want to Know (W), and Learned (L). Prior to reading, they should list under K what they already know about Earth's surface features, and they should list under W what they want to know. Tell students to keep their lists in mind as they read the lesson to help focus their attention. Finally, after reading the lesson, they should record under L what they learned. Did they learn everything they wanted to know? If not, help them find answers to these questions.

Enrichment

Ask one or more interested students to investigate how new ocean floor forms and how old ocean floor is destroyed. Have them make a diagram to show the processes involved and use the diagram to explain what happens to the class. Discuss as a class how these processes differ from constructive and destructive forces on land.

Science Inquiry

Have students look at the image of the Grand Canyon that opens this chapter. Challenge them to identify the force that created this impressive feature of the landscape and how long it took to form. (The Grand Canyon was created by water erosion caused by the Colorado River. It took tens of millions of years to form.)

Overcoming Misconceptions

Go to the AAAS site at the URL below to find common misconceptions students might hold about the processes that shape Earth's surface. Select several of the misconceptions that are held most frequently by students in grades 9–12, and discuss these misconceptions with the class. Call on volunteers to reword the misconceptions so they are correct statements.

<http://assessment.aaas.org/topics/WE#/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 2.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 2.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 2.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If erosion is constantly eating away at landforms, why isn't Earth's land surface completely flat?

Why do you think some regions of some continents, such as the middle part of the United States, are almost entirely flat?

Why are continents higher than ocean basins?

2.3 Lesson 2.2: Where in the World Are You?

Key Concepts

- Location and direction
- Latitude and longitude

Lesson Objectives

- Understand the difference between location and direction.
- Know how a compass works and how to use one.
- Know how to determine location using latitude and longitude.

Lesson Vocabulary

- **compass:** device with a magnetic needle that is used to find magnetic north
- **compass rose:** figure on a map or nautical chart that displays the directions north, south, east, and west
- **direction:** which way an object is moving, or location of something relative to something else
- **elevation:** height or depth measured relative to sea level
- **latitude:** distance in degrees north or south of the equator
- **location:** position on Earth's surface
- **longitude:** distance in degrees east or west of the Prime Meridian, which runs north-south through Greenwich, England
- **relief:** difference in elevation of landforms in a region
- **sea level:** average height of the ocean's surface, or the midpoint between high and low tide
- **topography:** three-dimensional shape of a landform or region on Earth's surface

Teaching Strategies

Introducing the Lesson

Tell students to write down the first word that comes to mind when they hear the term location. Call on several students to read their word until you get a variety of responses. Discuss how the words relate to the definition of location as “position on Earth’s surface.” Ask students why it is important to be able to pinpoint locations on Earth’s surface. Encourage a diversity of responses. Tell students they will learn more about location and how to find it in this lesson.

Activity

Have students do the “Compass Treasure Hunt” activity, which is described at the URL below. In this simple classroom activity, students will use a . compass for orientation and to follow a course. This will reinforce the importance of direction in locating features on Earth’s surface. The activity could be done as a class or group activity if the number of compasses is limited.

<http://www.wvgs.wvnet.edu/www/geoeduc/adaptiveactivities.PDF>

Differentiated Instruction

Assign students to small groups that combine any English language learners or less proficient readers with other students. Have students within each group work together to create a Venn diagram comparing and contrasting latitude and longitude. The area of overlap might include “imaginary line on Earth’s surface,” “used to find location,” and “expressed in degrees.” Under latitude, they might include “shows distance north or south of equator” and “runs parallel to equator.” Under longitude, they might include “shows distance east or west of Prime Meridian” and “passes through both poles.” Follow up by having students find several locations on a map by their coordinates and then the coordinates of known locations.

Enrichment

Ask one or more interested students to find out how to convert back and forth between true north and magnetic north and when each conversion is used. A good starting point is the URL below. Invite students to explain and demonstrate the conversions to the class. Conclude with a brief class discussion of why the two north poles are found in different locations.

http://www.nauticalcharts.noaa.gov/mcd/learnnc_rose.html

Science Inquiry

Students can apply lesson concepts with a collaborative problem-solving activity. Find and make copies of a map that shows at least three labeled point of interest (e.g., cities, historic markers, highway exits). The map must be marked with latitude and longitude and have a distance scale. Choose a “mystery” location on the map other than the three points, and find its latitude and longitude and also its straight-line distance from each of the three points. Divide the class into groups and provide each group with a copy of the map. Have students within each group work together to find the mystery location by coordinates and by triangulation. Working collaboratively, they should be able to figure out how to solve the triangulation problem. Refer them to the triangulation map in the lesson if they need help. Ask groups to compare their final answer. If they are not in agreement, they should review each other’s work to determine which answer is correct.

Overcoming Misconceptions

There is a widespread misconception that the end of a compass needle that points north must actually be the south end of the needle, because of the well-known fact that north and south magnetic poles attract one another. In other words, many people believe that the “N” label on a compass designates the direction the needle points and not the true polarity of the magnetic needle. This is completely incorrect, and you can demonstrate it with a regular magnet that has its north and south ends marked. If the magnet is floated on water (for example, by placing it on a cork), the north end will point north. The reason? The magnetic pole close to the geographic north pole of Earth is actually Earth’s magnetic south pole. It is called the magnetic north pole only because of its proximity to the geographic north pole.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 2.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 2.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 2.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How can a two-dimensional object, such as a map, express the features of an area in three dimensions?

To locate yourself accurately, should you use a compass or a map?

Why does California have such extreme relief?

2.4 Lesson 2.3: Modeling Earth's Surface

Key Concepts

- Globes
- Maps as models
- Map projections

Lesson Objectives

- Discuss the advantages and disadvantages of using a globe.
- Describe what information a map can convey.
- Identify some major types of map projections and discuss the advantages and disadvantages of each.

Lesson Vocabulary

- **map:** any two-dimensional representation of Earth's surface
- **projection:** any way of projecting Earth's curved, three-dimensional surface onto a flat, two-dimensional map

Teaching Strategies

Introducing the Lesson

Show students examples of several different types of world map projections (see URLs below for examples). Lead students in brainstorming ways that the different projections are similar and ways they are different. Tell students they will learn more about maps like these when they read this lesson.

http://geology.isu.edu/geostac/Field_Exercise/topomaps/images/projections.jpg

<http://jiscg3.blogspot.com/2011/06/reflective-teaching-practice-do-i-need.html>

Activity

At the following URL, students will find an interactive animated tutorial with questions that will help them understand different types of map projections and their advantages and limitations. The activity will both reinforce and extend material in the FlexBook® lesson.

http://www.classzone.com/books/earth_science/terc/content/investigations/es0301/es0301page01.cfm?chapter_no=investigation

Differentiated Instruction

Start a compare/contrast table on an overhead transparency or the board for two or more of the map projections described in the lesson. Call on students to add information to the cells of the table. Suggest that they make a copy of the table in their science notebook. It will make a good study tool to review lesson content.

Enrichment

In the 1970s, an historian named Arno Peters introduced the Peters projection. He called his map the only non-racist projection and proposed that it replace the Mercator projection, which he referred to as racist. Both maps are flawed and people argued the pros and cons of each. The entire issue became controversial. Ask students to learn more about the controversy, starting with the URL below. Then have them choose sides and debate the issue in front of the class.

<http://geography.about.com/library/weekly/aa030201a.htm>

Science Inquiry

In this activity about map projections, students will work in teams and use readily available materials to create two different map projections: a planar (or polar) and a cylindrical (or Mercator) projection. They will compare and contrast the two projections and decide which is more accurate. This activity will help students understand the challenges of creating maps of Earth.

<http://howtosmile.org/record/5081>

Political Science Connection

Despite its problems, the Mercator projection continued to be used for centuries. In fact, because of the way it distorted the sizes of certain nations, it may have been used longer than it might have been otherwise. Share with students two ways that the Mercator projection promoted particular political interests in the second half of the twentieth century. You can learn what they are at this URL: <http://www.learnnc.org/lp/editions/mapping/6434>.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 2.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 2.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 2.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Imagine you are a pilot and must fly from New York to Paris. Use a globe to determine the distance. Now do the same with a map. How are these activities the same and how are they different?

Would you choose a map that used a Mercator projection if you were going to explore Antarctica? What other type of map could you use?

Maps use a scale, which means a certain distance on the map equals a larger distance on Earth. Why are maps drawn to scale? What would be some problems you would have with a map that did not use a scale?

2.5 Lesson 2.4: Topographic Maps

Key Concepts

- Definition and value of topographic maps
- Contour lines and contour intervals
- Interpreting topographic maps
- Bathymetric maps
- Geologic maps

Lesson Objectives

- Explain how to read and interpret a topographic map.
- Explain how bathymetric maps are used to determine underwater features.
- Describe what a geologic map shows.

Lesson Vocabulary

- **bathymetric map:** map that shows depth below sea level of features on the floor of a body of water
- **contour interval:** constant difference in elevation between adjacent contour lines on a topographic map
- **contour line:** line connecting points with the same elevation on a topographic map
- **geologic map:** map that shows rock units and other geologic features
- **topographic map:** map that shows elevations above sea level of features on Earth's surface

Teaching Strategies

Introducing the Lesson

Show students a topographic map of a familiar nearby area. Ask students what they think the map shows. Query them specifically about the contour lines and symbols on the map. Explain that the map is a topographic map and its main purpose is to show the three-dimensional shape of the land. Tell students they will learn how to make and interpret topographic maps when they read this lesson.

Activity

Have students do the interactive activity at the URL below. In the activity, they are taken through all of the steps involved in creating a profile from a topographic map. The activity will help them understand how contour lines represent surface features and how to read topographic maps.

<http://www.tasagraphicarts.com/activities/profile.html>

Building Science Skills

The worksheet at the following URL will help students build topographic map reading skills.

<http://teacherweb.com/CA/TehachapiHighSchool/Guy/Topo-Practice-WS.pdf>

Differentiated Instruction

Have students make a main ideas/details chart for the lesson to improve their reading comprehension. One approach is to divide a sheet of paper down the middle and write the main ideas on the left side of the paper, leaving space between each main idea to fill in details on the right side of the paper. Suggest to students that they include at least one main idea for each heading in the lesson.

Enrichment

Urge interested students explore geologic maps, starting with the excellent National Park Service article at the URL below. They should find out what the maps show and how they are used. Ask the students to bring a relatively simple geologic map to class and explain it to the other students. They should point out what the colors, symbols, and lines on the map represent. Also have them discuss why geologic mapping is important.

<http://www.nature.nps.gov/geology/usgsnps/gmap/gmap1.html>

Science Inquiry

In the “Design an Island” inquiry activity at the following URL, students will make a map of an island, demonstrating their knowledge of landforms and mapping conventions. At the conclusion of the activity, students will be able to construct a realistic map from a mental image of a place, demonstrate how various topographic symbols and concepts are shown on a map, and explain how the topography of an area influences the location of water sources, ecosystems, and human settlements.

<http://www.sitesalive.com/oil/tg/private/oiltgdesign.html>

Real-World Connection

Ask students if they know what orienteering is. Some students may have familiarity with this sport through scouting or local orienteering clubs. You can learn more about orienteering yourself at the first two URLs below. Tell the class that orienteering is an Olympic sport in which participants use compasses and topographic maps to find the easiest or quickest routes between different locations. Explain (or ask students who have orienteered to explain) how topographic maps are used in the sport. If you want to teach your students the skills of orienteering as an applied mapping activity, see the third URL below.

- <http://geography.about.com/od/understandmaps/a/orienteering.htm>
- http://web.williams.edu/Biology/Faculty_Staff/hwilliams/Orienteering/o_index.html
- http://web.williams.edu/Biology/Faculty_Staff/hwilliams/Orienteering/teachingo.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 2.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 2.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 2.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How might a civil engineer use a topographic map to build a road, bridge, or tunnel through the area such as that shown in the figure above? What topography would be best for a road? Which areas might need a bridge? Where might a tunnel be helpful?

If you wanted to participate in orienteering, would it be better to have a topographic map or a road map? How would a topographic map help you?

If you were the captain of a ship, what type of map would you want and why?

2.6 Lesson 2.5: Using Satellites and Computers

Key Concepts

- Data from satellites
- Global positioning system (GPS)
- Computer-generated maps

Lesson Objectives

- Describe types of satellite images and the information that each provides.
- Explain how the global positioning system (GPS) works.
- Explain how computers can be used to make maps.

Lesson Vocabulary

- **geographic information system (GIS):** system that links GPS data with any type of spatial information to create maps
- **geostationary orbit:** type of orbit that allows a satellite to stay over the same location on Earth's surface
- **global positioning system (GPS):** system of satellites used to locate exact positions on Earth's surface
- **polar orbit:** type of orbit that passes over both poles in a direction perpendicular to Earth's rotation
- **satellite:** natural or human-made object that orbits a larger object

Teaching Strategies

Introducing the Lesson

Ask students to recall from Lesson 2.2 how triangulation is used to pinpoint an exact location. Explain that GPS uses distances to several satellites for triangulation in order to locate positions on the ground. Tell students they will learn how it's done when they read this lesson.

Activity

This is a fun activity that will engage students in using GPS and appreciating some of its applications. During the activity, students will use GPS receivers to "write" their initials or draw a simple diagram. They will download the data into their mapping software to see how accurate they were. The PDF file includes a student worksheet and teacher information.

<http://sciencespot.net/Media/GPSArtists.pdf>

Activity

In this activity, students will use ArcGIS Explorer Online to investigate 11 topographic map features and their surrounding landscapes. The GIS software runs entirely online and requires only a Web browser. Students can work independently or in groups through each of the activities, or they could choose just one of the activities to do. An answer key is included.

<http://edcommunity.esri.com/arclessons/lesson.cfm?id=529>

Differentiated Instruction

Help students distinguish between polar and geostationary orbits by having them make a table comparing and contrasting them. Tell them to include examples of satellites with each type of orbit.

Enrichment

Challenge interested students with the Earth quiz at the URL below. It is a 20 question interactive quiz based on ArcGIS Online. Although the quiz has a multiple-choice format, it provides explanations about each region and process.

<http://edcommunity.esri.com/arclessons/lesson.cfm?id=683>

Science Inquiry

This activity allows students to improve science inquiry skills using GIS. They will analyze extreme high and low temperatures in the U.S. from a spatial perspective. The resulting patterns are fascinating and make for excellent teaching points about altitude, latitude, proximity to coastlines, local weather, continental climate, and much more. If you have students save their work in their science notebooks, they can revisit it when you teach the class about weather and climate.

<http://edcommunity.esri.com/arclessons/lesson.cfm?id=730>

Overcoming Misconceptions

A common misconception about GPS is that a person with a receiver can be tracked by someone else. This reveals a fundamental misunderstanding of how the system works. Explain that GPS is a passive system. It only receives signals and does not transmit them.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 2.5 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 2.5 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 2.5 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Imagine tracking a hurricane across the Atlantic Ocean. What information would you need to follow its path? What satellite images might be most useful? Research how the National Weather Service tracks and monitors hurricanes.

What information and type of map would be most useful for understanding the distribution of natural resources for a particular state?

What are some ways that people use Global Positioning Systems? What problems are easier to solve using GPS?

Chapter Outline

- 3.1 CHAPTER 3: EARTH'S MINERALS**
 - 3.2 LESSON 3.1: MATTER MATTERS**
 - 3.3 LESSON 3.2: MINERALS AND MINERAL GROUPS**
 - 3.4 LESSON 3.3: MINERAL IDENTIFICATION**
 - 3.5 LESSON 3.4: MINERAL FORMATION**
 - 3.6 LESSON 3.5: MINING AND MINERAL USE**
-

3.1 Chapter 3: Earth's Minerals

Chapter Overview

This chapter describes types of minerals and explains how they form. It also explains how to identify minerals using their physical properties and describes uses of mineral resources.

Online Resources

See the following Web sites for appropriate laboratory activities:

The lab at the URL below deals with important concepts in Lesson 3.1: atoms, isotopes, and atomic mass. Students will be given a random sample of the fictitious element "M&Mium," which contains at least three different "isotopes" of the element. Students will design and carry out a procedure to determine the average "atomic" mass of the element M&Mium in their sample.

- <http://serc.carleton.edu/sp/mnstep/activities/20116.html>

You can introduce chemical bonding with the lab at this URL.

- <http://serc.carleton.edu/sp/mnstep/activities/20131.html>

In the lab at the following URL, students will use a variety of tests to identify several mineral samples. Use the lab when you teach Lesson 3.3, "Mineral Identification."

- http://pti.lsu.edu/Activities/A07%20Mineral_Identification_Lab.pdf

These Web sites may also be helpful:

Go to this site for mineral demonstrations for your class. The instructions for each demonstration can be downloaded freely as a PDF document.

- <http://www.mineraleducationcoalition.org/classroom-demonstrations>

For pictures of minerals, grouped by class, go to this URL:

- <http://www.rocksandminerals4u.com/minerals.html>

At the following URL, you can find properties of a wide range of minerals grouped by class.

- <http://www.galleries.com/>
-

Pacing the Lessons

TABLE 3.1: short caption

Lesson	Class Period(s) (60 min)
3.1 Matter Matters	1.0
3.2 Minerals and Mineral Groups	2.5
3.3 Mineral Identification	2.0
3.4 Mineral Formation	1.5
3.5 Mining and Mineral Use	1.5

3.2 Lesson 3.1: Matter Matters

Key Concepts

- Atoms and isotopes
- Ions and molecules
- Chemical bonding

Lesson Objectives

- Review basic chemistry concepts: atoms, elements, ions, and molecules.
- Understand the types of chemical bonding and how they result in molecules.

Lesson Vocabulary

- **atom:** smallest particle of an element that still has the element's properties
- **atomic mass:** number of protons and neutrons in an atom
- **chemical bond:** force that holds atoms or ions together
- **covalent bond:** chemical bond in which electrons are shared between atoms
- **electron:** negatively charged particle that orbits the nucleus of an atom
- **element:** substance that cannot be broken down into simpler substances by chemical means
- **hydrogen bond:** weak bond between oppositely charged ends of two different molecules
- **ion:** charged particle that forms when an atom gains or loses electrons
- **ionic bond:** chemical bond in which electrons are transferred between atoms
- **isotope:** atom of an element that has a different number of neutrons
- **molecular mass:** sum of the masses of all the atoms in a molecule
- **molecule:** smallest particle of a compound that still has the compound's properties
- **neutron:** uncharged particle in the nucleus of an atom
- **nucleus:** center of an atom consisting of protons and neutrons
- **polar molecule:** molecule that has slightly negative and positive ends
- **proton:** positively charged particle in the nucleus of an atom

Teaching Strategies

Introducing the Lesson

Students are likely to have some prior knowledge of atoms, elements, molecules, and compounds. Call on students to state what they already know about these concepts. Record the most important points on the board. Tell the class they will learn more about these basic ideas regarding matter when they read this lesson.

Activity

Students can learn about chemical bonding and different types of bonds by playing the bonding game at the following URL. By doing the activity, students will recognize how and why molecules form and will be able to identify four types of bonding. They will also be able to determine whether a molecule is polar.

<http://www.powayusd.com/pusdphs/webquests/chemwebquest/chemsite.htm>

Differentiated Instruction

Help students focus on the six most important concepts in the lesson: matter, element, atom, compound, molecule, and chemical bond. Pair students who need extra help with other students, and have partners make a concept map that relates the six terms.

Enrichment

Students who are interested in history might want to investigate the history of the atom. A few good sources of information are listed below. Ask the students to create a PowerPoint presentation to share what they learn with the rest of the class.

- http://profmokeur.ca/chemistry/history_of_the_atom.htm
- <http://www.cosmosmagazine.com/features/history-atom-part-1-the-birth-atoms/>
- <http://www.cosmosmagazine.com/features/history-atom-part-2-towards-chaos/>

Science Inquiry

Have students do the inquiry activity “Atoms Unite,” which can be accessed at the URL below. The purpose of the activity is to guide students in building their own concepts about bonding. They will explore the concepts of ionic and covalent bonds and form compounds.

http://www.nslc.ucla.edu/step/gk12/lessons.htm#Chemical_Bonds_

Overcoming Misconceptions

The URL below lists numerous common student misconceptions about basic chemistry concepts, including atoms, molecules, and chemical bonds. Discuss the misconceptions that are relevant to this lesson. Call on volunteers to restate them so they are correct.

<http://resources.educ.queensu.ca/science/main/concept/chem/c07/C07CDTL1.htm>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 3.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 3.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 3.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

The noble gases all have a full outermost electron level. How do they bind to other molecules?

Why don't electrons fly off into space? Is electrical force the same as the gravitational force that keeps planets orbiting the Sun?

Water has a lot of unusual properties: It forms droplets, lightweight insects can land on it, and it is less dense in solid form (ice) than in liquid form. Can you link these properties to hydrogen bonding?

3.3 Lesson 3.2: Minerals and Mineral Groups

Key Concepts

- Characteristics of minerals
- Groups of minerals

Lesson Objectives

- Describe the characteristics that all minerals share.
- Identify the groups in which minerals are classified and their characteristics.

Lesson Vocabulary

- **chemical compound:** unique substance made of two or more elements in a certain ratio
- **crystal:** solid in which atoms or ions are arranged in a regular repeating pattern
- **inorganic:** not organic; not relating to life or living things
- **mineral:** naturally occurring inorganic crystalline solid with a characteristic chemical composition
- **silicates:** largest group of minerals, containing silicon and oxygen

Teaching Strategies

Introducing the Lesson

Show students a quartz crystal and tell them that it is the mineral quartz. Add that there are thousands of known minerals and new minerals are being discovered each year. Then have students brainstorm common objects that they think might be made from minerals. (Possible answers include pencil “leads,” glass, sheetrock, gold and silver jewelry, watch crystals, toothpaste, clay pots, and table salt.) Tell students they will learn more about minerals in this lesson, including what makes a substance a mineral and how minerals are classified.

Activity

Use the activity at the URL below to challenge students to identify which of several different substances should be classified as a mineral. They will also be required to explain which criteria of a mineral the non-mineral substances fail to meet.

<http://pubs.usgs.gov/gip/2005/17/>

Cooperative Learning

Divide the class into eight groups, and assign each group a different mineral group to explore in a Web quest. Give each group the same list of types of information to gather for their mineral groups, such as chemical composition, distribution, uses, and examples. After their Web quest, have them assemble the information in a well-illustrated poster. Allow class time for groups to present their posters to the class. Display the posters in the classroom and encourage students to use them as a reference as they continue to study minerals in this chapter.

Differentiated Instruction

Pair more- and less-proficient English language learners, and have partners create a cluster diagram for the characteristics of minerals. The diagram should include a separate circle for each of the defining characteristics of minerals: crystalline solid, inorganic substance, formed by natural processes, and specific chemical composition. For each characteristic, they should add an explanation or description in terms that are understandable to them.

Enrichment

The silicate minerals are the most common, and all of them form silica tetrahedrons. Challenge one or more students to create three-dimensional models of silica tetrahedrons and demonstrate them to the class. They can follow the procedure described at this URL: http://www.windows2universe.org/teacher_resources/teach_silica.html.

Science Inquiry

In the activity at the URL below, students will grow different types of mineral crystals. They will create a model of crystal growth and observe that the process of crystal growth is a type of self-assembly. By doing the activity, students will apply scientific inquiry process skills.

<http://scme-nm.org/files/1-3%20Structure%20Crystals%20%20LAB%20Growing%20Crystals%20Rev%203.pdf>

Overcoming Misconceptions

The document at the following URL discusses common misconceptions about minerals and how they arise. For example, the words mineral and crystal are commonly misused in everyday language. In a study that included adolescents, students were asked to describe samples of rocks, minerals, and human-made materials. Students did not use the word mineral to describe any of samples, and they used terms such as rock, stone, and pebble in an intuitive, nonscientific way. Review the misconceptions with your students to ensure that they know the correct concepts.

<http://beyondpenguins.ehe.osu.edu/issue/rocks-and-minerals/common-misconceptions-about-rocks-and-minerals>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 3.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 3.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 3.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why is obsidian, a natural glass that forms from cooling lava, not a mineral?

Why are diamonds made in a laboratory not minerals?

Is coal, formed mostly from decayed plants, a mineral? Is it a rock?

Artists used to grind up the mineral azurite to make colorful pigments for paints. Is the powdered azurite still crystalline?

3.4 Lesson 3.3: Mineral Identification

Key Concepts

- Mineral color, streak, and luster
- Density and specific gravity of minerals
- Mineral hardness and Mohs hardness scale
- Cleavage and fracture of minerals
- Other identifying characteristics of minerals

Lesson Objectives

- Explain how minerals are identified.
- Describe how color, luster, and streak are used to identify minerals.
- Summarize specific gravity.
- Explain how the hardness of a mineral is measured.
- Describe the properties of cleavage and fracture.
- Identify additional properties that can be used to identify some minerals.

Lesson Vocabulary

- **cleavage:** tendency of a mineral to break along certain planes to make smooth, flat surfaces
- **density:** amount of mass per unit of volume
- **fracture:** how a mineral breaks when it does not break along a cleavage plane
- **hardness:** ability of a mineral to resist being scratched
- **luster:** how light reflects off the surface of a mineral
- **mineralogist:** scientist who studies minerals
- **streak:** color of the powder of a mineral

Teaching Strategies

Introducing the Lesson

Show the class two different mineral samples. Pass the samples around so students can inspect them closely. Call on volunteers to describe properties of the two minerals that appear to be different. Tell students they will learn in this lesson how properties of minerals can be used to identify them.

Demonstration

The eye-catching activity at the following URL makes a great classroom demonstration. It also relates to fireworks, so it will be likely to get students' attention. Using the flame test, you will produce colored flames from minerals. Discuss why the flames vary in color and how this relates to the colors of fireworks. Background information is provided in the document.

http://www.mineralseducationcoalition.org/pdfs/Tested_by_Fire.pdf

Activity

Students can test the reactivity of different minerals with the activity at the following URL. After they complete the activity, have them explain how reactivity can be used in mineral identification.

http://www.mineralseducationcoalition.org/pdfs/An_Acidic_Reaction.pdf

Differentiated Instruction

Have students click on “Properties of Common Minerals” at the URL below. It will open a reading worksheet titled “Identifying Minerals.” The worksheet provides a simpler, shorter version of lesson content, followed by objective recall questions so students can check their comprehension.

<http://newyorkscienceteacher.com/sci/files/topic-media.php?media=Worksheet&subject=earth+science&subtopic=Rocks+and+Minerals>

Enrichment

Have a few students brainstorm a card game that can be played with the mineral ID cards at the following URL. Their game might be modeled on a card game they know, such as Go Fish or Authors. Suggest that other students in the class play the game to familiarize themselves with the properties of specific minerals.

<http://www.oum.ox.ac.uk/thezone/funstuff/games/pdfs/minmast.pdf>

Science Inquiry

Students can learn through inquiry about three optical mineral properties not mentioned in the text: schiller, iridescence, and pleochroism. Have them do the hands-on activity at the URL below. They will read about the causes and effects of the properties and then try to identify them in mineral specimens.

http://www.mineralseducationcoalition.org/pdfs/Wild_and_Cool_Colors.pdf

Chemistry Connection

Explain why some minerals are fluorescent and show students pictures of fluorescent minerals. The URL below provides the background science, including a useful diagram, and also shows a vivid image of numerous fluorescent minerals.

<http://geology.com/articles/fluorescent-minerals/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 3.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 3.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 3.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If a mineral is magnetic, do you know for certain what mineral it is?

Some minerals are colored because they contain chemical impurities. How did the impurities get into the mineral?

What two properties of a mineral sample would you have to measure to calculate its density?

How much do minerals reflect the environment in which they formed?

3.5 Lesson 3.4: Mineral Formation

Key Concepts

- Formation of minerals from magma and lava
- Formation of minerals from solutions

Lesson Objectives

- Describe how melted rock produces minerals.
- Describe how hot rock produces different minerals.
- Explain how minerals form from solutions.

Lesson Vocabulary

- **lava:** molten rock that has reached Earth's surface
- **magma:** molten rock deep inside Earth
- **rock:** mixture of minerals
- **vein:** mineral deposit from a fluid that fills a crack in rock

Teaching Strategies

Introducing the Lesson

Introduce students to mineral formation by showing them the seven stunning mineral formations at the following URL. The article provides a brief description and explanation about how each formation developed. Tell students they will read in this lesson about some of the common ways that minerals form.

<http://mentalfloss.com/article/32101/7-stunning-mineral-formations>

Demonstration

Use the interactive animation at the following URL to show students how rates of cooling affect the size of mineral crystals from molten rock. Then, at the second URL, show students the sizes of crystals in different rock specimens, and challenge them to infer where the rocks formed. http://www.classzone.com/books/earth_science/terc/content/investigations/es0603/es0603page05.cfm?chapter_no=investigationhtt http://www.classzone.com/books/earth_science/terc/content/investigations/es0603/es0603page05.cfm?chapter_no=investigationhtt

Activity

Students can form the mineral calcium carbonate by precipitation with the simple activity at the URL below. The reaction occurs when carbon dioxide gas (CO₂) in exhaled air enters a saturated lime (CaO) solution.

<http://www.mines.unr.edu/museum/activities/Precipitation%20of%20CaCO3%20activity.pdf>

Differentiated Instruction

Suggest that students make a table comparing and contrasting the formation of mineral crystals from magma and lava. They should compare where the mineral crystals form (in or on Earth), how quickly they form, and their size.

Enrichment

Students may be curious about diamonds because they are expensive gemstones and also the hardest mineral known. Ask one or more volunteers to investigate how diamonds form. They can start with the URLs below. Have them summarize what they learn in a brief oral presentation to the class. Ask them to relate the hardness of diamonds to the manner in which they form.

- <http://www.smithsonianmag.com/science-nature/diamond.html>
- <http://www.nhm.ac.uk/nature-online/earth/rock-minerals/diamonds/diamond-formation/>
- <http://geology.com/articles/diamonds-from-coal/>

Science Inquiry

Have students heat water on a hot plate to about 60 °C and then add an equal amount of Epsom salts to make a saturated solution. Then have them separate the solution into three equal parts. One-third of the solution they should leave to cool slowly at room temperature, one-third they should cool more quickly in a refrigerator, and the remaining one-third they should cool most quickly in a freezer. As the solutions cool, ask students to predict the relative sizes of the crystals that will form in the three solutions. When all three solutions have cooled completely, have students measure the crystals. They may need to use a hand lens or microscope to observe crystal sizes.

Chemistry Connection

Relate the chemistry concept of supersaturation to the formation of minerals. Explain that the term supersaturation refers to a solution that contains more of the dissolved material than could be dissolved by the solvent under normal circumstances. For example, a supersaturated solution of salt and water can be made by heating the water. When the salt water cools, it can no longer hold as much dissolved solute, so the solute precipitates out of the solution, forming salt crystals. The same thing occurs in carbonated drinks, except in this case, the supersaturated solution forms because the solution is put under pressure. That's why opening a can of a carbonated drink leads to the formation of bubbles of carbon dioxide. The gas comes out of solution when the pressure is released. Relate this discussion of supersaturation to the formation of mineral crystals from an underground water solution that has been heated to a high temperature by magma.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 3.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 3.4 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 3.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Is a mineral a static thing or does it change? If it changes, on what time frame?

When most minerals form, they combine with other minerals to form rocks. How can these minerals be used?

The same mineral can be formed by different processes. How can the way a mineral forms affect how the mineral is used?

3.6 Lesson 3.5: Mining and Mineral Use

Key Concepts

- Finding and mining minerals
- Ore extraction
- Mining and the environment
- Valuable minerals

Lesson Objectives

- Explain how minerals are mined.
- Describe how metals are made from mineral ores.
- Summarize the ways in which gemstones are used.
- Identify some useful minerals.

Lesson Vocabulary

- **gemstone:** mineral that is cut and polished to use in jewelry
- **ore:** rock that contains useful minerals
- **ore deposit:** mineral deposit that contains enough minerals to be mined for profit
- **placer:** valuable metal found in modern or ancient stream gravels
- **reclamation:** restoration of mined land to its pre-mining state

Teaching Strategies

Introducing the Lesson

Refer students to the picture of the Bingham open-pit copper mine in the lesson and then show them the video about the mine at the URL below. The Bingham mine is a good example for introducing mining to students because it is the first and largest open-pit copper mine in the world. In fact, it is the largest artificial excavation on Earth—so large that it can be seen from space. By 2008, the Bingham mine was 0.75 mile deep and 2.5 miles wide at the top, and it covered almost 2000 acres. Share these facts with the class. Then tell students they will learn more about mines and mining when they read this lesson.

<http://www.youtube.com/watch?v=IEL7Vwm1PXU>

Activity

This fun class activity demonstrates the steps that are taken to find, extract, process, and use mineral resources. Teams of students will simulate all the steps a peanut “mining” company must take to find and mine the resource and then reclaim the site. They will also calculate their profit or loss.

<http://www.nvmineraleducation.org/Activities/MiningInANutshellAdv.pdf>

Differentiated Instruction

Have students make a Venn diagram to compare and contrast surface and open-pit mining. They should include pros and cons of each mining method in their diagram.

Enrichment

Assign a few students to debate the environmental and economic impacts of a proposed new mine in a fictitious community that is suffering financially and needs new jobs. Recommend to students that they first gather background information, starting with the URLs below. All but the last URL provide background information on environmental and/or economic impacts of mining. The last URL describes an actual community in which re-opening a mine and creating new jobs is being debated. Allow class time for students to present their debate.

- <http://www.pollutionissues.com/Li-Na/Mining.html>
- <http://www.okinternational.org/mining>
- <http://www.catapa.be/en/mining/economic>
- <http://www.miningfacts.org/Blog/Mining-News/The-Impact-of-Mining-on-British-Columbia%E2%80%99s-Economy/>
- <http://ecorestitution.montana.edu/mineland/guide/problem/impacts/default.htm>
- <http://minnesota.publicradio.org/display/web/2013/03/02/regional/minnesota-mining-jobs>

Science Inquiry

In the activity at the URL below, copper is leached from finely ground rock and recovered by reduction on iron paper clips. The activity models the actual procedures used for recovering some metals, including gold. Students will understand the chemistry involved in leaching and recovering a metal from solution.

http://www.nvmineraleducation.org/Activities/OpChem_Metal_From_Rocks.pdf

Real-World Connection

The concept of sustainable development is important for nonrenewable resources such as minerals. In this group activity, students will see how sustainable development can be applied to help resolve controversial issues associated with mineral mining.

http://www.nvmineraleducation.org/Activities/Sustainable_Development_V_3_LV_2006.pdf

Social Science Connection

Share with students the importance of minerals throughout human history and prehistory. Tell them that the main ages of ancient human civilization are defined by the use of minerals. They include the Stone Age, Bronze Age, and Iron Age. Encourage students to learn more about each of these ages.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 3.5 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 3.5 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 3.5 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Are all mineral deposits ores?

Why might an open pit mine be turned into an underground mine?

How well does reclaimed land resemble the land before mining began?

Diamonds are not necessarily the rarest gem so why do people value them more than most other gems?

Under what circumstances might a mineral deposit be an ore one day and not the next?

CHAPTER **4**

HS TE Rocks

Chapter Outline

- 4.1 CHAPTER 4: ROCKS
 - 4.2 LESSON 4.1: TYPES OF ROCKS
 - 4.3 LESSON 4.2: IGNEOUS ROCKS
 - 4.4 LESSON 4.3: SEDIMENTARY ROCKS
 - 4.5 LESSON 4.4: METAMORPHIC ROCKS
-

4.1 Chapter 4: Rocks

Chapter Overview

This chapter describes the rock cycle and the three major types of rocks that form on Earth: igneous, sedimentary, and metamorphic rocks. A separate lesson is devoted to each of these three rock types.

Online Resources

See the following Web sites for appropriate laboratory activities:

In this lab, students receive two small blocks of chocolate (white and dark) and follow them through the entire rock cycle by melting, grinding, and otherwise processing them. Students compare the chocolate "rocks" in each of the stages with real rock samples. As the final step, they describe the life story of a rock sample.

- <http://serc.carleton.edu/NAGTWorkshops/intro/activities/23590.html>

Have students do the metamorphic rock lab described on pages 13-18 of the URL below. In the activity, they will use a hand lens to compare and contrast different metamorphic textures and learn how to identify foliated texture.

- <http://www.msncucleus.org/membership/html/jh/earth/metamorphic/jhmetamorphic.pdf>

These Web sites may also be helpful:

These URLs are good sources of photos of the different types of rocks covered in this chapter:

- <http://geology.com/rocks/igneous-rocks.shtml>
- <http://geology.com/rocks/sedimentary-rocks.shtml>
- <http://geology.com/rocks/metamorphic-rocks.shtml>

You may want to teach the processes involved in the rock cycle with some of the activities described in this useful resource:

- http://geoscience.msc.sa.edu.au/library/dynamic_rock_cycle.pdf

The PowerPoint presentations at the following URLs may be useful when you teach your students about (1) the rock cycle and (2) the three types of rocks (igneous, sedimentary, and metamorphic).

1. http://www.science-class.net/PowerPoints/Predicting%20the%20Rock%20Cycle_files/frame.htm
2. http://schools.paulding.k12.ga.us/ischooldistrict/teacherhome_more.php?TeacherHomePage_ID=6391&school_ID=52&user_ID=2708

Pacing the Lessons

TABLE 4.1: short caption

Lesson	Class Period(s) (60 min)
4.1 Types of Rocks	2.0
4.2 Igneous Rocks	2.0
4.3 Sedimentary Rocks	2.0
4.4 Metamorphic Rocks	1.5

4.2 Lesson 4.1: Types of Rocks

Key Concepts

- Definition of rock
- Three main categories of rocks
- Overview of the rock cycle
- Processes of the rock cycle

Lesson Objectives

- Define rock and describe what rocks are made of.
- Know how to classify and describe rocks.
- Explain how each of the three main rock types formed.
- Describe the rock cycle.

Lesson Vocabulary

- **crystallization:** formation of mineral crystals as molten rock cools
- **erosion:** transport of weathered sediments by water, wind, ice, or gravity
- **igneous rock:** rock that forms when magma or lava cools
- **metamorphic rock:** rock that forms when existing rock is changed by extreme heat and/or pressure inside Earth
- **metamorphism:** process in which existing rock changes inside Earth to metamorphic rock due to extreme heat and/or pressure
- **outcrop:** exposed rock formation that extends out of the ground
- **precipitate:** solid that separates out of a liquid, usually when the liquid evaporates
- **rock cycle:** continuous series of processes by which rocks change from one type to another
- **sediment:** small particle of soil or rock deposited by wind, water, or other agent of erosion
- **sedimentary rock:** rock that forms when sediments are compacted and cemented or precipitate from liquid
- **sedimentation:** process in which sediments are laid down in a deposit
- **weathering:** chemical or physical breakdown of rocks, soils, or minerals at Earth's surface

Teaching Strategies

Introducing the Lesson

Show students examples of igneous, sedimentary, and metamorphic rock. Ask them to speculate how one type of rock might change to another. Tell them they will learn how when they read this lesson.

Activity

A good starting point in teaching your class about the rock cycle is the interactive rock cycle animation at the URL below.

http://www.classzone.com/books/earth_science/terc/content/investigations/es0602/es0602page02.cfm

Building Science Skills

Students can model processes of the rock cycle with the relatively quick and simple activity at the following URL. Using crayons and other commonly available materials, they will simulate melting, crystallization, weathering, sedimentation, and metamorphism. Then they will relate the simulations to the actual processes of the rock cycle.

<http://www.geosociety.org/educate/LessonPlans/RockCycleLab.pdf>

Differentiated Instruction

Use the activity at the URL below for kinesthetic learners and students who have less proficient verbal skills. The purpose of this activity is to gain an understanding of the rock cycle by physically traveling through the stages of the cycle.

<http://www.eequalsmcq.com/rock%20cycle.pdf>

Enrichment

Challenge a small group of students to make a rock cycle board game. They might model their game on the game at the following URL. After they complete their board game, have them explain it to the rest of the class. Encourage other students in the class to play the game.

<http://edweb.sdsu.edu/courses/edtec670/cardboard/board/r/rockcyclrace/index.htm>

Science Inquiry

An important step in science inquiry is basic background research. Have students do the rock cycle Web quest at the URL below. They will be guided through a series of animations, illustrations, and articles to gain more in-depth knowledge about the rock cycle and its processes. The Web site includes a packet of pages for students to complete in their own words as they go through the Web quest.

http://brandon06.gar.groupfusion.net/modules/groups/group_pages.phtml?gid=1965778&nid=188559&sessionid=

Creative Writing Connection

Story telling can be used to help students understand the changes a rock undergoes as it passes through the rock cycle. In this activity, students will use creative storytelling and their own illustrations to describe the rock cycle.

http://www.pbs.org/americanfieldguide/teachers/rocks/rocks_sum.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 4.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 4.1 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 4.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If Earth's interior were no longer hot but all other processes on Earth continued unchanged, what would happen to the different rock types in the rock cycle?

Stone tools were important to early humans. Are rocks still important to humans today?

4.3 Lesson 4.2: Igneous Rocks

Key Concepts

- Composition of magma
- Intrusive and extrusive igneous rocks
- Classification of igneous rocks

Lesson Objectives

- Describe how igneous rocks form.
- Describe the properties of some common types of igneous rocks.
- Relate some common uses of igneous rocks.

Lesson Vocabulary

- **Bowen's Reaction Series:** order in which minerals undergo melting or crystallization as temperature increases or decreases
- **extrusive rock:** any type of igneous rock that forms on Earth's surface from rapidly cooling lava
- **felsic rock:** type of igneous rock that is made mostly of low-density, light-colored minerals such as quartz and feldspar
- **fractional crystallization:** crystallization of a fraction of the minerals in magma
- **intermediate rock:** type of igneous rock that is intermediate in density and color between felsic rock and mafic rock
- **intrusive rock:** any type of igneous rock that forms beneath Earth's surface from slowly cooling magma
- **mafic rock:** type of igneous rock that is made mostly of high-density, dark-colored minerals such as olivine and pyroxene
- **partial melting:** melting of some but not all of the minerals in rock
- **pluton:** intrusive igneous rock that has cooled in the crust
- **porphyritic:** type of igneous rock texture in which large, visible crystals are found within a matrix of tiny crystals
- **ultramafic rock:** type of igneous rock that contains more than 90 percent mafic minerals such as olivine and pyroxene
- **vesicular:** type of igneous rock texture that includes holes left by gas bubbles in the magma
- **volcanic rock:** another name for extrusive igneous rock because it forms from volcanic activity

Teaching Strategies

Introducing the Lesson

Pass a piece of pumice around the class so students can feel how light it is. Point out the tiny holes in the rock. Ask students if they know why pumice is full of holes and so light in weight. Tell them they will learn why when they read this lesson.

Demonstration

Use the interactive animation at the URL below to show students how igneous rocks form. Clicking on the labeled features show microscopic views of igneous crystals forming under different cooling conditions and relates cooling rates to rock texture.

http://www.classzone.com/books/earth_science/terc/content/investigations/es0603/es0603page05.cfm

Building Science Skills

You can use the lesson plan at the following URL when you teach your class about igneous rocks. The purpose of the lesson is to compare and contrast intrusive and extrusive igneous rocks, demonstrate how the rate of cooling affects an igneous rock's texture, and classify igneous rocks according to texture and composition

http://alex.state.al.us/lesson_view.php?id=23943

Differentiated Instruction

Pair less proficient readers with other students, and ask partners to create a Venn diagram comparing and contrasting intrusive and extrusive igneous rocks.

Enrichment

Have students read the detailed analogy at the URL below, which explains how granite is like ice cream. Challenge the students to think of their own, unique analogy for an igneous rock such as granite. Ask them to explain their analogy to the class.

<http://uts.cc.utexas.edu/rmr/analogy.html>

Science Inquiry

Provide groups of students with an igneous rock sample. Have them identify and describe important features of their rock and classify it as intrusive or extrusive. You may also want to have them try to classify their rock by composition based on color and density. Discuss with the class what minerals might make up the different rocks.

Real-World Connection

Discuss the diversity of everyday uses of igneous rocks. Call on students to identify igneous rocks in or around their home. (Answers might include buildings, statues, paving, countertops, jewelry, and toothpaste.)

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 4.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 4.2 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 4.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Are igneous rocks forming right now?

Why don't all igneous rocks with the same composition have the same name?

Could an igneous rock cool at two different rates? What would the crystals in such a rock look like?

4.4 Lesson 4.3: Sedimentary Rocks

Key Concepts

- Weathering, erosion, and deposition of sediments
- Sedimentary rock formation
- Clastic, chemical, and biochemical rocks
- Uses of sedimentary rocks

Lesson Objectives

- Describe how sedimentary rocks form.
- Describe the properties of some common sedimentary rocks.
- Relate some common uses of sedimentary rocks.

Lesson Vocabulary

- **biochemical sedimentary rock:** rock that forms mostly from the remains of organisms
- **bioclastic rock:** sedimentary rock that forms from sediments that include organic remains
- **cementation:** sticking together of sediments by mineral crystals from fluids
- **chemical sedimentary rock:** rock that forms from the hardening of chemical precipitates
- **clastic rock:** sedimentary rock that forms from inorganic sediments
- **compaction:** squeezing together of sediments by the weight of overlying sediments
- **lithification:** formation of rock from sediments by the processes of compaction and cementation
- **organic:** related to living things

Teaching Strategies

Introducing the Lesson

Show the class several different sedimentary rocks, either photos or actual specimens. The URLs below are good sources for photos. Call on students to point out properties of the rocks. Tell them that all of the specimens are sedimentary rocks, or rocks formed from sediments. Review the meaning of sediments with the class, including chemical precipitates. Tell students they will learn more about sedimentary rocks in this lesson.

http://www.rocksandminerals4u.com/igneous_metamorphic_sedimentary_rock.html

<http://geology.com/rocks/sedimentary-rocks.shtml>

Activity

Assign the article and interactive table on sedimentary rocks at the URL below. Students can explore how sedimentary rocks contain clues to ancient environments.

http://www.windows2universe.org/earth/geology/sed_facies.html&edu=mid

Building Science Skills

Have students do the online sedimentary rock identification exercise at the following URL. They will use an interactive dichotomous key to identify sedimentary rock specimens. Excellent background on sedimentary rock identification is also provided at the Web site.

<http://newterra.chemeketa.edu/afrank1/rocks/sedimentary/sedrxs.htm>

Differentiated Instruction

Make sure students do not confuse the crystallization of molten rock to form igneous rock with the crystallization of mineral precipitates to form sedimentary rock. Point out that precipitates are transported and deposited by water so they are sediments, like sand or other sediments deposited by water or other agents of erosion.

Enrichment

Students may not appreciate the long time scale involved in the formation of sedimentary rocks. Ask one or more students to create a time scale for the rocks in the Grand Canyon that correctly (to scale) shows how short a time humans have existed since the oldest rock layers started to form. The article below provides background information and ideas. Post their time line in the classroom.

http://southwest.library.arizona.edu/azso/back.1_div.1.html

Science Inquiry

In the inquiry activity at the URL below, groups of students will design an experiment to show how sedimentary rocks form when dissolved minerals precipitate from water. They will develop a hypothesis and procedure, identify variables and controls, list materials needed, and identify safety measures. (A sample experiment might involve placing table salt in water, then heating the water until it evaporates.) If time permits, allow students to carry out their experiments.

http://alex.state.al.us/lesson_view.php?id=23945

Overcoming Misconceptions

Students commonly think that cementation of sediments results from drying and requires pressure. You can model cementation with a simple procedure that clearly counters these misconceptions. Pour a supersaturated solution of sodium acetate trihydrate over gravel in an aquarium. Within minutes, the gravel will be cemented together with easy-to-see sodium acetate crystals. The model shows students that drying and pressure are not needed because they are clearly not present in the demonstration. The idea for this demonstration is based on the following URL:

https://gsa.confex.com/gsa/2011NE/finalprogram/abstract_185053.htm

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 4.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 4.3 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 4.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Is a rock always made of minerals? Do the requirements for something to be a mineral need to be met for something to be a rock?

Which type of rocks do you think yields the most information about Earth's past?

Could a younger layer of sedimentary rock ever be found under an older layer? How do you think this could happen?

Could a sedimentary rock form only by compaction from intense pressure?

4.5 Lesson 4.4: Metamorphic Rocks

Key Concepts

- Formation of metamorphic rocks
- Regional and contact metamorphism
- Uses of metamorphic rocks

Lesson Objectives

- Describe how metamorphic rocks form.
- Describe the properties of some common metamorphic rocks.
- Relate some common uses of metamorphic rocks.

Lesson Vocabulary

- **contact metamorphism:** changes in rock due to heating by contact with hot magma
- **foliation:** formation of layers in rock due to extreme pressure
- **regional metamorphism:** changes in rock over a large area due to pressure from other rock or geological processes

Teaching Strategies

Introducing the Lesson

Have one or more students crumple a sheet of paper between their hands. Then tell the class to look in the lesson at the figure of foliated metamorphic rock. Tell students that a similar force created the crumpled folds in the rock as was exerted on the paper. They will learn about it when they read this lesson.

Activity

Have students complete the interactive module at the URL below to explore the causes and consequences of metamorphism.

<http://ees.as.uky.edu/sites/default/files/elearning/module02swf.swf>

Differentiated Instruction

Pair students who need extra help with other students, and have partners collaborate on making a compare/contrast table for foliated and non-foliated metamorphic rocks. They might compare and contrast how the two types of rocks form and how they appear. Suggest that they include examples and sketches of each type of rock.

Enrichment

Have a few students use rock specimens to create a display that shows how rocks change with metamorphism. They can use the table in the lesson as a guide. For example, their display might show that the sedimentary rock sandstone changes by contact metamorphism to quartzite, and the sedimentary rock limestone changes by contact metamorphism to marble. Alternatively they might show how increasing pressure and temperature change the sedimentary rock shale first into slate, then into phyllite, then into schist, and last into gneiss. Provide a prominent place for their display in the classroom.

Science Inquiry

The class activities at the following URL simulate one or more ways that metamorphic rocks form. Activity 1 simulates contact metamorphism, activity 2 simulates the formation of slate by regional metamorphism, and activity 3 simulates the distortion of fossils under pressure using plaster of Paris models.

<http://www.rsc.org/education/teachers/resources/jesei/meta/home.htm>

Chemistry Connection

Explain that metamorphic minerals are those that form only at the high temperatures and pressures associated with the process of metamorphism. These minerals, known as index minerals, include sillimanite, kyanite, staurolite, andalusite, and some garnet. Other minerals, such as olivines, pyroxenes, amphiboles, micas, feldspars, and quartz, may be found in metamorphic rocks, but are not necessarily the result of the process of metamorphism. These minerals formed during the crystallization of igneous rocks. They are stable at high temperatures and pressures and may remain chemically unchanged during the metamorphic process. However, all minerals are stable only within certain limits, and the presence of certain minerals in metamorphic rocks indicates the approximate temperatures and pressures at which they formed.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 4.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 4.4 in *CK-12 Earth Science for High School*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Quiz

Check students' mastery of the lesson with Lesson 4.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What type of rock forms if an existing rock heats up so much that it melts completely and then forms a different rock?

What clues can a rock give about its history if it was so altered by metamorphism that it is unrecognizable?

CHAPTER

5

HS TE Earth's Energy

Chapter Outline

- 5.1 CHAPTER 5: EARTH'S ENERGY
 - 5.2 LESSON 5.1: ENERGY RESOURCES
 - 5.3 LESSON 5.2: NONRENEWABLE ENERGY RESOURCES
 - 5.4 LESSON 5.3: RENEWABLE ENERGY RESOURCES
-

5.1 Chapter 5: Earth's Energy

Chapter Overview

This chapter discusses nonrenewable energy resources, including fossil fuels and nuclear energy; and renewable energy resources, including solar, wind, water, geothermal, and biomass energy.

Online Resources

See the following Web sites for appropriate laboratory activities:

In this lab, students will investigate the law of conservation of energy. They will develop and carry out a lab procedure to maximize the conversion of potential energy to kinetic energy.

- <http://serc.carleton.edu/sp/mnstep/activities/19872.html>

Students can explore nuclear energy with the lab at the URL below. The lab is based on a nuclear fission simulation at the same Web site.

- <http://phet.colorado.edu/en/contributions/view/3335>

The booklet below provides high school students with a variety of projects to broaden their knowledge of renewable energy resources and the scientific method. Projects are available on biofuels, wind, and solar energy.

- http://www1.eere.energy.gov/biomass/pdfs/highschool_projects.pdf

These Web sites may also be helpful:

The following URL provides several fossil fuel study guides and activities for high school students.

- http://www.fossil.energy.gov/education/energylessons/Study_Guides_and_Activities.html

Go to the URL below for a guide to teaching high school students about renewable energy.

- http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf
-

Pacing the Lessons

TABLE 5.1: short caption

Lesson	Class Period(s) (60 min)
5.1 Energy Resources	1.5
5.2 Nonrenewable Energy Resources	2.5
5.3 Renewable Energy Resources	2.0

5.2 Lesson 5.1: Energy Resources

Key Concepts

- The need for energy
- Energy, fuel, and heat
- Types of energy resources

Lesson Objectives

- Compare ways in which energy changes from one form to another.
- Discuss what happens when a fuel burns.
- Describe the difference between renewable and nonrenewable resources.
- Classify different energy resources as renewable or nonrenewable.

Lesson Vocabulary

- **chemical energy:** energy that is stored in the chemical bonds of molecules
- **energy:** ability to do work or produce change in matter
- **fuel:** material that can release energy in a chemical change
- **heat:** energy associated with the movement of atoms or molecules
- **kinetic energy:** energy that an object in motion has because of its motion
- **law of conservation of energy:** law stating that energy cannot be created or destroyed
- **nonrenewable resource:** resource that is used more quickly than it is replaced or that is limited to what is currently available on Earth
- **potential energy:** energy stored within a physical system that has the potential to do work
- **renewable resource:** resource that is limitless or that is replaced as quickly as it is used

Teaching Strategies

Introducing the Lesson

Hold a pen, book, or other object at arm's length in each hand. As students observe, hold one of the objects motionless while dropping the other object to the floor. Ask students which object had more energy while one object was falling. (Students are likely to think that the falling object had more energy while it was moving.) Tell students that the stationary object and falling object have the same amount of energy. They will learn why when they read this lesson.

Activity

You may want to use the lesson plan and activity at the URL below when you teach this lesson. This is a multi-day lesson plan that includes an introduction to energy resources, an activity to understand the value of renewable energy resources, and research on specific energy resources.

<http://www.clarkson.edu/highschool/k12/project/documents/energysystems/5-Energy-Sources-and-Systems.pdf>

Demonstration

Show students the video clip “Conservation of Mechanical Energy” at the URL below. The video defines potential and kinetic energy and shows how energy is conserved when it changes form.

<http://ocw.mit.edu/high-school/physics/work-energy-power/conservation-of-energy/>

Discussion

Have students watch the high-speed video of a roller coaster at the following URL to observe how the coaster changes back and forth between kinetic and potential energy. Discuss how some energy is “lost” as heat because of friction between the wheels and track and between the car and air (air resistance).

<http://serc.carleton.edu/sp/compadre/teachingwdata/examples/48922.html>

Differentiated Instruction

Have students create a table comparing and contrasting renewable and nonrenewable energy resources. They should include in their table several examples of each type of energy resource.

Enrichment

Ask a student who has knowledge of chemistry to find and write on the board the equation for the combustion of the fuel methane ($\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$). Have the student explain the equation to the rest of the class and identify the products of combustion (CO_2 and H_2O). Relate the production of CO_2 to the effects of fossil fuel combustion on the greenhouse effect and global climate change.

Science Inquiry

Have groups of students do simulation activity 1 in the “Four Skate Park Activities” PDF document at the URL below. Students will explain the conservation of energy using kinetic and gravitational potential energy as an example. Then they will design a simulated skate park using the concepts.

<http://phet.colorado.edu/en/contributions/view/3134>

Overcoming Misconceptions

The URL below lists a number of misconceptions about energy that have been documented in students in grades 9–12. Read the misconceptions that are relevant to lesson content, and ask students if they think the statements are true or false. For any misconceptions students identify as true, explain why the statements are false.

<http://assessment.aaas.org/topics/EG#,tabs-247/2>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 5.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 5.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 5.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How long do fossil fuels take to form?

Are all fossil fuels nonrenewable resources?

Do all fossil fuels affect the environment equally?

How is food energy measured?

Is a rechargeable battery a renewable source of energy?

5.3 Lesson 5.2: Nonrenewable Energy Resources

Key Concepts

- Formation of fossil fuels
- Coal, oil, and natural gas
- Nuclear energy

Lesson Objectives

- Describe the natural processes that form the different fossil fuels.
- Describe different fossil fuels, and understand why they are non-renewable resources.
- Explain how fossil fuels are turned into useful forms of energy.
- Understand that when we burn a fossil fuel, its energy is released as heat.
- Describe how a nuclear power plant produces energy.

Lesson Vocabulary

- **coal:** solid fossil fuel that formed over millions of years from dead swamp plants
- **crude oil:** unrefined oil as it is taken from below Earth's surface
- **fossil:** any remains or traces of a long-dead organism
- **fossil fuel:** substance consisting of hydrocarbons that formed from the remains of dead organisms and can be burned for energy; coal, oil, or natural gas
- **hydrocarbon:** any chemical compound consisting only of hydrogen and carbon
- **natural gas:** gaseous fossil fuel that formed over millions of years from dead sea organisms and that consists mainly of the hydrocarbon methane (CH₄)
- **nuclear energy:** energy released from the nucleus of an atom when it is changed into another atom by a nuclear reaction
- **oil:** liquid fossil fuel that formed over millions of years from dead sea organisms

Teaching Strategies

Introducing the Lesson

Students are unlikely to have given much thought to where their electricity comes from. Ask them if they know what energy resource is used to make the electricity that supplies their community. Chances are the electricity comes from coal, natural gas, or nuclear energy, all of which are nonrenewable energy resources. Share the **Table 5.2** with the class, and tell them they will learn more about these nonrenewable energy resources in this lesson.

TABLE 5.2: Sources of Electricity

Energy Resource	Percent of U.S. Electricity Generated with this Resource (2011)
Coal	42%
Natural Gas	25%
Nuclear Energy	19%
All Other Energy Resources	14%

Building Science Skills

In the document below, have students read the background on ocean energy (page 4) and petroleum and natural gas (pages 5–6). Then assign groups of students to do activities 2–4 (pages 15–17). In the activities, they will create models of stationary and floating oil rigs and simulate drilling for oil on the ocean floor. The activities will address the following research questions: What are the challenges of finding and producing oil from offshore basins? What is the maximum depth in which a stationary rig could be used? What are some unique challenges of drilling in deep water?

<http://www.fossil.energy.gov/education/OceanEnergyMMS.pdf>

Differentiated Instruction

Have pairs of students make an illustrated flow chart showing how coal or petroleum forms. In their flow chart, they might include the following steps: plants or animals dying and their remains settling on the ground, deposition of overlying sediment layers, thick layers of sediments creating intense heat and pressure, and formation of hydrocarbons (coal or oil) from the organic remains.

Enrichment

Ask a few interested students to do a Web quest to investigate the following questions:

1. What is clean coal?
2. How does clean coal differ from other coal?
3. Is clean coal really clean (nonpolluting)?
4. What is the future of clean coal use in the U.S.?

Invite students to share the results of their investigation with the rest of the class in a PowerPoint presentation.

Science Inquiry

In this problem-solving classroom activity, students will gather and analyze data to determine how much it costs to light their school. They will also compute the amount of coal needed to produce the electricity.

http://www.fe.doe.gov/education/energylessons/coal/How_Much_Does_It_Cost_to_Light_Your_Scho.pdf

Physics Connection

Explain in greater detail how nuclear fission reactions occur and why they release so much energy. You and/or your students can learn more at this URL: <http://hyperphysics.phy-astr.gsu.edu/hbase/nucene/fission.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 5.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 5.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 5.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What are the main categories of nonrenewable energy discussed in this chapter?

Why is nuclear energy considered nonrenewable?

Are nonrenewable energy sources equally harmful? What are the advantages of using them?

Are renewable energy sources harmful or beneficial for the environment?

5.4 Lesson 5.3: Renewable Energy Resources

Key Concepts

- Solar energy
- Water energy
- Wind energy
- Geothermal energy
- Biomass energy

Lesson Objectives

- Describe different renewable resources and understand why they are renewable.
- Discuss how the sun is the source of most of Earth's energy.
- Describe how energy is carried from one place to another as heat and by moving objects.
- Discuss why some renewable energy sources cost less than others do and why some cause less pollution than others.
- Explain how renewable energy resources are turned into useful forms of energy.
- Describe how the use of different renewable energy resources affects the environment.

Lesson Vocabulary

- **biofuel:** fuel made from biomass, or living things, usually crop plants such as corn
- **conduction:** transfer of heat by direct contact from a higher-temperature to a lower-temperature object
- **radiation:** transfer of energy through space or matter by electromagnetic waves

Teaching Strategies

Introducing the Lesson

Share the following facts and figures with the class to spur interest in solar energy. Then tell students they will read about solar and other renewable energy resources in this lesson.

- Earth receives more energy from the sun in an hour than is used in the entire world in one year.
- It would take only around 0.3 % of the world's land area to gather enough solar energy for the world's electricity needs.
- If only 5 % of American households were to go solar, it would be the equivalent of taking 7.7 million cars off the road and removing almost 90 million pounds of CO₂ from the environment.

Building Science Skills

With the activity “Solar Water Heater” at the following URL, students will build a model water heater, which is based on home solar water heaters. The modeling activity will demonstrate to students how sunlight can be used to heat water.

http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf

Cooperative Learning

Have your class investigate renewable energy technologies. Divide the class into groups and have each group read about and explain to the class the scientific principles and technology underlying the following renewable energy resources:

- solar thermal energy for heating homes and water
- photovoltaic cells
- wind energy
- biomass for electricity generation, heat, and transportation fuels
- hydropower
- geothermal energy

Differentiated Instruction

Before students read the lesson, have them start a cluster diagram of renewable energy resources. They should label the center circle “Renewable Energy Resources,” and they should label each surrounding with one of the forms of renewable energy described in the lesson. Then, as students read the lesson, they should add one or two of the most important details to each surrounding circle. Tell them to add their diagrams to their science notebook.

Enrichment

Ask a few students to research the following question, take different stances on the issue, and then debate the issue in front of the rest of the class.

Question: Should we develop nonrenewable energy resources, renewable energy resources, or both?

Science Inquiry

In Activity 6 (“The Answer is Blowing in the Wind”) at the URL below, students will make three wind machines and test them in order to determine the factors that affect how well they turn with the least amount of wind and how much electricity they can generate. This engineering connection will help them appreciate some of the technical issues involved in developing renewable resources.

<http://www.nrel.gov/docs/gen/fy01/30927.pdf>

Economics Connection

Have students play the game “Playing It Cool: A Renewable Energy Economics Game” at the following URL. The game simulates some of the economic changes necessary to make renewable energy resources successful as large-scale sources of electricity. In the activity, students will buy and sell electricity from various nonrenewable and renewable sources and learn about economic considerations in using renewable energy resources.

http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 5.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 5.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 5.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What areas do you think would be best for using solar energy?

What causes the high temperatures deep inside Earth that make geothermal energy possible?

Do you think your town or city could use wind or water power?

CHAPTER

6

HS TE Plate Tectonics

Chapter Outline

- 6.1** **CHAPTER 6: PLATE TECTONICS**
 - 6.2** **LESSON 6.1: INSIDE EARTH**
 - 6.3** **LESSON 6.2: CONTINENTAL DRIFT**
 - 6.4** **LESSON 6.3: SEAFLOOR SPREADING**
 - 6.5** **LESSON 6.4: THEORY OF PLATE TECTONICS**
-

6.1 Chapter 6: Plate Tectonics

Chapter Overview

This chapter covers properties of Earth's interior, continental drift, seafloor spreading, the theory of plate tectonics, and plate boundaries.

Online Resources

See the following Web sites for appropriate laboratory activities:

Use the continental drift lab at the following URL when you teach the first two lessons in this chapter. The lab incorporates collaborative groups and introduces the basic principles that underlie the theory of plate tectonics. It will help students visualize Earth as a "living" planet that is constantly changing. This lab was created as a result of the Girls Engaged in Math and Science Project.

- http://alex.state.al.us/lesson_view.php?id=23948

In the lab activity at the following URL, students will gain an understanding of how geologists determine rates of sea floor spreading. They will also practice applying some basic mathematical concepts, including conversion from one set of units to another.

- http://www.beloit.edu/sepm/Earth_Works/Sea_floor_spreading.html

In the following plate tectonics lab, students will analyze the tectonics of a simple hypothetical planet that features continents with ancient mountain ranges, oceans (complete with magnetic "stripes" and a hotspot volcanic chain), an island arc, and a trench. They will estimate rates of plate movement and reconstruct past and future plate tectonic regimes. The lab will give students a deeper understanding of fundamental plate tectonic concepts.

- http://serc.carleton.edu/sp/library/guided_discovery/examples/geoworld.html

These Web sites may also be helpful:

The online USGS publication This Dynamic Earth (see URL below) provides excellent background for you or your advanced students on plate tectonics.

- <http://pubs.usgs.gov/gip/dynamic/dynamic.html>

This URL contains links to numerous Web sites related to the study of plate tectonics: <http://www.tectonicplate.com/resource/>

The videos below provide excellent visuals and explanations of seafloor spreading and plate movements.

- <http://www.youtube.com/watch?v=ryrXAGY1dmE>
- http://www.youtube.com/watch?v=1-HwPR_4mP4
- <http://www.youtube.com/watch?v=JmC-vjQGSNM>

Pacing the Lessons

TABLE 6.1: short caption

Lesson	Class Period(s) (60 min)
6.1 Inside Earth	2.0
6.2 Continental Drift	1.5
6.3 Seafloor Spreading	1.0
6.4 Theory of Plate Tectonics	2.5

6.2 Lesson 6.1: Inside Earth

Key Concepts

- Exploring Earth's interior
- Seismic waves and other evidence about Earth's interior
- Earth's layers (crust, mantle, and inner and outer core)
- Asthenosphere and lithosphere

Lesson Objectives

- Compare and describe each of these Earth layers: lithosphere, oceanic crust, and continental crust.
- Compare some of the ways geologists learn about Earth's interior.
- Describe how convection takes place in the mantle.
- Compare the two parts of the core and describe why they are different from each other.

Lesson Vocabulary

- **conduction:** transfer of heat by direct contact from a higher-temperature to a lower-temperature object
- **continental crust:** thicker, denser part of Earth's crust that makes up the continents
- **convection:** transfer of heat by the movement of molecules in currents through a fluid
- **convection cell:** circular current of warm material rising and cool material sinking
- **core:** dense, metallic innermost layer of Earth, consisting of the inner and outer core
- **crust:** rocky, outermost layer of Earth, consisting of continental and oceanic crust
- **lithosphere:** rigid part of Earth that consists of the crust and upper mantle
- **mantle:** middle layer of Earth, consisting of hot rock that circulates by convection
- **meteorite:** rocky fragment of a planetary body that strikes Earth's surface from space
- **oceanic crust:** thinner, less dense part of Earth's crust that makes up the ocean basins
- **P-wave:** primary waves, or seismic waves that arrive first at a seismograph
- **S-wave:** secondary waves, or seismic waves that arrive second at a seismograph
- **seismic wave:** earthquake wave that transports energy from an earthquake through the ground in all directions

Teaching Strategies

Introducing the Lesson

Use the video collage and layers of Earth song at the following URL to introduce your class to Earth's interior. The song also makes a good review of Earth's layers after students have read the lesson.

<http://www.youtube.com/watch?v=Q9j1xGaxYzY>

Demonstration

Demonstrate how Earth's layers are sorted by density, using as a model three liquids of different densities: water, vegetable oil, and pancake syrup. Ask students to predict the relative densities of the three liquids and what will happen if they are placed in the same container. Test their predictions by gently pouring the three liquids into a clear glass container. The liquids will form separate layers by density, with the syrup on the bottom, the water in the center, and the vegetable oil on top. Compare the relative densities of Earth's layers to the densities of the liquid layers. Tell students that Earth's core consists of the densest materials, followed by the mantle, with the crust consisting of the least dense materials. You can also go into more detail regarding the actual composition of each layer. Then relate the sorting of Earth materials into layers by density to the way in which the planet formed.

Differentiated Instruction

Suggest that students make a compare/contrast table for the three main layers of Earth. They should compare and contrast the layers in terms of position, temperature, thickness, and composition.

Enrichment

Have a few creative students collaborate on writing a story in which the main character travels to the center of Earth. They should include information about each layer as the character passes through it. In their story, they should give the reason for the trip and describe obstacles the character must overcome to get to the center of Earth. Invite the students to share their story with the class.

Science Inquiry

In the activity at the following URL, students can experiment with thermal convection and observe how thermal energy (heat) can generate motion (flow) in a fluid. The activity will model thermal convection similar to the convection that is inferred for Earth's mantle. It will show how convection can produce horizontal flow that can cause plate motions. Students will also investigate the viscosity of a fluid and learn that Earth's mantle can be thought of as a solid for short duration processes (such as the propagation of seismic waves), and as a very viscous fluid for long duration processes (such as mantle convection and plate tectonic movements).

<http://web.ics.purdue.edu/braille/edumod/convect/convect.htm>

Overcoming Misconceptions

Several common misconceptions about Earth's interior structure are listed at the URL below. Discuss each of the misconceptions with your students. Call on volunteers to explain why each misconception is false.

http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 6.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 6.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 6.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Oceanic crust is thinner and denser than continental crust. All crust sits atop the mantle. What might Earth be like if this were not true?

If sediments fall onto the seafloor over time, what can sediment thickness tell scientists about the age of the seafloor in different regions?

How might convection cells in the mantle affect the movement of solid crust on the planet's surface?

6.3 Lesson 6.2: Continental Drift

Key Concepts

- The idea of continental drift
- Wegener's original evidence for continental drift
- More recent magnetic polarity evidence for continental drift

Lesson Objectives

- Explain the continental drift hypothesis.
- Describe the evidence Wegener used to support his continental drift idea.
- Describe later evidence for continental drift.

Lesson Vocabulary

- **apparent polar wander:** way in which Earth's magnetic pole appears to shift position over time
- **continental drift:** early 20th century hypothesis that the continents move over Earth's surface
- **magnetic field:** area surrounding a magnet over which it exerts magnetic force
- **magnetic polarity:** direction of a magnetic field, such as Earth's magnetic field
- **magnetite:** magnetic mineral that aligns with Earth's magnetic polarity as it crystalizes
- **magnetometer:** instrument that measures the intensity of a magnetic field

Teaching Strategies

Introducing the Lesson

Introduce continental drift with the animation at the URL below. Ask students to describe what they are observing. (The continents are drifting.) Tell them they will read about evidence for continental drift when they read this lesson.

http://education.sdsc.edu/optiputer/flash/pangea_4.htm

Demonstration

The video at the URL below is an excellent, grade-appropriate way to introduce students to Alfred Wegener, his continental drift hypothesis, and the diversity of evidence for it.

<http://education-portal.com/academy/lesson/alfred-wegeners-theory-of-continental-drift.html>

Activity

Students can further explore continental drift using the interactive animated module at the following URL. They can control the timeline of continental drift to see where the continents were located during different geologic time periods. Locations of fossils and other evidence are marked on the drifting continents.

<http://www.exploratorium.edu/origins/antarctica/ideas/gondwana2.html>

Differentiated Instruction

Have students do a think-pair-share activity about continental drift. First ask students to think about the following questions:

1. What is continental drift?
2. What is the evidence for continental drift?
3. Does the evidence convince you that continents really do drift?
4. How do you think continental drift might occur?

After students have had time to think about the questions, divide the class into pairs, matching any English language learners with native English speakers. Have partners share and discuss their answers to the questions.

Enrichment

Ask one or more students to write a brief biography of Alfred Wegener. They can begin their research with the following URLs. Encourage other students to read the biographies.

- <http://www.ucmp.berkeley.edu/history/wegener.html>
- <http://www.pbs.org/wgbh/aso/databank/entries/bowege.html>
- <http://pangaea.org/wegener.htm>

Science Inquiry

The inquiry activity at the URL below guides students through the history of continental drift. Students will gather evidence and use scientific reasoning to reconstruct Pangaea. They will also propose their own mechanism for how drift occurs.

http://www.wilson.wnyric.org/david/images/stories/history_labs/pt_history_cont_drift.doc

History Connection

The way that Alfred Wegener and his continental drift hypothesis were treated by most other scientists of his time is a good example of how difficult it can be to change science orthodoxy. The historical context of Wegener's life and work are well described in the article below. Assign it to your students to read, and then discuss it as a class.

<http://www.smithsonianmag.com/science-nature/When-Continental-Drift-Was-Considered-Pseudoscience.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 6.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 6.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 6.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why is continental drift referred to as a hypothesis (or idea) and not a theory?

What did Wegener's idea need for it to be accepted?

What other explanations did scientists come up with to explain the evidence Wegener had for continental drift?

6.4 Lesson 6.3: Seafloor Spreading

Key Concepts

- Seafloor bathymetry and seafloor features
- Seafloor magnetism
- Seafloor spreading hypothesis

Lesson Objectives

- Describe the main features of the seafloor.
- Explain what seafloor magnetism tells scientists about the seafloor.
- Describe the process of seafloor spreading.

Lesson Vocabulary

- **abyssal plain:** one of the flat areas that make up most of the ocean floor
- **echo sounder:** device that uses sound waves to calculate distances to underwater objects and the seafloor
- **seafloor spreading:** hypothesis explaining how the ocean floor forms and how continents can drift
- **trench:** deep crack in the ocean floor

Teaching Strategies

Introducing the Lesson

Show students the brief video about the discovery of seafloor spreading at the URL below. Tell them they will learn more about this amazing discovery when they read the lesson.

<http://science.discovery.com/tv-shows/greatest-discoveries/videos/100-greatest-discoveries-sea-floor-spreading.htm>

Activity

Have students use the interactive animation at the following URL to simulate seafloor spreading and magnetic reversals. By doing the activity, they will see how the pattern of magnetic stripes forms on the seafloor.

http://earthguide.ucsd.edu/eoc/teachers/t_tectonics/p_paleomag.html

Building Science Skills

If you use the activity at the URL below, students can further explore some of the evidence that led to the discovery of sea floor spreading. They will use a simple seafloor model and collect magnetic polarity evidence to identify the ages of seafloor rock and the location of a mid-ocean ridge.

http://www.sea.edu/academics/k-12_detail/mid_ocean_magnetism

Differentiated Instruction

Ask students to make a concept map of seafloor spreading that includes the process of seafloor spreading, evidence for seafloor spreading, and the relationship of seafloor spreading to continental drift. Suggest that students keep their concept map in their science notebook.

Enrichment

Have students learn more about the work of Harry Hess, the scientist credited with the discovery of seafloor spreading. They can start with the URL below, which explains how Hess's skills and observations allowed him to develop the hypothesis of seafloor spreading and support the theory of plate tectonics.

http://www.amnh.org/education/resources/rfl/web/essaybooks/earth/p_hess.html

Science Inquiry

The URL below describes how to build a model of the seafloor that will help them develop a better understanding of seafloor spreading, the pattern of magnetic stripes "frozen" into the seafloor, subduction, and related topics.

http://jclahr.com/science/earth_science/platemod/index.html

Overcoming Misconceptions

Make sure that students do not hold the misconception that the seafloor spreads only because of the pushing of new seafloor away from the axis of a mid-ocean ridge. Explain that the pulling of old seafloor into a deep-sea trench is also an important force in seafloor spreading. Add that both forces occur because of gravity. Gravity pulls the new seafloor down the slope of a mid-ocean ridge, and gravity also pulls old seafloor down into the mantle at a deep-sea trench. This can be thought of as analogous to a rug on a table with little friction. When part of the rug is off of the table, its weight pulls the rest of the rug down with it.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 6.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 6.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 6.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How were the technologies that were developed to fight World War II used by scientists for the development of the seafloor-spreading hypothesis?

In what two ways did magnetic data lead scientists to understand more about continental drift and plate tectonics?

How does seafloor spreading provide a mechanism for continental drift?

Look at the features of the North Pacific Ocean basin and explain them in seafloor spreading terms.

What would have to happen if oceanic crust was not destroyed at oceanic trenches, but new crust was still created at mid-ocean ridges?

6.5 Lesson 6.4: Theory of Plate Tectonics

Key Concepts

- Earth's tectonic plates
- How tectonic plates move
- Divergent, convergent, and transform plate boundaries
- Earth's changing surface and the supercontinent cycle
- Intraplate activity and hotspots
- Plate tectonics theory

Lesson Objectives

- Describe what a plate is and how scientists can recognize its edges.
- Explain how mantle convection moves lithospheric plates.
- List the three types of boundaries. Are they prone to earthquakes or volcanoes?
- Describe how plate tectonics processes lead to changes in Earth's surface features.

Lesson Vocabulary

- **batholith:** large body of intrusive igneous rock at the edge of a subducting plate
- **continental arc:** line of coastal volcanic islands at the edge of a subducting plate
- **continental rifting:** splitting of a continent at a divergent plate boundary
- **convergent plate boundary:** edge where two lithospheric plates come together
- **divergent plate boundary:** edge where two lithospheric plates move apart
- **epicenter:** point on Earth's surface directly above the focus of an earthquake
- **hotspot:** plume of hot material that rises through the mantle and can cause volcanoes
- **intraplate activity:** geologic activity that takes place within a plate away from plate boundaries
- **island arc:** line of ocean island volcanoes resulting from subduction beneath oceanic lithosphere
- **plate:** slab of lithosphere that can move over Earth's surface
- **plate boundary:** location where two lithospheric plates meet
- **plate tectonics:** theory that Earth's surface is divided into lithospheric plates that move over the planet's surface
- **subduction:** sinking of one lithospheric plate beneath another
- **subduction zone:** area where two lithospheric plates come together and one sinks beneath the other
- **supercontinent cycle:** repeated formation and breakup of one supercontinent after another
- **transform fault:** fracture in rock where one plate slides past another
- **transform plate boundary:** edge where two lithospheric plates slide past one another

Teaching Strategies

Introducing the Lesson

Introduce plate tectonics by showing students the map of Earth's lithospheric plates at the following URL. Briefly discuss the thought questions below the map with the class. Tell students to keep these questions in mind as they read the lesson.

http://earthguide.ucsd.edu/eoc/teachers/t_tectonics/p_plates.html

Discussion

Use the animation at the URL below when you discuss subduction with your class. You can use the key points listed below the animation when you explain how subduction occurs and why it generates volcanoes and earthquakes. Discuss as a class the thought questions at the bottom of the Web page.

http://earthguide.ucsd.edu/eoc/teachers/t_tectonics/p_subduction.html

Differentiated Instruction

Work with students to make a compare/contrast table of types of plate boundaries (divergent, convergent, and transform). Suggest that they add sketches to the table to show how each type of plate boundary occurs.

Enrichment

Challenge interested students to investigate how the Global Positioning System (GPS) is used to measure the movement of Earth's tectonic plates and why measuring plate movement is important. The following URLs provide relevant information. Ask the students to summarize what they learn in a brief report to the class.

- <http://pubs.usgs.gov/gip/dynamic/understanding.html>
- http://www.iris.edu/hq/files/programs/education_and_outreach/aotm/14/1.GPS_Background.pdf
- http://www.e-education.psu.edu/earth520/content/17_p7.html

Science Inquiry

In the “Discovering Plate Boundaries” inquiry activity at the following URL, students will use four global data maps (earthquakes, volcanoes, seafloor age, and topography/bathymetry) to discover the processes that occur at plate boundaries. The activity requires students to observe and classify data.

<http://terra.rice.edu/plateboundary/>

Overcoming Misconceptions

A dozen student misconceptions about plate tectonics are presented at the URL below. Use these misconceptions as a true-false quiz to identify misconceptions held by your students. After the quiz, discuss these misconceptions with the class and explain why they are false.

http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 6.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 6.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 6.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

On the map in the figure above, the arrows show the directions that the plates are going. The Atlantic has a mid-ocean ridge, where seafloor spreading is taking place. The Pacific Ocean has many deep sea trenches, where subduction is taking place. What is the future of the Atlantic plate? What is the future of the Pacific plate?

Using your hands and words, explain to someone how plate tectonics works. Be sure you describe how continents drift and how seafloor spreading provides a mechanism for continental movement.

Now that you know about plate tectonics, where do you think would be a safe place to live if you wanted to avoid volcanic eruptions and earthquakes?

CHAPTER **7**

HS TE Earthquakes

Chapter Outline

- 7.1 CHAPTER 7: EARTHQUAKES
 - 7.2 LESSON 7.1: STRESS IN EARTH'S CRUST
 - 7.3 LESSON 7.2: THE NATURE OF EARTHQUAKES
 - 7.4 LESSON 7.3: MEASURING AND PREDICTING EARTHQUAKES
 - 7.5 LESSON 7.4: STAYING SAFE IN EARTHQUAKES
-

7.1 Chapter 7: Earthquakes

Chapter Overview

This chapter describes the stresses on rocks and how mountain building occurs. It also discusses the causes of earthquakes, seismic waves, tsunamis, earthquake prediction, and earthquake safety.

Online Resources

See the following Web sites for appropriate laboratory activities:

In this fieldwork lab, students will use fractures in sidewalks as an analog for natural rock outcrops in a study of rock fractures. They will make systematic observations and measurements of sidewalk fractures, manipulate and analyze the data, and consider the origin and significance of the fractures. This is a good lab to launch the chapter.

- <http://serc.carleton.edu/NAGTWorkshops/structure04/activities/3860.html>

In the lab at the URL below, students use walking and running speeds and travel times to simulate S-waves and P-waves and their arrival times at seismographs. Based on the data, a hypothetical earthquake epicenter is calculated by triangulation. The lab can be performed outdoors or in the classroom.

- <http://web.ics.purdue.edu/braile/edumod/walkrun/walkrun.htm>

These Web sites may also be helpful:

Go to this URL for animations of the major types of faults:

- <http://www.iris.edu/gifs/animations/faults.htm>

This resource provides a series of short articles on earthquake basics for students, teachers, and parents originally. It was originally published as weekly features in The San Francisco Chronicle.

- <http://pubs.usgs.gov/gip/2006/21/>

You can link with several earthquake photo collections at these URLs:

- <http://earthquake.usgs.gov/learn/photos.php>
- <http://www.exploratorium.edu/faultline/activezone/photos.html>

The URL below has links to several short video lectures on earthquakes.

- http://www.iris.edu/hq/programs/education_and_outreach/videos#H

Numerous useful publications and other media relating to earthquakes can be accessed at this URL:

- <http://www.exploratorium.edu/faultline/activezone/links.html>

At the following URL, you can find information and links for using an AS-1 seismograph and AmaSeis software (which can be used with or without the seismograph). Also available are several teaching modules so students can use the data to locate earthquakes and determine their magnitude.

- <http://web.ics.purdue.edu/braile/edumod/as1lessons/as1lessons.htm>

A series of seismology resources for teachers from the Seismological Society of America can be accessed at the following URL. The resources include reference information, maps, slide sets, videotapes, computer hardware and software, seismographs, and data sets.

- <http://web.ics.purdue.edu/braile/edumod/seisres/seisresweb.htm>

Pacing the Lessons

TABLE 7.1: short caption

Lesson	Class Period(s) (60 min)
7.1 Stress in Earth's Crust	2.5
7.2 The Nature of Earthquakes	2.0
7.3 Measuring and Predicting Earthquakes	1.5
7.4 Staying Safe in Earthquakes	1.5

7.2 Lesson 7.1: Stress in Earth's Crust

Key Concepts

- Causes and types of stress in Earth's crust
- Folds, fractures, joints, and faults
- Stress and mountain building

Lesson Objectives

- List the different types of stresses that cause different types of deformation.
- Compare the different types of folds and the conditions under which they form.
- Compare fractures and faults and define how they are related to earthquakes.
- Compare how mountains form and at what types of plate boundaries they form.

Lesson Vocabulary

- **anticline:** fold in rock that arches upward so older rock is at the center
- **basin:** circular syncline that forms a depression in the ground
- **compression:** stress that squeezes rocks together
- **confining stress:** stress from the weight of material above buried rocks that does not allow the rocks to change shape
- **deformation:** change in the shape of rocks due to stress
- **dip:** angle of a fault relative to the horizontal surface of Earth
- **dip-slip fault:** fault in which the dip of the fault plane is inclined relative to the horizontal surface of Earth
- **dome:** circular anticline that forms a mound on the ground
- **elastic deformation:** strain that temporarily alters the shape of rocks
- **fault:** fracture along which one side has moved relative to the other
- **fold:** bend in rocks caused by compression
- **fracture:** crack in rocks caused by stress
- **joint:** break in rocks along which there is no movement
- **monocline:** bend in rocks that causes them to be inclined relative to the horizontal
- **normal fault:** dip-slip fault in which the hanging wall drops down relative to the footwall
- **plastic deformation:** strain that permanently alters the shape of rocks
- **reverse fault:** dip-slip fault in which the hanging wall pushes up relative to the footwall
- **shear:** parallel stresses on rocks that push them past each other in opposite directions
- **slip:** distance rocks move along a fault
- **strain:** deformation in rocks because of a stress that exceeds the rocks' internal strength
- **stress:** force per unit area on rocks
- **strike-slip fault:** fault in which the dip of the fault plane is vertical
- **syncline:** fold in rocks that bends downward so younger rocks are at the center

- **tension:** stress that pulls rocks in opposite directions
- **thrust fault:** reverse fault in which the dip of the fault plane is nearly horizontal
- **uplift:** upward movement of a block of rocks

Teaching Strategies

Introducing the Lesson

Ask students to recall the three types of plate boundaries from the FlexBook® chapter “Plate Tectonics.” Call on volunteers to describe how plates move relative to one another at each type of boundary. Explain that these plate movements place stresses on Earth’s crust. Tell students they will read about the stresses in this lesson.

Building Science Skills

In the activity at the following URL, students model faults and stresses using processed cheese food, which acts quite similar to homogeneous rocks. Students make predictions before each of several brief experiments with the model. At the end of the activity, ask each group explain their results to the rest of the class.

<http://serc.carleton.edu/introgeo/demonstrations/examples/cheese.html>

Differentiated Instruction

Have students make a compare/contrast table for types of faults, including the type of stress that causes each type of fault and how rocks move at each type of fault. Students should illustrate their table with simple sketches of the different types of faults. Tell them to use arrows to show the direction rocks move at each type of fault.

Enrichment

Ask one or more students to create a Web page titled “How the Himalayas Were Born.” They should include plenty of photos and a detailed explanation of the plate tectonics and types of stresses that built the highest mountains on Earth. Tell other students to visit the finished Web site.

Science Inquiry

This inquiry activity is based on QuickTime movies and color digital photographs derived from sandbox experiments that produce normal faults in a variety of boundary conditions. Students will view specially edited movies to gain awareness of the evolution of normal fault systems. Then they will investigate the formation and evolution of a fault system for a particular structural setting by tracing and labeling individual faults on a set of photographs taken at regular intervals during an experiment. This activity helps students develop an awareness of how faults occur and how they deform rocks. The activity was written for college undergraduates but can be adapted for high school students.

<http://serc.carleton.edu/NAGTWorkshops/structure04/activities/3861.html>

Overcoming Misconceptions

A common student misconception is that the ground opens up during an earthquake. Explain to students that shallow crevasses may form during an earthquake, but the surface does not actually “open up” along a fault line. If it did, it

would relieve the stress and prevent an earthquake.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 7.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 7.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 7.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Where in an ocean basin would you find features that indicate tensional stresses? Where would you find the features that indicate compressional stresses?

Earthquakes are primarily the result of plate tectonic motions. List the three types of plate boundaries and what you think the stresses are that would cause earthquakes there.

Which type of plate boundary do you think has the most dangerous earthquakes? How do earthquakes cause the greatest damage?

7.3 Lesson 7.2: The Nature of Earthquakes

Key Concepts

- Causes of earthquakes
- Earthquake zones
- Seismic waves
- Tsunamis

Lesson Objectives

- Be able to identify an earthquake focus and its epicenter.
- Identify earthquake zones and what makes some regions prone to earthquakes.
- Compare the characteristics of the different types of seismic waves.
- Describe how tsunamis are caused by earthquakes, using the 2004 Boxing Day Tsunami as an example.

Lesson Vocabulary

- **amplitude:** height of a wave from the center to the top of a crest (or bottom of a trough)
- **body wave:** type of seismic wave that travels through Earth's interior; either a primary wave or a secondary wave
- **crest:** highest point of a wave
- **earthquake:** ground movement caused by the sudden release of energy stored in rocks
- **elastic rebound theory:** theory that earthquakes occur when rocks break and snap back to their original position after being deformed elastically until they cannot deform any more
- **focus:** point beneath the surface where rocks break and start an earthquake
- **seismology:** study of seismic waves
- **surface wave:** type of seismic wave that travels along the surface of the ground; either a Love wave or a Rayleigh wave
- **trough:** lowest point of a wave
- **tsunami:** large water wave caused by a shock to ocean water, often due to an undersea earthquake
- **wavelength:** horizontal distance between two corresponding points on adjacent waves, such as the distance between two crests or two troughs

Teaching Strategies

Introducing the Lesson

Introduce earthquakes by sharing with students some of the earthquake facts at the following URL. Tell students they will learn more about earthquakes when they read this lesson.

<http://earthquake.usgs.gov/learn/facts.php>

Demonstration

You may want to use the USGS PowerPoint slideshow presentation entitled “Earthquakes 101” when you teach this lesson. It covers all the basics, from plate tectonics to seismic waves.

<http://earthquake.usgs.gov/learn/topics/EQ101.zip>

Activity

Have students use the interactive wave maker at the following URL to investigate the different types of seismic waves, including how they move rocks and what they can tell us about Earth’s interior. The activity includes questions and answers.

<http://aspire.cosmic-ray.org/labs/seismic/index.htm>

Building Science Skills

With the activity at the URL below, students will plot the locations of faults and then map recent earthquakes in order to see the relationship between earthquakes and faults.

<http://www.teachingboxes.org/earthquakes/lessons/lesson2.jsp>

Differentiated Instruction

Using a spring toy, demonstrate different types of seismic waves to visual learners. Give volunteers a chance to make the different types of waves themselves. Relate the spring toy waves to the corresponding seismic waves. You can learn more at this URL: <http://www.geo.mtu.edu/UPSeis/making.html>.

Enrichment

Ask one or more students to investigate careers in seismology. They can find excellent information at the following URL. Have the students use the information to make “help-wanted” ads for a few of the careers. Share the ads with the class.

<http://www.seismosoc.org/society/education/careers.php>

Science Inquiry

In the inquiry activity at the following URL, students will learn about the four types of seismic waves, including their characteristics and effects. Then students will predict the level of damage each wave might cause in a residential area. Finally, they will test their predictions against several computer animations.

<http://www.teachingboxes.org/earthquakes/lessons/lesson4.jsp>

History Connection

Share information from the URL below with your class, or assign the article for students to read. It provides a brief history of seismology to 1910. The history is a good example of the cumulative nature of scientific knowledge and how researchers all over the world make contributions to science.

<http://projects.crystal.ucsb.edu/understanding/history/history3.html>

Literature Connection

Suggest that students read first-hand accounts of famous earthquakes written by Mark Twain, Jack London, and other authors (see URL below). The accounts will give students unique insights into the nature of earthquakes.

<http://projects.crystal.ucsb.edu/understanding/accounts/twain.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 7.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 7.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 7.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Do the largest earthquakes cause the most deaths and the most damage to property?

The last time there was a large earthquake on the Hayward Fault in the San Francisco Bay area of California was in 1868. Use elastic rebound theory to describe what may be happening along the Hayward Fault today and what will likely happen in the future.

Why is California so prone to earthquakes?

How could coastal California be damaged by a tsunami? Where would the earthquake occur? How could such a tsunami be predicted?

7.4 Lesson 7.3: Measuring and Predicting Earthquakes

Key Concepts

- Measuring earthquake magnitude
- Finding the epicenter of an earthquake
- Earthquake intensity
- Earthquake prediction

Lesson Objectives

- Describe how to find an earthquake epicenter.
- Describe the different earthquake magnitude scales and what the numbers for moment magnitude mean.
- Describe how earthquakes are predicted and why the field of earthquake prediction has had little success.

Lesson Vocabulary

- **seismogram:** paper record of seismic activity produced by a seismograph
- **seismograph:** older type of device that measures and records seismic waves using a suspended, weighted pen that writes on a drum of paper that moves with the ground
- **seismometer:** modern device that uses electronic motion detectors to measure and record seismic waves and other ground motions

Teaching Strategies

Introducing the Lesson

Show the class a video clip of a recent major earthquake, showing how it felt to people on the ground and the damage it caused. The first few minutes of the video at the URL below provide good examples. It shows scenes from the 1989 Loma Prieta earthquake that affected the San Francisco region of California. Tell students they will learn in this chapter more about earthquakes and the damage they cause and why predicting earthquakes is so important.

<http://www.youtube.com/watch?v=VvTCNgZwygg>

Building Science Skills

In the real-world problem-solving activity at the URL below, students will play the role of geologist hired by the city of San Francisco to evaluate urban development in the earthquake-prone San Francisco Bay area. They will use

1973 and 1999 satellite images of the region along with other data to determine whether development is getting too close to active faults.

http://www.ebsinstitute.com/EBS.EQ1_RS.html

Differentiated Instruction

Have students make a main ideas/details chart of lesson content. This will help them identify and focus on the most important ideas in the lesson. Tell them to draw a line down the center of a sheet of paper and record the main ideas in the left column, leaving room between the ideas to add supporting details in the right column.

Enrichment

The Richter and moment magnitude scales of earthquake magnitude are logarithmic scales. A logarithmic scale is a scale of measurement that displays the value of a physical quantity using intervals corresponding to orders of magnitude rather than linear increases in magnitude. Ask any students who excel in math and have a good understanding of logarithms to explain how a logarithmic scale is constructed and how it is interpreted. Have them find and share examples of other common logarithmic scales (e.g., decibel scale of sound intensity and pH scale of hydrogen ion concentration, or acidity).

Science Inquiry

In this inquiry activity, students will use an earthquake simulator to determine the location of an earthquake's epicenter and estimate its Richter magnitude. They will be working with seismograms from three locations to triangulate the earthquake's epicenter.

<http://www.sciencecourseware.org/eec/Earthquake/>

Overcoming Misconceptions

At the URL below, you can find a list of many common earthquake myths. Share the myths with students and point out why they are not true. Discuss as a class which of the myths might lead to greater risk of injury during an earthquake.

http://www.consrv.ca.gov/index/Earthquakes/Pages/qh_earthquakes_myths.aspx

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 7.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 7.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 7.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If you live in an earthquake-prone area, how do you feel about your home now? What can you do to minimize the risk to you and your family? If you do not live in an earthquake-prone area, what would it take to get you to move to one? What risks from natural disasters do you face where you live?

What do you think are the most promising clues that scientists might someday be able to use to predict earthquakes?

What good does information about possible earthquake locations do for communities in those earthquake-prone regions?

7.5 Lesson 7.4: Staying Safe in Earthquakes

Key Concepts

- Damage from earthquakes
- Earthquake-safe structures
- Protecting yourself in an earthquake

Lesson Objectives

- Describe different types of earthquake damage.
- Describe the features that make a structure earthquake safe.
- Describe how to protect a person or household in earthquake country.

Lesson Vocabulary

- **liquefaction:** process in which saturated sediments become like quicksand during an earthquake

Teaching Strategies

Introducing the Lesson

Show students dramatic images of buildings that have collapsed in an earthquake while other nearby buildings remain standing. Some examples are shown in the URLs below. Ask students why they think some buildings collapsed while others withstood the earthquake. Tell them they will learn how buildings can be constructed to withstand earthquakes when they read this lesson.

- http://www.terraily.com/reports/Taiwan_to_boost_quake_warning_system_with_undersea_facility_999.html
- <http://www.newenglandpost.com/2011/09/28/northeastern-university-student-designs-system-earthquake-proofing-buildings/>
- http://www.nist.gov/public_affairs/factsheet/earthquake2009.cfm

Activity

In the activity at the following URL, students will construct towers out of drinking straws that must withstand simulated earthquake vibrations and an increasing load. By doing the activity, students will learn basic principles

of earthquake engineering and design, as well as practice team skills that are needed in all fields of science and engineering.

<http://teachers.egfi-k12.org/activity-earthquake-proof-structure/>

Differentiated Instruction

Have students do a think-pair-share activity. First ask students to think about the following questions: How can a building be made earthquake safe? How can you stay safe in an earthquake? After students have time to think about the questions, divide the class into pairs, matching any English language learners or less proficient readers with other students. Then ask partners to discuss how they would answer the questions.

Enrichment

Have interested students learn about earthquake building codes in an earthquake-prone region such as California (see URLs below). Ask them to report back to the class on some of the building requirements and to explain how they help buildings withstand earthquakes.

<http://homeguides.sfgate.com/california-building-codes-earthquakes-2592.html>

http://www.ehow.com/about_4692663_california-seismic-building-codes.html

Science Inquiry

In the lesson at the following URL, students will use both online and hands-on inquiry activities to explore landslides, liquefaction, and structural failures caused by earthquakes.

<http://www.teachingboxes.org/earthquakes/lessons/lesson6.jsp>

Overcoming Misconceptions

Some students may think that it is now possible to construct completely earthquake-proof buildings. In reality, buildings can be designed and constructed to withstand most, but not all, earthquakes. Earthquake damage is always a possibility, especially in very strong earthquakes.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 7.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 7.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 7.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Many people think that in a large earthquake, California will fall into the ocean and that Arizona and Nevada will become beachfront property. Why is this not true?

If you were the mayor of a small city in an earthquake-prone area, what would you like to know before choosing the building site of a new hospital?

How are decisions made for determining how much money to spend preparing people and structures for earthquakes?

Why do wealthy communities (such as those in California) tend to have greater earthquake protection than poorer communities (such as those in developing nations)?

CHAPTER

8

HS TE Volcanoes

Chapter Outline

- 8.1** **CHAPTER 8: VOLCANOES**
 - 8.2** **LESSON 8.1: WHERE VOLCANOES ARE LOCATED**
 - 8.3** **LESSON 8.2: VOLCANIC ERUPTIONS**
 - 8.4** **LESSON 8.3: TYPES OF VOLCANOES**
 - 8.5** **LESSON 8.4: VOLCANIC LANDFORMS AND GEOTHERMAL ACTIVITY**
-

8.1 Chapter 8: Volcanoes

Chapter Overview

This chapter explains how and where volcanoes form, types of magma and types of eruptions, and landforms from lava and magma.

Online Resources

See the following Web sites for appropriate laboratory activities:

In the lab “Volcano on Io,” students will use simple materials and graphics to study features associated with active volcanoes on Jupiter’s moon Io. They will learn how the shape and size of a volcano, as well as the explosiveness of its eruptions, is related to the chemical composition of its magma. They will also learn how volcanoes on Io differ from those found on Earth.

- <http://europa.la.asu.edu/education/activities/voi/voi.pdf>

In the lab activity at the following URL, small groups of students will work with maps, rocks, photographs of volcanic deposits, and a variety of other data to construct a hazard map and a risk communication plan for a specific volcano. Each group is assigned a different “volcano scenario,” which is based on a real volcano.

- <http://serc.carleton.edu/NAGTWorkshops/assess/activities/srogi.html>

This online lab activity uses highly interactive animations, illustrations, activities, and quizzes to show how eruptions at Mount St. Helens were accurately predicted by USGS scientists. It then allows students to predict an actual eruption using real data.

- <http://volcanoes.usgs.gov/about/edu/predict/index.php>

These Web sites may also be helpful:

For a diversity of educational resources on volcanoes, see this URL:

- <http://vulcan.wr.usgs.gov/Outreach/framework.html>

You can link with a variety of volcano videos at the following URL.

- <http://dsc.discovery.com/video-topics/other/other-topics-volcano-videos.htm>

These URLs have links to volcano Web sites for teachers and students:

- <http://voices.yahoo.com/great-volcano-web-sites-teachers-students-3069577.html>
- <http://exworthy.tripod.com/sciearthvolcanoes.htm>
- <http://www.lpi.usra.edu/education/step2012/participant/VolcanoResources.pdf>

Pacing the Lessons

TABLE 8.1: short caption

Lesson	Class Period(s) (60 min)
8.1 Where Volcanoes Are Located	1.0
8.2 Volcanic Eruptions	2.5
8.3 Types of Volcanoes	2.0
8.4 Volcanic Landforms and Geothermal Activity	1.0

8.2 Lesson 8.1: Where Volcanoes Are Located

Key Concepts

- Volcanoes and plate tectonics
- Volcanoes at convergent and divergent plate boundaries
- Hotspot volcanoes

Lesson Objectives

- Describe how the locations of volcanoes are related to plate tectonics.
- Suggest why volcanoes are found at convergent and divergent plate boundaries.
- Describe how intraplate volcanoes can form.

Lesson Vocabulary

- **fissure:** crack in the crust at a divergent plate boundary where magma may erupt

Teaching Strategies

Introducing the Lesson

Introduce volcanoes in a dramatic fashion by showing students a short video (such as <http://www.youtube.com/watch?v=xP2dreOI8gI>) of the 1980 eruption of Mount St. Helens, which opens the chapter. After the video, briefly discuss the destruction caused by the Mount St. Helens eruption. You might want to share the list of facts below. Tell students they will learn more about volcanoes such as Mount St. Helens when they read this lesson.

- Mount St. Helen's 1980 eruption was the deadliest and most economically destructive volcanic eruption in U.S. history.
- The volcanic eruption killed 57 people.
- The eruption destroyed 250 homes, 47 bridges, 24 km of railways, and 298 km of highways.
- The eruption caused a 5.1 Richter magnitude earthquake, which triggered a massive avalanche of debris.
- The explosive eruption reduced the mountain's elevation by 400 m and replaced it with a 1.6 km wide crater.

Activity

Have students explore the interactive module "Volcanoes and Hot Spots" at the URL below. The module uses multimedia to cover and extend content of the Flexbook lesson. For this lesson, they should focus on the parts of the

module titled “Inside an Active Volcano,” “Tracking Volcanoes,” and “Above Hotspots.”

http://www.mnh.si.edu/earth/main_frames.html

Differentiated Instruction

Have students make a Venn diagram comparing and contrasting volcanoes that occur at convergent plate boundaries with volcanoes that occur at hotspots.

Enrichment

Ask interested students to learn more about the 1980 eruption of Mount St. Helens, which is mentioned in the chapter. Tell them to collect photos, maps, diagrams, and statistics that show why and how the volcano erupted and the death and destruction it caused. Have students use the materials they collect to create a classroom display about Mount St. Helens.

Science Inquiry

In the inquiry activity below, students will examine the processes leading to a volcanic eruption, including mantle melting, magma formation, and magma ascent. Objectives of the activity are for students to understand how subducting plates trigger melting of mantle to form magma and how gas pressure initiates the ascent of magma into the magma chamber.

http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_one_magma_elevator.pdf

Overcoming Misconceptions

Many common misconceptions about volcanoes are listed at the following URL. Be aware that your students may hold some of these misconceptions. Discuss them with the class and point out how the misconceptions arise.

http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 8.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 8.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students’ mastery of the lesson with Lesson 8.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Some volcanoes are no longer active. What could cause a volcano to become extinct?

Hotspots are still poorly understood by Earth scientists. Why do you think it's hard to understand hotspots? What clues are there regarding these geological phenomena?

Volcanoes have been found on Venus, Mars, and even Jupiter's moon Io. What do you think this indicates to planetary geologists?

8.3 Lesson 8.2: Volcanic Eruptions

Key Concepts

- Composition of magma
- Types of volcanic eruptions
- Predicting volcanic eruptions

Lesson Objectives

- Explain how magma composition affects the type of eruption.
- Compare the types of volcanic eruptions.
- Distinguish between different types of lava and the rocks they form.
- Describe a method for predicting volcanic eruptions.

Lesson Vocabulary

- **active volcano:** volcano that is currently erupting or showing signs that it will erupt soon
- **dormant volcano:** volcano that is not currently erupting but has erupted in recorded history and may erupt again
- **effusive eruption:** relatively gentle, non-explosive volcanic eruption
- **eruption:** release of lava, tephra, and gases from a volcano
- **explosive eruption:** violent eruption of rock, lava, ash, and large amounts of gas from a volcano
- **extinct volcano:** volcano that has not erupted in recorded history and is unlikely to erupt again
- **lahar:** volcanic mudflow that occurs when a pyroclastic flow melts snow
- **magma chamber:** region in the crust below a volcano where magma and gases collect
- **pyroclastic flow:** hot ash, gas, and rock that race down a volcano's slopes during an explosive eruption
- **tephra:** fragments of solid material produced in an explosive volcanic eruption, which may include ash, cinders, rock fragments, and rocks
- **viscosity:** thickness of a liquid, or its resistance to flow

Teaching Strategies

Introducing the Lesson

Guide students in recalling what they know about igneous rocks from the Flexbook chapter “Rocks.” Ask them to distinguish between mafic and felsic rocks. (Mafic rocks are low in silica and dark in color; felsic rocks are high in silica and light in color.) Explain that differences in the silica content of magma determine how thick the magma

is and the thickness of the magma, in turn, determines how a volcano erupts. Tell students they will learn about different types of volcanic eruptions in this lesson.

Buildings Science Skills

Students can simulate building volcanoes with different values for three variables (volume, viscosity, and volatiles) by doing the “Build a Volcano” activity at the following URL from the Smithsonian. Students will be able to observe the type of eruption that occurs with each combination of variables they select.

http://www.mnh.si.edu/earth/main_frames.html

Activity

In the activity at the following URL, students measure the volume and mass of popcorn before and after popping in an exploration of how expanding gas bubbles inflate and fragment magma during a volcanic eruption. They also study the physical characteristics of tephra using actual samples or photographs of samples.

http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_two_tephra_popcorn.pdf

Differentiated Instruction

Have students make a compare/contrast table for types of magma (mafic and felsic) and the types of volcanoes they cause (effusive and explosive, respectively).

Enrichment

Ask a small group of students who need extra challenges to do the activity at the following URL as a classroom demonstration. The students will show how gases create explosive volcanic eruptions by conducting a controlled “eruption” of baking soda/vinegar or soda water. The activity will underscore the important role of gases in providing energy for explosive volcanic eruptions. Although the activity was designed as a middle school activity, it makes a great demonstration for any grade level.

http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_one_soda_bottle_volcano.pdf

Science Inquiry

In the activity module at the URL below, students investigate the processes that build volcanoes, the factors that influence different eruption types, and the threats volcanoes pose to their surrounding environments. After exploring these characteristics, students use what they have learned to identify physical features and eruption types in some real-life documented volcanic episodes.

http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.lp_volcanoes/

Overcoming Misconceptions

Students commonly think that if a volcano doesn’t erupt for a relatively short period of time, such as a century, then it must be extinct. Point out that the lifespan of a volcano may be millions of years, so a volcano that has not erupted in hundreds or even thousands of years would probably be considered dormant rather than extinct. For example, a Yellowstone volcano hasn’t erupted violently for more than 600,000 years, but it recently showed signs of activity so it has just been dormant for all that time. Volcanoes become extinct when they run out of magma. However, this

is hard to detect. For example, until recently, Mount Vesuvius in Italy was thought to be extinct, but then it erupted violently showing that it too was just dormant and not extinct.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 8.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 8.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 8.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What would you look for to determine if an old eruption was explosive or non-explosive?

Given the different styles of eruptions discussed above, what do you think the shapes of volcanoes are?

Where do you think the names a'a and pāhoehoe came from?

Do earthquakes always indicate an imminent eruption? What factors about an earthquake might indicate a relationship to a volcanic eruption?

8.4 Lesson 8.3: Types of Volcanoes

Key Concepts

- Composite volcanoes
- Shield volcanoes
- Cinder cones
- Supervolcanoes

Lesson Objectives

- Describe the basic shapes of volcanoes.
- Compare the features of volcanoes.
- Describe the stages in the formation of volcanoes.

Lesson Vocabulary

- **caldera:** large, circular hole formed when the top of a volcano collapses after an eruption empties the magma chamber
- **cinder cone:** small volcano composed of rock fragments piled on top of one another
- **composite volcano:** large volcano with steeply sloping sides composed of alternating layers of ash and lava flows
- **shield volcano:** broad-based volcano with gently sloping sides composed almost entirely of lava flows
- **supervolcano:** massive volcano that can produce rare but enormous eruptions

Teaching Strategies

Introducing the Lesson

Project images of a composite volcano and a shield volcano (see URLs below), and ask students to describe how the two volcanoes appear to differ. Identify the two types of volcanoes represented by the images, and tell students they will learn how the two types form when they read this lesson

- http://www.windows2universe.org/earth/interior/composite_volcanos.html
- http://www.ms-starship.com/sciencenew/images/shield_volcano.md.jpg

Activity

In the activity at the following URL, students can investigate how the viscosity of magma influences the shape of a volcano. Students will be able to relate the general viscosity of lava flows to type of volcano. They will also make some comparisons of lava flow behavior at Mount Rainier, Mount St. Helens, and Kilauea Volcano.

http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_two_lava_blocks.pdf

Building Science Skills

Students can simulate the collapse that forms a caldera with the activity at the URL below. They will use a balloon and a box of flour to model a magma chamber and overlying rock. The activity will take them through the stepwise process of predicting what they might see before and after the collapse. Students will then describe what happens with the collapse in their simulation.

http://media.up.edu/Physics/TOLE/CascadeVolcanoes/LessonPlans/FlourBoxVolcano_LessonPlan_VVP.pdf

Differentiated Instruction

Suggest that students make a compare/contrast table for composite and shield volcanoes. They should compare such features as shape of volcano, type of eruption, and type of magma. Tell them to add a simple sketch of each type of volcano to their table.

Enrichment

Volcanic eruptions obviously can have devastating impacts on people and the environment. However, unlike earthquakes, volcanoes can also have positive impacts, which may help explain why people choose to live near volcanoes. Ask a few students to debate whether they think volcanic eruptions have an overall more positive or more negative effect. They can learn more at the URL below. Set aside class time for their debate.

http://www.bbc.co.uk/schools/gcsebitesize/geography/natural_hazards/volcanoes_rev5.shtml

Science Inquiry

Have students do the activity “Piles of Fire” at the URL below. They will use simple materials to simulate a volcanic eruption in order to investigate how particle size affects the angle of a volcano’s slope.

http://www.spacegrant.hawaii.edu/class_acts/PilesFireTe.html

Creative Writing Connection

In the writing assignment described at the following URL, students create an original work of fiction pertaining to the geology of composite volcanoes and the dangers of their eruptions.

<http://serc.carleton.edu/NAGTWorkshops/intro/activities/25036.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 8.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 8.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 8.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Composite volcanoes and volcanic cones usually have craters on the top. Why are the craters sometimes U- or horseshoe-shaped?

Think about plate boundaries again. What type of volcanoes do you think are found at convergent, divergent, and transform boundaries? How about at intraplate sites?

Some people have theorized that if a huge asteroid hits Earth, the results would be catastrophic. How might an asteroid impact and a supervolcano eruption be similar?

8.5 Lesson 8.4: Volcanic Landforms and Geothermal Activity

Key Concepts

- Landforms from lava
- Landforms from magma
- Hot springs and geysers

Lesson Objectives

- List and describe landforms created by lava.
- Explain how magma creates different landforms.
- Describe the processes that create hot springs and geysers.

Lesson Vocabulary

- **geyser:** fountain of hot groundwater and steam that erupts under pressure onto the surface
- **hot spring:** place where hot water bubbles or flows continuously out of the ground
- **lava dome:** dome-shaped landform of igneous rock that forms when viscous lava cools near the vent of a volcano
- **lava plateau:** large, flat landform of igneous rock that forms when large amounts of non-viscous lava flow quickly over the ground

Teaching Strategies

Introducing the Lesson

As an introduction to geothermal activity, show students a short video of Old Faithful erupting. The video at the URL is a good example because it includes basic information about the geyser and its eruption cycle. Tell students they will read in this lesson about geysers like Old Faithful as well as other interesting features related to volcanic activity.

<http://www.youtube.com/watch?v=dStibCCOOyE>

Activity

Use Activity I at the URL below to teach students about volcanic landforms, using the volcanic landforms of Alaska as an example. In the activity, students will develop an understanding of the volcanic landforms in Alaska using photographs and worksheets. The activity concludes with student papers, presentations, and/or posters. The PDF

document includes the photographs and worksheets as well as a teaching strategy, extension activities, a glossary, and other useful materials.

http://pubs.usgs.gov/gip/99/pdf/gip99_chapter4.pdf

Differentiated Instruction

Have students outline the lesson as good way to organize and remember the most important content. Show them how to use the heading structure in the lesson to frame the basic outline. Then tell them to add important details under the relevant headings after they read the lesson.

Enrichment

Ask a small group of students to discuss how groundwater that has been heated by magma might be used to generate electricity. After they have come up with their own ideas, they can find out three different ways it can be done at the following URLs. Ask the students to describe one or more of the methods to the rest of the class.

- http://www.powerscorecard.org/tech_detail.cfm?resource_id=3
- <http://www.renewableenergyworld.com/rea/tech/geoelectricity>
- http://geo-energy.org/basics.aspx#how_plant_work

Science Inquiry

With the guided inquiry activity at the following URL, students can create a model of a geyser and use it to learn more about these geothermal features. For example, they will observe that there are three main phases in a geyser's cycle (heating, erupting, and refilling).

<http://www.exploratorium.edu/snacks/geyser/index.html>

Biology Connection

Tell students about thermophile (“heat-loving”) bacteria that are able to survive at very high temperatures in hot springs. These bacteria are important because they provide clues about what early life forms on Earth might have been like. They have also proven useful in biotechnology because their enzymes remain active at high temperatures. You (or your students) can learn more at the following URLs.

- <http://bioinfo.bact.wisc.edu/themicrobialworld/LAHT/b27.html>
- <http://serc.carleton.edu/microbelife/extreme/extremeheat/index.html>
- <http://whyfiles.org/2011/biology-critters-that-should-not-exist/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 8.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 8.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 8.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What might Earth look like if there were no tectonic plates? Are there any planets or satellites (moons) that may not have tectonic plates? How is their surface different from that of Earth?

The largest volcano in the solar system is Olympus Mons on Mars. How could this volcano have formed?

What kind of land formations are the result of volcanic activity? Are all of these created by extrusive igneous rocks?

How are hydrothermal vents at mid-ocean ridges like the geysers of Yellowstone?

CHAPTER **9**

HS TE Weathering and Formation of Soil

Chapter Outline

- 9.1 CHAPTER 9: WEATHERING AND FORMATION OF SOIL
 - 9.2 LESSON 9.1: WEATHERING
 - 9.3 LESSON 9.2: SOILS
-

9.1 Chapter 9: Weathering and Formation of Soil

Chapter Overview

This chapter describes mechanical and chemical weathering of rock. It also explains how soil forms, identifies soil horizons, and relates soil type to climate.

Online Resources

See the following Web sites for appropriate laboratory activities:

Have students do the real-world weathering project described at the following URL. They will photograph and document examples of different types of weathering around their community. (The lab was written for a community in Virginia, so you will have to substitute the correct place names for your community.) Students will also investigate specifically the effects of exposure (north, south, east, or west) on rate of weathering. Finally, they will do library research on weathering and conclude the activity with a written report.

- http://www.earth2class.org/docs/tchrlessonplans/Stallard_weathering.php

In the soil lab described at the URL below, students will test a soil sample for levels of three major soil elements and for pH. The experiment leads to a soil analysis in which students answer questions about optimum growing conditions with their soil, including preferred fertilizer and plants.

- <http://bostonteachnet.org/Quinones/QuinonesSp3/>

These Web sites may also be helpful:

The National Geographic article below has excellent images of weathering. It is also a good alternative presentation of the content of the first lesson in this chapter (“Weathering”).

- http://education.nationalgeographic.com/education/encyclopedia/weathering/?ar_a=1

At the following URL, you can find 18 short, narrated video clips on different types of soil organisms.

- <http://www.agron.iastate.edu/loynachan/mov/>

The USDA provides many soil resources for teachers and students at this URL:

- <http://soils.usda.gov/education/index.html>

You can find an entire multimedia library devoted to soils at the following URL.

- http://forces.si.edu/soils/04_00_00.html

Pacing the Lessons

TABLE 9.1: short caption

Lesson	Class Period(s) (60 min)
9.1 Weathering	2.0
9.2 Soils	2.0

9.2 Lesson 9.1: Weathering

Key Concepts

- Definition of weathering
- Mechanical weathering
- Chemical weathering
- Factors that affect rates of weathering

Lesson Objectives

- Define mechanical and chemical weathering.
- Discuss agents of weathering.
- Give examples of each type of weathering.

Lesson Vocabulary

- **abrasion:** form of mechanical weathering that occurs when rocks and rock particles scrape against other rocks
- **chemical weathering:** type of weathering that changes the mineral composition of rocks
- **climate:** average weather of a location over a long period of time
- **hydrolysis:** chemical change in which hydrogen or hydrogen ions replace positive ions in a mineral
- **ice wedging:** form of mechanical weathering that occurs when water enters a crack in rock, expands as it freezes, and wedges the rock apart
- **leaching:** process in which minerals in soil are dissolved and carried to lower layers of soil
- **mechanical weathering:** type of weathering that breaks rocks into smaller pieces without changing their mineral composition
- **oxidation:** chemical change in which oxygen reacts with another element to create a metal oxide

Teaching Strategies

Introducing the Lesson

Project the photo at the URL below. It shows an astronaut on the moon. Point out the astronaut's footprints in the dust on the moon's surface. Tell the class that the footprints were made in the early 1970s but they remain virtually unchanged decades later. Similar footprints left in most places on Earth would quickly be disturbed. That's because on Earth, unlike the moon, forces of weathering are continuously changing the surface. Tell students they will learn about weathering when they read this lesson.

http://www.nasa.gov/images/content/371255main_Seismic_full.jpg

Demonstration

Use a simple demonstration to make clear the differences between mechanical and chemical weathering. Demonstrate mechanical weathering by placing an effervescent antacid tablet on a table and breaking it with a hammer. Explain that this is a form of mechanical weathering, in which rocks are physically broken into smaller fragments without changing their chemical composition. Ask students what natural processes break rocks into fragments in this way. (ice wedging, abrasion, and actions of living things) Demonstrate chemical weathering by dropping an effervescent antacid tablet into a beaker of water. As the tablet dissolves, explain that it contains sodium bicarbonate, which dissolves in water similar to the way that carbonate rocks dissolve in water.

Differentiated Instruction

Suggest that less proficient readers make a concept map of lesson concepts. It should include the following concepts: weathering, agents of weathering (water, wind, glaciers, and gravity), mechanical weathering (by ice wedging, abrasion, and plants and animals), chemical weathering (by water, carbon dioxide, and oxygen), and influences on weathering (rock types and climate).

Enrichment

Challenge students to compute how much the surface area of a cube increases if it is cut into two equal pieces. (Its surface area will increase by 25 percent.) Ask them to demonstrate their solution to the class and explain how it relates to the weathering of rock.

Science Inquiry

Obtain permission to visit a nearby cemetery with your class. The cemetery should have tombstones made from different types of rock, including marble, slate, and granite. Help students identify the different types of rock, and tell them to look for evidence of weathering on tombstones of each rock type. They should look for cracks or missing pieces of rock, legibility of the inscription, surface texture of the tombstone, and biological alterations such as mildew, mold, or lichen. Be sure to have students make note of the year the tombstone was put in place (assumed to be the date of death) so they will be able to factor in the amount of time the tombstone has been weathering. As a class, have students create a rubric that assigns a numeric value for the extent of weathering observed. Have students graph their results to show which type of rock weathers most quickly in their climate. Discuss the particular climate factors that contribute to weathering in their area.

Overcoming Misconceptions

Listed below are several misconceptions about weathering, each of which is held by at least a third of high school students (AAAS Project 2061). Use the list as a true/false quiz to identify which misconceptions are held by your own students. Discuss these misconceptions with the class and show students examples that disprove the misconceptions.

1. Wind cannot break grains of sand.
2. Wind cannot break solid rock.
3. The growth of plant roots cannot break rock.
4. Wind can carry small rocks (e.g., sand) but never carries large rocks (e.g., fist-sized).
5. A small stream cannot wear away the solid rock of a cliff over time.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 9.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 9.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 9.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What types of surfaces are affected by weathering other than rock?

What might the surface of Earth look like if there was no weathering? Think about the Moon or other planets.

Do you think that you would be alive today if water did not dissolve elements?

Would the same composition of rock weather the same way in three very different climates?

9.3 Lesson 9.2: Soils

Key Concepts

- Characteristics of soil
- Soil texture and composition
- Soil horizons and profiles
- Types of soils
- Factors that determine soil type
- Soil conservation

Lesson Objectives

- Discuss why soil is an important resource.
- Describe how soil forms from existing rocks.
- Describe the different textures and components of soil.
- Draw and describe a soil profile.
- Define three climate related soils: pedalfer, pedocal, and laterite.

Lesson Vocabulary

- **B-horizon:** layer of a soil profile beneath the topsoil where iron oxides and clay minerals accumulate; also called subsoil
- **C-horizon:** lowest layer of a soil profile consisting of partially altered bedrock
- **humus:** organic portion of soil that consists of partially decayed remains of plants and animals
- **inorganic:** not related to life or living organisms; not organic
- **laterite:** nutrient-poor, red soil that forms in tropical rainforests
- **loam:** type of soil that contains about equal proportions of sand, silt, and clay
- **pedalfer:** very fertile, dark soil that forms in mid-latitude deciduous forests
- **pedocal:** moderately fertile soil that forms in grasslands
- **permeable:** material with tiny holes that water can pass through easily
- **residual soil:** soil that forms from the bedrock upon which it is found
- **soil:** top layer of Earth's surface containing weathered rocks and minerals and organic materials
- **soil horizon:** individual layer of a soil profile; A-, B-, or C-horizon
- **soil profile:** entire set of soil layers, or horizons, for a particular soil
- **subsoil:** B-horizon of a soil profile, which lies beneath the topsoil
- **topsoil:** A-horizon of a soil profile, which is the uppermost and most fertile layer of soil, containing humus, plant roots, and living organisms
- **transported soil:** soil that forms from weathered components that have been transported from a different area

Teaching Strategies

Introducing the Lesson

Introduce soil with the beautiful Smithsonian video, “Soil: the Secret Ingredient,” at the following URL. The brief video will show students some of the many ways that soil affects our lives.

http://forces.si.edu/soils/04_00_00.html

Activity

Healthy soils are held together by “soil glue,” or glomalin, that is produced by fungi. Soils rich in soil organisms hold together well, whereas soils lacking soil organisms fall apart easily. These differences have implications for water retention by soils, the ability of soils to support plant growth, and how easily soils erode. Help students understand this important property of soils by having them do the activity at the URL below. The activity will demonstrate that less disturbed soils contain more “soil glue” and hold together better than more disturbed soils. It will show why it is important to protect soils from disturbance.

http://soils.usda.gov/sqi/publications/files/soil_glue_lesson_plan.pdf

Differentiated Instruction

Have students make a compare/contrast table for the three types of soils described in the lesson (pedalfer, pedocal, and laterite). They should include distinguishing features of the soils and where they form.

Enrichment

Ask a small group of students to demonstrate how the amount of organic matter in soil influences the extent to which the soil can be eroded by flowing water. They can follow the procedure at the URL below. It uses only readily available materials.

<http://soils.usda.gov/education/resources/lessons/experiments/erosion/>

Science Inquiry

Students can analyze a soil sample with the activity at the URL below. In the activity, students will collect a local soil sample and use a simple procedure to determine what type of soil it is by its proportion of particles of different sizes. They will also decide on the soil’s potential for supporting plant growth.

http://ia700204.us.archive.org/20/items/AP_Environmental_Sci_Lab_11/chapter11extralab1.html

Real-World Connection

The use of geological materials such as soils to solve criminal cases began with the great fictional detective Sherlock Holmes. Today, it is commonplace. At the URLs below, students can read about several criminal cases that were solved with the help of soil forensics.

<http://www.forensicgeology.net/science.htm>

<http://www.csiro.au/Outcomes/Environment/Australian-Landscapes/soil-evidence-murder-case.aspx>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 9.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 9.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 9.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why is soil such an important resource?

Would soil mature faster from unaltered bedrock or from transported materials?

If soil erosion is happening at a greater rate than new soil can form, what will eventually happen to the soil in that region?

Do you think there are pollutants that could not easily be removed from soil?

CHAPTER **10**

HS TE Erosion and Deposition

Chapter Outline

- 10.1 CHAPTER 10: EROSION AND DEPOSITION
 - 10.2 LESSON 10.1: WATER EROSION AND DEPOSITION
 - 10.3 LESSON 10.2: WAVE EROSION AND DEPOSITION
 - 10.4 LESSON 10.3: WIND EROSION AND DEPOSITION
 - 10.5 LESSON 10.4: GLACIAL EROSION AND DEPOSITION
 - 10.6 LESSON 10.5: EROSION AND DEPOSITION BY GRAVITY
-

10.1 Chapter 10: Erosion and Deposition

Chapter Overview

This chapter explains how erosion and deposition shape Earth's surface through the action of streams, groundwater, waves, wind, glaciers, and gravity.

Online Resources

See the following Web sites for appropriate laboratory activities:

The first three stream table labs accessible at the following URL allow students to investigate erosion and deposition by flowing water. Students will learn how a stream forms; how the processes of erosion and deposition occur in a stream, including where they occur on both a large and a small scale; how stream velocity relates to the rate of erosion and deposition; and how sorting of sediments occurs in streams and its relationship to water velocity. Students will also learn how to make good observations, how to apply the different parts of the scientific method, and how to design a simple experiment with provided materials.

- http://csip.cornell.edu/Curriculum_Resources/CEIRP/streamtable.html

In the investigation at the URL below, students will model glacial dynamics with flubber (glue, water, and detergent). They will run several tests with different values for valley slope, flubber temperature, and basal conditions; and they will calculate the "glacier's" velocity for each scenario. Students will also compare their glacier models to the dynamics of real glaciers and discuss how and why glaciers might be changing over time.

- <http://nagt.org/nagt/programs/teachingmaterials/11337.html>

These Web sites may also be helpful:

Visit the URL below for information on building and using a stream table to simulate erosion and other processes involving sediment transport by water.

- <http://www.mostreamteam.org/pdfs/bldusng.pdf>

The following URL is a database of incredible photos for many glacier education topics including glacier hazards, how glaciers shape the landscape, and benefits of glaciers.

- http://www.swisseduc.ch/glaciers/earth_icy_planet/glaciers16-en.html

This URL contains common questions and myths about glaciers.

- <http://ak.water.usgs.gov/glaciology/FAQ.htm>

At the URL below, you can download a free handbook on landslides titled “The Landslide Handbook—A Guide to Understanding Landslides.” The handbook answers questions such as: What are landslides? Where do they occur? What causes them? How are they monitored? How can they be prevented? What safety measures can you follow if you live near steep hills? Written for a general audience, the handbook is heavily illustrated with diagrams and photographs taken at locations around the globe.

- <http://pubs.usgs.gov/circ/1325/>

Pacing the Lessons

TABLE 10.1: short caption

Lesson	Class Period(s) (60 min)
10.1 Water Erosion and Deposition	1.5
10.2 Wave Erosion and Deposition	1.5
10.3 Wind Erosion and Deposition	1.5
10.4 Glacial Erosion and Deposition	1.5
10.5 Erosion and Deposition by Gravity	1.5

10.2 Lesson 10.1: Water Erosion and Deposition

Key Concepts

- Erosion and deposition by streams
- Groundwater erosion and deposition

Lesson Objectives

- Describe how surface streams produce erosion.
- Describe the types of deposits left behind by streams.
- Describe landforms that are produced as groundwater flows.

Lesson Vocabulary

- **alluvial fan:** fan-shaped landform created where a stream goes from a steep slope to flat ground and deposits its sediments
- **base level:** elevation of the mouth of a stream where it enters a large body of standing water such as the ocean
- **bed load:** sediments that move by rolling or bumping along a streambed
- **column:** cave deposit formed when a stalactite and stalagmite merge
- **competence:** measure of the largest particle size that a stream can transport
- **delta:** triangular landform created where a river flows into a body of standing water and deposits its sediments
- **dissolved load:** elements carried in solution by flowing water
- **floodplain:** flat area on both sides of a stream channel that is covered with water when the stream floods its banks
- **gradient:** slope of a stream
- **groundwater:** fresh water that moves through pores and fractures in soil and rock beneath Earth's surface
- **headwaters:** location where a stream forms, often high in the mountains
- **meander:** large curve in a stream caused by erosion of the outside of a curve and deposition on the inside of a curve
- **natural levee:** raised strip of coarse-grained sediments that are deposited on a stream's banks when it floods its channel
- **saltation:** transport of bed load along a stream bed in little jumps
- **sinkhole:** circular hole in the surface of the ground that forms when the roof of a cave collapses
- **stalactite:** icicle-like formation of calcium carbonate that comes out of solution when water drips from the ceiling of a cave
- **stalagmite:** deposit of calcium carbonate on the floor of a cave that comes out of solution when water drips onto the cave floor
- **suspended load:** very small particles such as clay that are carried by the main stream flow but are not dissolved by water

- **travertine:** type of deposit of calcium carbonate that forms from mineral spring water and is valued for its beauty

Teaching Strategies

Introducing the Lesson

Introduce water erosion and deposition by referring students to the chapter opener photo and accompanying description in their FlexBook® resource.

Question: Why did astronauts say that Madagascar is “bleeding into the ocean”?

Answer: The river in the photo is carrying huge amounts of soil from Madagascar’s land into the ocean.

Question: What conditions cause the river to carry more soil from the land into the ocean?

Answer: The river carries more soil because the forest has been cleared by logging. The river also carries more soil during tropical storms.

Tell students they will learn in this lesson why factors such as these cause flowing water to wash away so much soil.

Activity

Students can learn more about groundwater erosion and deposition with the interactive “Virtual Cave” activity at the following URL. They can click on a wide variety of cave features to see photographs and read descriptions. The Web site includes a background essay and discussion questions.

<http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.virtmap/>

Differentiated Instruction

Have students who need extra help make a main ideas/details chart for the lesson. This will help them focus on the most important ideas and supporting information. To start the chart, they can divide a sheet of paper down the middle and use the left column for the main ideas, each separated by several lines to make room for adding details to the right column. Suggest that students include at least one main idea for each heading and subheading in the lesson. Advise them to keep the details brief and to the point.

Enrichment

Tell students that sinkholes are especially common in Florida. Shows them pictures of Florida sinkholes at the first URL below. Then challenge a few students to find out why sinkholes are so common in Florida and to report back to the class with the explanation. The second URL below is a good place for them to learn more.

<http://www.weather.com/news/florida-sinkhole-photos-20130301>

<http://www.dep.state.fl.us/geology/geologictopics/hazards/sinkholes.htm>

Science Inquiry

In the inquiry activity at the following URL, students will model stream erosion and deposition. Using their model, they will observe the effects of changes in water velocity on erosion and deposition of sediments of different sizes.

<http://www.mysciencebox.org/book/export/html/209>

Science Inquiry

If possible, take your class on a fieldtrip to investigate erosional and depositional features of a stream in your area. You can follow the guidelines in the URL below, which incorporates technology including Internet research, GPS mapping, and PowerPoint presentations. Students will learn about four types of features created by stream erosion and four types created by stream deposition. Then they will find likely locations for the features on their trip. In the field, they will use a mobile device to document and explain how each of the features formed. Finally, they will use GPS to make a map showing the locations of the features and create a PowerPoint presentation with their documentation.

<http://edtech2.boisestate.edu/hyattb/502/mobile.html>

Overcoming Misconceptions

More than half of high school students questioned think that it takes flowing water millions of years to wear away just a few inches or feet of rock (AAAS Project 2061). Use the following multiple choice questions to check for this misconception in your students. (For both questions, the correct choice is 'a.')

Then make sure students are aware of the correct facts.

1. Which of the following statements describes how water can change mountains?
 - a. Water can gradually wear away the solid rock of mountains as much as thousands of feet over many millions of years.
 - b. Water can wear away the solid rock of mountains no more than several feet over many millions of years.
 - c. Water can wear away the solid rock of mountains no more than several inches over many millions of years.
 - d. Water cannot wear away the solid rock of mountains, even over many millions of years.
2. Which of the following statements describes how water can change river valleys?
 - a. Water can gradually wear away the solid rock of river valleys as much as thousands of feet over millions of years.
 - b. Water can wear away the solid rock of river valleys no more than several feet over many millions of years.
 - c. Water can wear away the solid rock of river valleys no more than several inches over many millions of years.
 - d. Water cannot wear away the solid rock of river valleys, even over many millions of years.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 10.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 10.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 10.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Would a stream at higher elevations erode more than a stream at lower elevations?

How would Earth's surface look without streams?

Would a flash flood along a normally dry river valley be a dangerous event?

Do you think caves could form in your neighborhood?

10.3 Lesson 10.2: Wave Erosion and Deposition

Key Concepts

- Wave action and erosion
- Wave deposition
- Protecting shorelines

Lesson Objectives

- Describe how the action of waves produces different shoreline features.
- Discuss how areas of quiet water produce deposits of sand and sediment.
- Discuss some of the structures humans build to help defend against wave erosion.

Lesson Vocabulary

- **arch:** landform created when waves erode through a cliff from opposite sides
- **barrier island:** long, narrow island of sand parallel to shore that is deposited by waves
- **beach:** sediments deposited in a relatively quiet area on shore, consisting mainly of sand
- **breakwater:** artificial barrier built in the water parallel to shore to protect the shore from erosion by strong incoming waves
- **groin:** artificial barrier built in the water perpendicular to shore to trap sand carried along the shore by longshore drift
- **refraction:** change in direction of a wave caused by a change in wave speed, which occurs when a wave strikes the shore at an angle
- **sea stack:** isolated tower of rock created when the top of a sea arch erodes and collapses
- **sea wall:** artificial barrier built on a beach parallel to the shoreline to protect the beach from erosion by strong waves
- **spit:** ridge of sand extending out from shore that is deposited by longshore drift
- **wave-cut cliff:** sea cliff created by wave erosion
- **wave-cut platform:** level area created by wave erosion as waves undercut a cliff

Teaching Strategies

Introducing the Lesson

Grab students' attention by showing a short video of surfers riding waves to shore (see URLs below). Ask students if they know what causes the waves that make surfing possible. (wind) Tell them they will learn how waves form and also how they cause erosion and deposition when they read this lesson.

<http://mpora.com/surfing/videos>

<http://www.dailysurfvideos.com/>

Building Science Skills

If you use the lesson plan “Who Moved the Beach?” at the following URL, students can investigate the primary causes and impacts of wave erosion and how human communities should respond to this process.

http://oceanservice.noaa.gov/education/classroom/lessons/09_coastmanag_erosion.pdf

Differentiated Instruction

Have students make a KWL chart for wave erosion and deposition. Before they read the lesson, they should list what they already know (K) in the first column of the chart and what they want to know (W) in the second column of the chart. Then, after they finish reading the lesson, they should list what they learned (L) in the last column of the chart.

Enrichment

Point out that barrier islands are some of the most highly developed, urbanized coastal areas. Cities built at least partially on barrier islands include Miami Beach, Florida; Atlantic City, New Jersey; and Long Beach, New York. Ask a few students to learn about the effects of urbanization on barrier islands and their subsequent ability to protect coasts from erosion. Students should also identify pros and cons of barrier-island living for residents and businesses. Then ask the students to present a debate to the class in which they argue for or against development on barrier islands.

Science Inquiry

With the inquiry activity at the following URL, students investigate how wave erosion and deposition can change the shape of coastlines. They model how waves cause longshore drift and how wave speed relates to deposition. They also model how groins and boulders placed at the foot of cliffs can slow down erosion.

http://www.earthlearningidea.com/PDF/73_Coastal_crumble.pdf

Overcoming Misconceptions

Students may erroneously think that wave erosion is a problem only along the shorelines of the oceans. Make sure students are aware that waves can also cause erosion along the shorelines of lakes. Very large lakes, such as the Great Lakes of North America, may have very high waves and serious wave erosion. For example, waves greater than 30 feet in height have been recorded in Lake Superior. Homes built close to a lake may be threatened by the continuous nibbling away of land along the shore by waves.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 10.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 10.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 10.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What situations would increase the rate of erosion by waves?

If barrier islands are nature's first line of defense against ocean storms, why do people build on them?

Could a seawall ever increase the amount of damage done by waves?

10.4 Lesson 10.3: Wind Erosion and Deposition

Key Concepts

- Transport of particles by wind
- Wind erosion
- Wind deposition

Lesson Objectives

- Describe the ways particles are carried by wind.
- Discuss several ways that wind erosion changes land surfaces.
- Describe how sand dunes form.
- Describe the type of deposits formed by windborne silts and clays.

Lesson Vocabulary

- **deflation:** process in which wind erodes silt and clay, causing the ground surface to subside
- **desert pavement:** rocky, pebbled surface created when silt and clay are eroded from the surface of a desert by wind
- **desert varnish:** dark mineral coating that forms on exposed rock surfaces when windborne clay particles are deposited on them
- **loess:** type of deposit that forms when wind drops layers of silt and clay in nearly vertical cliffs
- **sand dune:** small hill of sand deposited by wind in a region with abundant sand and steady winds
- **slip face:** steeper, downwind side of a sand dune where grains of sand fall down from the crest of the dune because of gravity
- **ventifact:** polished, faceted stone formed through abrasion by windborne sand

Teaching Strategies

Introducing the Lesson

Introduce wind erosion with the short video on wind erosion of soil at the URL below. Tell students they will learn more about wind erosion when they read this lesson.

<http://www.youtube.com/watch?v=PQmon7Rj6ns>

Discussion

Discuss factors that result in the formation of the different types of sand dunes pictured in the link below. (You can share the figure with your students by making a transparency or copies to handout). The arrows in the sketch show the direction of the wind, which is one of the factors that determines dune type. The other factor is the amount of sand. Explain that transverse dunes form where there is a lot of sand, whereas barchans (small, crescent-shaped dunes) form where there is little sand. Transverse, parabolic, and longitudinal dunes form where wind blows steadily from a single direction. Over time, a transverse dune may change to a parabolic dune, which in turn may change to a longitudinal dune. Finally, a star-shaped dune forms where wind keeps changing from one direction to another.

<http://www.uwgb.edu/dutchs/EarthSC202Notes/WINDeros.HTM>

Differentiated Instruction

Have students make a Venn diagram comparing and contrasting the formation of a sand dune with the formation of loess. This will help them appreciate the role of particle size in deposition by wind.

Enrichment

Ask one or more interested students to create a Web page about the Dust Bowl, which has been called our nation's worst ecological disaster. It occurred during the 1930s in Oklahoma and neighboring states when huge amounts of precious topsoil were lost to wind erosion following a prolonged drought and mismanagement of soil by farmers. Students can learn more about the Dust Bowl at the first two URLs below. Other resources they might consider using for their Web page include a map of the Dust Bowl area and some of the iconic photos of the Dust Bowl, all of which can be found at the last URL below. Encourage other students in the class to visit the completed Web page.

- <http://www.kshs.org/kansapedia/dust-bowl/12040>
- <http://drought.unl.edu/DroughtBasics/DustBowl.aspx>
- http://www.weru.ksu.edu/new_weru/multimedia/dustbowl/dustbowlpics.html

Science Inquiry

Use the simple activity at the following URL to allow students to model how wind erodes sand. Students will also build different types of barriers to see which design is most effective in stopping erosion by the wind.

http://www.spacegrant.hawaii.edu/class_acts/Wind.html

Overcoming Misconceptions

A common misconception is that wind is the major agent of erosion in deserts. Ironically, flowing water is responsible for more erosion in deserts. Explain to students that when it rains in a desert, the runoff is very fast and often causes flash floods. With little or no vegetation, there are few if any plant roots to help hold the soil and sand in place and prevent erosion by the running water. Another common misconception about deserts is that they are mostly covered with sand dunes. Tell students that only about 10 percent of deserts are covered with sand dunes.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 10.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 10.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 10.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Would hurricane-force winds along a coastline produce wind-related erosion?

What would be needed to convert a desert area back to a productive region for farming?

Do you think wind could sculpt exposed rocks? Explain how this might happen.

10.5 Lesson 10.4: Glacial Erosion and Deposition

Key Concepts

- Formation and movement of glaciers
- Glacial erosion
- Glacial deposition

Lesson Objectives

- Discuss the different erosional features formed by alpine glaciers.
- Describe the processes by which glaciers change the underlying rocks.
- Discuss the particles deposited by glaciers as they advance and recede.
- Describe the landforms created by glacial deposits.

Lesson Vocabulary

- **alpine (valley) glacier:** mass of ice that flows downhill through a mountain valley
- **continental glacier:** mass of flowing ice that covers a large area and is not confined to a valley
- **end moraine:** ridge of glacial till deposited by a glacier where it paused while receding
- **glacial erratic:** large rock deposited by a glacier that is different from surrounding bedrock
- **glacial striation:** long, deep groove scratched in underlying bedrock by sediment carried on the bottom of a glacier
- **glacial till:** mixture of particles and rocks of different sizes deposited by a glacier
- **glacier:** large mass of flowing ice
- **ground moraine:** thick layer of sediment deposited under a glacier
- **hanging valley:** cliff formed where a large alpine glacier cut off the U-shaped valley of a tributary glacier
- **lateral moraine:** linear deposit of glacial till at the edge of an alpine glacier
- **medial moraine:** linear deposit of glacial till in the middle of an alpine glacier where lateral moraines of two tributary glaciers merge
- **moraine:** any linear deposit of unsorted sediments that have been dropped by a glacier
- **plucking:** process in which a glacier picks up sediments as it flows over the ground and the sediments freeze to the bottom of the glacier
- **terminal moraine:** ridge of glacial till deposited by a glacier at the farthest point it reached
- **varve:** paired layers of alternately finer and coarser sediments deposited in a glacial lake and representing an annual cycle

Teaching Strategies

Introducing the Lesson

Introduce glaciers by having students do the interactive activity at the URL below. This activity provides a comprehensive introduction to glaciers. By exploring the different sections, students will learn where and why glaciers form, what influences their growth and decline, and how an apparently solid mass of ice can flow like a river.

<http://www.teachersdomain.org/resource/ess05.sci.ess.earthsys.glaciers/>

Activity

Students will have a more detailed understanding of how a glacier forms and melts if they do the interactive “Life Cycle of a Glacier” at the following URL.

<http://www.pbs.org/wgbh/nova/vinson/glacier.html>

Differentiated Instruction

Have students make a flow chart to show how a snowflake that falls on a glacier becomes part of the ice of the glacier, is transported by the glacier, and ultimately melts to become part of glacial meltwater. Suggest that they add sketches to illustrate their flow chart.

Enrichment

Ask students to predict how global warming is affecting glaciers around the world. Then have a few students find photos of the same glaciers at different time periods over the past several decades to see how they have changed as global temperature has increased. Ask the students to prepare a display with the photos and explain them to the rest of the class.

Science Inquiry

When you teach this lesson, use the gold-star glacier simulation activity at the URL below. In the activity, students will use a simulation program to determine factors that affect the motion of glaciers, calculate the speed of glacier movement, and discover what a glacier budget means for the growth and destruction of a glacier.

<http://phet.colorado.edu/en/contributions/view/3133>

Overcoming Misconceptions

Students commonly have the misconception that a melting glacier “retreats,” or reverses direction. Explain that a glacier can only move downhill because of gravity. When a glacier recedes, it continues to move in the same direction, but its leading edge melts, giving it the appearance of moving in the opposite direction.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 10.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 10.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 10.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What features would you look for to determine if glaciers had ever been present?

If glaciers had never formed, how would soil in Midwestern North America be different?

Can the process of erosion produce landforms that are beautiful?

10.6 Lesson 10.5: Erosion and Deposition by Gravity

Key Concepts

- Types of movement caused by gravity
- Landslides and avalanches
- Mudflows and lahars
- Slump and creep
- Factors contributing to mass movement

Lesson Objectives

- Describe the ways that material can move downhill by gravity.
- Discuss the factors that increase the likelihood of landslides.
- Describe the different types of gravity-driven movement of rock and soil.
- Describe ways to prevent and be aware of potential landslides or mudflows.

Lesson Vocabulary

- **avalanche:** sudden movement of a mass of snow down a slope due to gravity
- **creep:** extremely slow movement of rock and soil downhill because of gravity
- **landslide:** rapid movement of soil, loose rock, and debris downhill under the influence of gravity
- **mass movement:** any erosion in which soil, rock, debris, and/or mud move down a slope due to gravity; also called mass wasting
- **mass wasting:** any erosion in which soil, rock, debris, and/or mud move down a slope due to gravity; also called mass movement
- **mudflow:** movement of saturated, slippery soil downhill under the influence of gravity
- **slump:** movement of a large block of rock and soil as a single unit down a slope due to gravity
- **talus slope:** pile of angular rock fragments that have fallen down a cliff because of gravity and accumulated at the bottom

Teaching Strategies

Introducing the Lesson

Introduce mass movement with the 11-minute trailer for the USGS video “Riding the Storm: Landslide Danger in the San Francisco Bay Area” (see URL below). The trailer shows the incredible destruction that can be caused by a landslide from the point of view of people who have experienced one. It also explains why landslides are common in the San Francisco Bay area. Tell students they will learn more about landslides in this lesson.

<http://pubs.usgs.gov/gip/2007/48/>

Discussion

Discuss how gravity compares with other agents of erosion and deposition. For example, gravity can move materials only down a slope; and certain other conditions, such as saturated soil or an earthquake, may also be needed for mass movement to occur. On the other hand, gravity can move materials more quickly than other agents of erosion. In fact, gravity can move tons of material in a few seconds. For running water or wind to move that much material might take millions of years.

Differentiated Instruction

Pair students with differing abilities and have partners make a cluster diagram for mass movement. The center circle should be labeled “mass movement” and include a definition of the term. The surrounding circles should be labeled with the different types of mass movement and include brief descriptions of each type.

Enrichment

Ask interested students to learn more about avalanches, such as what factors suggest that an avalanche is likely to occur and what snow enthusiasts can do to avoid avalanches. Suggest that they start with the URLs below. Have them share what they learn with the rest of the class in a PowerPoint presentation.

- <http://www.pbs.org/wgbh/nova/avalanche/textindex.html>
- <http://www.avalanche.org/tutorial/tutorial.html>
- <http://www.pbs.org/wnet/savageplanet/04extremes/01avalanche/indexmid.html>

Science Inquiry

Have students explore the “Landslide Overview Map of the Conterminous United States” at the URL below. Tell them to identify where in the United States the risk of landslides is greatest. Then challenge students to explain what physical features of these areas predispose these areas to landslides.

<http://landslides.usgs.gov/learning/nationalmap/>

Real-World Connection

Tell students that landslides and mudflows can do billions of dollars’ worth of damage but the costs are difficult to estimate because there are both direct and indirect costs. Direct costs include damage to structures and roads. Indirect costs include decreased property values, lost productivity, and the cost of driving longer distances because roads are blocked.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 10.5 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 10.5 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 10.5 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why might someone build a home on top of land where a landslide has happened before?

What factors make it likely or unlikely that a landslide could happen in your area?

What new technologies might help people to know when a landslide will occur?

CHAPTER **11**

HS TE Evidence About Earth's Past

Chapter Outline

- 11.1 CHAPTER 11: EVIDENCE ABOUT EARTH'S PAST
 - 11.2 LESSON 11.1: FOSSILS
 - 11.3 LESSON 11.2: RELATIVE AGES OF ROCKS
 - 11.4 LESSON 11.3: ABSOLUTE AGES OF ROCKS
-

11.1 Chapter 11: Evidence about Earth's Past

Chapter Overview

This chapter explains ways that fossils form and the methods of relative and absolute dating of rocks.

Online Resources

See the following Web sites for appropriate laboratory activities:

The lab at the following URL guides students through an inquiry-based study of absolute and relative dating methods. In the lab, students are asked to interpret an archaeological site and decide on appropriate dating methods. They will apply knowledge in a way that is similar to how scientists approach the dating of sites.

- <http://gk12.asu.edu/absoluteandrelativedating>

Another lab on relative and absolute dating is available in the PDF document below. It is a two-part lab titled “It’s Not Your Average Friday Night; Relative and Absolute Dating of Geological Materials” (Lesson #4, pages 15–18). In the lab, students will gain an understanding of the differences between relative and absolute dating techniques and how they may be used in Carlsbad Caverns National Park or a local national park.

- http://www.nps.gov/cave/forteachers/upload/geology_curriculum_high_school_pdf.pdf

In the gold-star simulation lab at the following URL, students will identify isotopes that are commonly used to determine how old matter might be. They will also be able to explain how radiometric dating works and why different elements are used for dating different objects. They will use the percent of an isotope measured in an object to estimate its age.

- <http://phet.colorado.edu/en/contributions/view/3636>

These Web sites may also be helpful:

This highly recommended Web site has detailed descriptions of different types of fossils and how they form.

- <http://www.ucmp.berkeley.edu/paleo/fossils/>

At the URL below, you can find detailed information about fossilization that goes beyond lesson content.

- <http://www.fossilmuseum.net/fossilrecord/fossilization/fossilization.htm>

This Web site is all about fossils. It includes fossil lesson plans, activities, articles, and extreme fossil facts.

- <http://www.fossils-facts-and-finds.com/>

You can find a fossil image gallery at this URL: <http://www.fossilmuseum.net/FossilGalleries.htm>.

For more in-depth coverage of methods of dating fossils and rocks, go to this URL: http://paleobiology.si.edu/geotime/main/foundation_dating1.html.

At the following URL, you can find a much more detailed geologic time scale.

- http://paleobiology.si.edu/geotime/main/pdf/timescale_isc_american.pdf

Pacing the Lessons

TABLE 11.1: short caption

Lesson	Class Period(s) (60 min)
11.1 Fossils	2.0
11.2 Relative Ages of Rocks	2.5
11.3 Absolute Ages of Rocks	1.5

11.2 Lesson 11.1: Fossils

Key Concepts

- How fossils form
- Types of fossils
- Clues from fossils

Lesson Objectives

- Explain why it is rare for an organism to be preserved as a fossil.
- Distinguish between body fossils and trace fossils.
- Describe five types of fossilization.
- Explain the importance of index fossils, and give several examples.

Lesson Vocabulary

- **amber:** fossilized tree sap
- **body fossil:** fossilized remains of a long-dead organism
- **cast:** mold filled with sediment that has hardened to create a replica of the original fossil
- **fossilization:** any process by which remains or traces of once-living organisms become fossils
- **index fossil:** fossil of a species that was widespread but short-lived and can be used to determine the age of rock layers in different places
- **microfossil:** fossil that is so small that it must be observed with the aid of a microscope
- **mold:** impression made in sediments by the hard parts of an organism
- **permineralization:** fossilization process in which water deposits minerals into empty spaces in the remains of a dead organism
- **trace fossil:** evidence of the activity of an ancient organism, such as tracks, burrows, or feces

Teaching Strategies

Introducing the Lesson

Tell the class that on a recent hike in high mountains, a hiker found fossil shells of a marine organism embedded in a massive rock. Challenge students to explain the situation. Accept all reasonable responses at this point, and tell students they will learn the correct explanation when they read this lesson.

Activity

With level 2 of the interactive activity at the URL below, students will gain a basic understanding of what a fossil is and how fossilization occurs. The URL includes a suggested lesson plan, classroom handouts, and assessments.

<http://www.ucmp.berkeley.edu/education/explorations/tours/fossil/index.html>

Collaborative Learning

Divide the class into five groups and assign each group one of the types of fossilization described in the lesson: preserved remains, permineralization, molds and casts, replacement, or compression. Students in each group should work together to learn more about their assigned type of fossilization, including where fossils formed this way have been found and the conditions under which this type of fossilization occurs. Students should prepare a 5–10 minute presentation about their type of fossilization. During the presentations, other students in the class should take notes.

Differentiated Instruction

Have students make a cluster diagram for different types of fossilization. A central circle should be labeled “Fossilization” and include a general definition of the term. Five surrounding circles should each be labeled with one of the five types of fossilization covered in the lesson, with definitions or brief descriptions of each type.

Enrichment

Ask a small group of students to create a Jeopardy-style game for the whole class to play based on the content of this lesson. At the URL below, students can learn how to create a Jeopardy-style game using PowerPoint. Schedule time for the students to lead the class in playing the game.

<http://www.joe.org/joe/2003april/tt2.php>

Science Inquiry

In the activity at the following URL, students take part in an imaginary fossil hunt. Following a script read by the teacher, students “find” (remove from an envelope) paper “fossils” of some unknown creature, only a few at a time. Each time they find new fossils, they must attempt to reconstruct the creature, and their interpretation will keep changing as new pieces are “found.” From the activity, students will realize that science is uncertain; as new evidence is revealed, ideas may change.

[<http://www.indiana.edu/ensiweb/lessons/gr.fs.fd.html> <http://www.indiana.edu/ensiweb/lessons/gr.fs.fd.html>]

Overcoming Misconceptions

Because the chances of an individual organism becoming a fossil are very small, students may hold the misconception that fossils are very rare. Make sure they realize that billions of fossils have been found and that the fossil record is actually very rich. You may want to share the following facts with your class (<http://www.redundancydept.com/fiction.htm>).

- A half-mile layer of rock in Wyoming contains some 12 billion fish fossils.
- Under each square mile of soil in Nebraska, there are an estimated 3000 mammoth fossils.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 11.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 11.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 11.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What are some other examples of mythical creatures that may be based on fossils?

- [Some other examples of mythical creatures that may be based on fossils include unicorns and mermaids.]

Some organisms are more easily preserved than others. Why is this a problem for scientists who are studying ancient ecosystems?

Why are examples of amazing fossil preservation so valuable for scientists?

Many fossils of marine organisms have been found in the middle of continents, far from any ocean. What conclusion can you draw from this?

11.3 Lesson 11.2: Relative Ages of Rocks

Key Concepts

- Steno's laws of superposition, original horizontality, and lateral continuity
- Smith's principle of faunal succession
- Hutton's principles of cross-cutting relationships, uniformitarianism, and unconformity
- Determining the relative ages of rocks
- Matching up rock layers in different places
- The geologic time scale

Lesson Objectives

- Explain Steno's laws of superposition and original horizontality.
- Based on a geological cross-section, identify the oldest and youngest formations.
- Explain what an unconformity represents.
- Know how to use fossils to correlate rock layers.

Lesson Vocabulary

- **biozone:** rock unit that is defined by a characteristic index fossil or fossil assemblage
- **cross-cutting relationships:** principle stating that an intrusion or fault is younger than the rocks across which it cuts
- **geologic time scale:** division of Earth's history into blocks of time distinguished by major geologic and evolutionary events
- **key bed:** thin rock layer that is unique and widespread so it can be used to match rock layers by age in different areas
- **lateral continuity:** principle that sedimentary rock layers extend as wide as the basin in which they form
- **microfossil:** fossil that is so small that it must be observed with the aid of a microscope
- **original horizontality:** principle that the sediments that form sedimentary rocks are deposited in horizontal layers
- **relative age:** the age of an object (younger or older) in comparison with the ages of other objects
- **superposition:** law stating that younger layers of sedimentary rock are deposited on top of older layers of sedimentary rock
- **unconformity:** gap in a sequence of rock layers
- **uniformitarianism:** principle that natural processes have operated in the same way throughout Earth's history as they do today

Teaching Strategies

Introducing the Lesson

Introduce stratigraphy as the basis of relative dating by asking students to recall what they already know about sedimentary rocks. For example, ask them to explain how sedimentary rocks differ from other types of rocks and how sedimentary rocks form. Tell students that this knowledge will help them understand how scientists know which fossils or rock layers are older or younger than others.

Building Science Skills

The activity below is a great way to introduce relative dating. Students will work to decide the sequence in which certain events occurred, using their powers of observation and logic. Pairs of students will be given a block of wood that has been painted, nailed, and gouged. Then they will be instructed to deduce the order of events and to justify their answers. Relate the activity to the process in which rock layers are assigned relative ages.

<http://serc.carleton.edu/sp/mnstep/activities/35609.html>

Activity

Have students explore geologic time with the interactive time scale at the following URL. The time scale shows geologic subdivisions of time to scale so students can easily see their relative lengths. They can also click on specific blocks of geologic time to see them in greater detail and read about their major evolutionary events.

<http://www2.nature.nps.gov/geology/usgsnps/gtime/gtime2.html>

Differentiated Instruction

Give kinesthetic learners and students with limited English proficiency hands-on experience creating “sedimentary rock layers” and “fossils.” Provide them with a clear glass jar, samples of different colors of sand or other similar materials (e.g., colored sugar), and small plastic animals to represent fossils. Then have students use the materials to make a multi-layered “sedimentary rock” containing “fossils” at different layers. Discuss how the activity relates to the actual formation of sedimentary rocks and fossils.

Enrichment

Challenge students to relate the significance of uniformitarianism to Darwin’s development of evolutionary theory. They should express their ideas in a concise paragraph. (For more information, suggest that they start with the URL below.) Ask each student to read his or her paragraph to the class. Then hold a general discussion of how advances in one area of science often lead to new developments in other areas of science, as this example illustrates.

http://evolution.berkeley.edu/evolibrary/article/history_12

Science Inquiry

With the inquiry activity “Who’s on First?” at the URL below, students will sequence information using items that overlap specific sets. They will also relate sequencing to the law of superposition and show how fossils can be used to give relative dates to rock layers.

<http://www.ucmp.berkeley.edu/fosrec/BarBar.html#topbar>

History Connection

Understanding how scientific knowledge accumulates and develops helps students understand the nature of the scientific endeavor. Suggest that they learn how and why the geologic time scale was developed. The two URLs below are good sources for this purpose.

<http://www.ucmp.berkeley.edu/exhibit/histgeoscale.html>

<http://www2.nature.nps.gov/geology/usgsnps/gtime/gtime1.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 11.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 11.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 11.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How did preconceived ideas in Steno's time make people blind to the reality of what fossils represent?

How did Steno explain the presence of marine fossils in high mountains?

Why was Hutton's recognition of unconformities so significant?

Can the relative ages of two rock layers that are very far apart be determined?

Can the same principles used to study Earth's history also be used to study the history of other planets?

11.4 Lesson 11.3: Absolute Ages of Rocks

Key Concepts

- Tree ring dating
- Ice cores and varves
- Radioactive decay
- Radiometric dating of rocks
- Age of Earth

Lesson Objectives

- Define the differences between absolute age and relative age.
- Describe four methods of absolute dating.
- Explain what radioactivity is and give examples of radioactive decay.
- Explain how the decay of radioactive materials helps to establish the age of an object.
- Estimate the age of an object, given the half-life and the amounts of radioactive and daughter materials.
- Give four examples of radioactive materials that are used to date objects, and explain how each is used.
- Describe how scientists know Earth is billions of years old.

Lesson Vocabulary

- **absolute age:** actual age of a rock or fossil in years
- **daughter product:** product of the radioactive decay of a parent isotope
- **half-life:** rate of decay of a radioactive isotope, equal to the time it takes for half of an original amount of the parent isotope to decay to the daughter product
- **ice core:** cylinder of ice extracted from a glacier or ice sheet
- **parent isotope:** unstable isotope that undergoes radioactive decay to form a daughter product
- **radioactive isotope:** isotope that is unstable and likely to decay into another, more stable isotope
- **radioactivity:** emission of high-energy particles by unstable isotopes
- **radiometric dating:** use of the concentrations of radioactive parent isotopes and daughter products to estimate the absolute age of a fossil or rock
- **tree ring:** ring of wood in a tree trunk that corresponds to one year of tree growth

Teaching Strategies

Introducing the Lesson

Display a timeline of horse evolution, such as the timeline at the URL below. Point out the ages in years that different horse ancestors lived. Ask students how they think the ages were determined. Accept all reasonable responses at this point, and tell students they will learn how ages are assigned to fossils and rocks when they read this lesson.

http://vcbequine.webstarts.com/all_about_horses.html

Using Visuals

Refer students to the images in the FlexBook® lesson that show tree rings, ice core layers, and varve sediments. Point out and explain the alternating light and dark bands in each object.

Question: How are these three objects similar?

Answer: All three provide an annual record of the past that can be used to determine their age in years.

Differentiated Instruction

Have students make a table comparing and contrasting the different methods of radiometric dating described in the lesson. Their table should include an example of a rock or fossil that might be dated with each method.

Enrichment

Use the AP-level activity at the URL below for students who need enrichment. It is a virtual lab in which students determine half-lives and absolute ages of rock samples. When students have finished the simulation, they can print a “Certificate of Completion as a Virtual Geochronologist.” The lab is well suited for small groups of students working together.

<http://www.sciencecourseware.com/VirtualDating/>

Science Inquiry

Use the simple inquiry activity below so students can model the half-life of a radioactive element. This will give them a better understanding of the principles behind radiometric dating techniques.

<http://evolution.about.com/od/teaching/a/Modeling-Half-Life-Lab.htm>

Overcoming Misconceptions

Students may think that radiometric dating can be applied to any rock, including the sedimentary rock layers where most fossils are found. Explain that most sedimentary rocks cannot be dated with radiometric techniques because sedimentary rocks are composed of particles of pre-existing rock of various types and the particles can have different ages.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 11.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 11.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 11.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why are techniques for dating, such as using tree rings, ice cores, and varves, only useful for events that occurred in the last few thousand years?

Why is it important for geological and biological processes that Earth is very old?

Why is it important to use more than one method to find the age of a rock or other object?

CHAPTER

12

HS TE Earth's History

Chapter Outline

- 12.1 CHAPTER 12: EARTH'S HISTORY
 - 12.2 LESSON 12.1: EARLY EARTH
 - 12.3 LESSON 12.2: THE PRECAMBRIAN
 - 12.4 LESSON 12.3: PHANEROZOIC EARTH HISTORY
 - 12.5 LESSON 12.4: HISTORY OF EARTH'S COMPLEX LIFE FORMS
-

12.1 Chapter 12: Earth's History

Chapter Overview

This chapter explains how Earth formed, how its atmosphere and oceans developed, and how its continents changed. It reviews geological changes that occurred during the Phanerozoic eon and traces the evolution of life on Earth, from its earliest beginnings during the Precambrian to the present.

Online Resources

See the following Web sites for appropriate laboratory activities:

When you teach about the origin of life in Lesson 12.2 (“Early Earth”), use the inquiry lab “Creating Coacervates” at the following URL. In the lab, students will make and observe coacervates: amoeba-like objects that change shape, flow, merge, divide, form "vacuoles," release "vacuole contents," and show other life-like properties. The lab will demonstrate how, under suitable conditions, life-like structures can form naturally from relatively simple materials, similar to how life may have begun on early Earth.

- <http://www.indiana.edu/ensiweb/lessons/coacerv.html>

In this real-world simulation lab, students investigate the chapter concepts of variation, natural selection, and evolution, by focusing on wood lice as a case study. First, they measure the amount of variation in a natural population of wood lice. Then, they perform a simulated predation experiment to determine which traits are subject to selection by predators.

- <http://www.ableweb.org/volumes/vol-19/15-berkelhamer.pdf>

This Web-based lab leads students through an exploration of the patterns of biodiversity across planet Earth. Students are scaffolded as they practice data interpretation and scientific reasoning skills.

- http://evolution.berkeley.edu/evolibrary/article/0_0_0/ldg_01

These Web sites may also be helpful:

You (or your students) can review more detailed information on the origin of Earth and the moon at these URLs:

- http://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=446
- <http://www.onlineuniversity.net/earth-science/origin-of-the-moon/>

This website offers a growing collection of teaching materials and research results that will aid in the understanding of, and teaching about, early Earth.

- <http://serc.carleton.edu/NAGTWorkshops/earlyearth/index.html>

You can find free online access to the National Academy of Sciences book “Teaching Evolution and the Nature of Science” at the following URL. It provides great perspective on a topic that is still controversial in some school districts. The book includes a discussion of the importance of teaching evolution and describes several classroom activities on the subject.

- http://www.nap.edu/openbook.php?record_id=5787&page=R1

Pacing the Lessons

TABLE 12.1: short caption

Lesson	Class Period(s) (60 min)
12.1 Early Earth	1.5
12.2 The Precambrian	2.5
12.3 Phanerozoic Earth History	1.5
12.4 History of Earth's Complex Life Forms	3.0

12.2 Lesson 12.1: Early Earth

Key Concepts

- Formation of Earth
- How the moon formed
- Earth's early atmosphere and oceans

Lesson Objectives

- Describe how Earth formed with other parts of the solar system about 4.6 billion years ago.
- Recount the moon's birth story.
- Explain how Earth's atmosphere has changed over time.
- Explain the conditions that allowed the first forms of life to develop on Earth.

Lesson Vocabulary

- **differentiation:** separation of planetary materials by density to create different layers
- **outgassing:** transfer of gases from Earth's mantle to the atmosphere by volcanic eruptions
- **paleontologist:** scientist who finds and studies fossils to learn about the history of life

Teaching Strategies

Introducing the Lesson

There's no better way to introduce the formation of the solar system than with an animated video showing how scientists think it happened. Show students the video at the URL below and tell them they will learn more about how Earth and the rest of the solar system formed when they read this lesson.

http://www.metacafe.com/watch/1111454/formation_of_the_solar_system_great_animation/

Discussion

Students learn in the FlexBook® lesson that soon after Earth formed it underwent differentiation and its matter separated into layers by density. Explain why Earth's differentiation is so important for the subsequent geologic history of Earth. Without differentiation, plate tectonics would not occur, and without plate tectonics, Earth would be a very different place. You can learn more at these URLs:

<http://csep10.phys.utk.edu/astr161/lect/earth/differentiation.html>

<http://csep10.phys.utk.edu/astr161/lect/earth/consequences.html>

Differentiated Instruction

Have students make a main ideas/details chart for the lesson. Suggest that they include at least one main idea for each heading in the lesson. Details should add supporting information for each main idea.

Enrichment

The modern impact hypothesis for the formation of the moon is described in the FlexBook® lesson. Ask a few students to learn about earlier hypotheses for the origin of the moon. Then have them present the hypotheses to the class and discuss how or whether they are supported by evidence. Some earlier hypotheses are given at the URL below. This is a good example of how science progresses as new evidence is discovered.

<http://www.onlineuniversity.net/earth-science/origin-of-the-moon/>

Science Inquiry

Elaborate on the nebular hypothesis of solar system formation. Explain that because of gas pressure and gravity, the rotating nebula began to contract and flatten into a spinning pancake shape with a bulge at the center. The bulge eventually formed the sun and the rest of the pancake became the planets and other bodies in the solar system. After sharing this information with students, provide them with the following evidence for the nebular hypothesis and ask them to explain how the evidence supports the hypothesis. You can find more information at the URL below.

- The orbits of the planets lie nearly in a plane with the sun at the center.
- The planets all revolve in the same direction.
- The planets mostly rotate in the same direction, with rotation axes nearly perpendicular to the orbital plane.

<http://csep10.phys.utk.edu/astr161/lect/solarsys/nebular.html>

History Connection

The nebular hypothesis has a surprisingly long history, as described at the URLs below. Share the history of the hypothesis with your students. It shows how good scientific ideas may withstand the test of time.

<http://history.nasa.gov/SP-436/preface.htm>

<http://www.infoplease.com/encyclopedia/science/solar-system-origin-solar-system.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 12.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 12.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 12.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What would you recognize from modern times if you traveled back to the early days of Earth?

How do scientists know what happened on early Earth?

When was the planet ready for life to begin?

12.3 Lesson 12.2: The Precambrian

Key Concepts

- Early continents
- Origin of life on Earth
- Changes in Earth's early atmosphere
- Evolution of early life forms

Lesson Objectives

- Describe how the early continents came together.
- Understand what was needed for the first life and the various ways it may have come about.
- Discuss the early atmosphere and how and why free oxygen finally increased.
- Know the features and advantages of multicellular organisms.

Lesson Vocabulary

- **amino acid:** type of organic molecule that is a building block of proteins and necessary for life
- **craton:** Precambrian felsic continental crust that forms the core of a continent
- **cyanobacteria:** single-celled prokaryotes abundant during the Precambrian and the first photosynthesizers
- **eukaryote:** type of organism whose cells contain a nucleus and other organelles
- **extinct:** event in which a species stops existing because it either dies out or evolves into a different species
- **greenstone:** metamorphosed volcanic rock that forms at a subduction zone and is found in deep-sea trenches
- **LUCA (last universal common ancestor):** last life form that was the ancestor of all life that evolved afterward
- **metabolism:** all of the chemical reactions that take place in the cells of an organism and allow the organism to live, grow, and reproduce
- **microbe:** microscopic organism, or microorganism
- **microcontinent:** fragment of crust that is smaller than a continent
- **nucleic acid:** organic compound that stores genetic information and passes it to the next generation; either DNA or RNA
- **paleogeography:** arrangement of the continents on early Earth; ancient geography
- **photosynthesis:** process in which plants produce simple sugars from carbon dioxide, water, using energy from sunlight, and release oxygen into the atmosphere
- **platform:** craton and its overlying younger sedimentary rocks
- **prokaryote:** type of organism whose cells lack a nucleus and other organelles
- **RNA world hypothesis:** hypothesis that RNA was the first organic molecule to evolve
- **shield:** place where a craton crops out at the surface
- **stromatolite:** reef-like structure of cyanobacteria that existed in the Precambrian and continued on into the Cambrian

- **supercontinent:** single, massive continent that formed when all of Earth's landmasses came together
- **symbiotic:** relationship between different species in which both benefit and neither is harmed

Teaching Strategies

Introducing the Lesson

Pique student interest by showing the class “Origin of Life” cartoon 1 (search ID bven864) at the URL below. Tell students that the cartoon contains a germ of truth. Life on Earth really may have come from some other part of the solar system, as they will learn in this lesson.

http://www.cartoonstock.com/directory/o/origin_of_life.asp

Discussion

Ask students to relate the warmer interior of Earth during the Pre-Archean and Archean with plate tectonic activity during that time.

Question: Why were plate tectonic processes more vigorous during the Pre-Archean and Archean?

Answer: Earth's interior was warmer, so mantle convection was faster.

Question: Why were the early crustal plates relatively small?

Answer: The plates were small because subduction zones were more common.

Demonstration

Demonstrate Precambrian plate tectonics with the animations at the URL below. Students can observe the formation and breakup of Rodinia.

<http://geosphere.gsapubs.org/content/3/6/511/suppl/DC1>

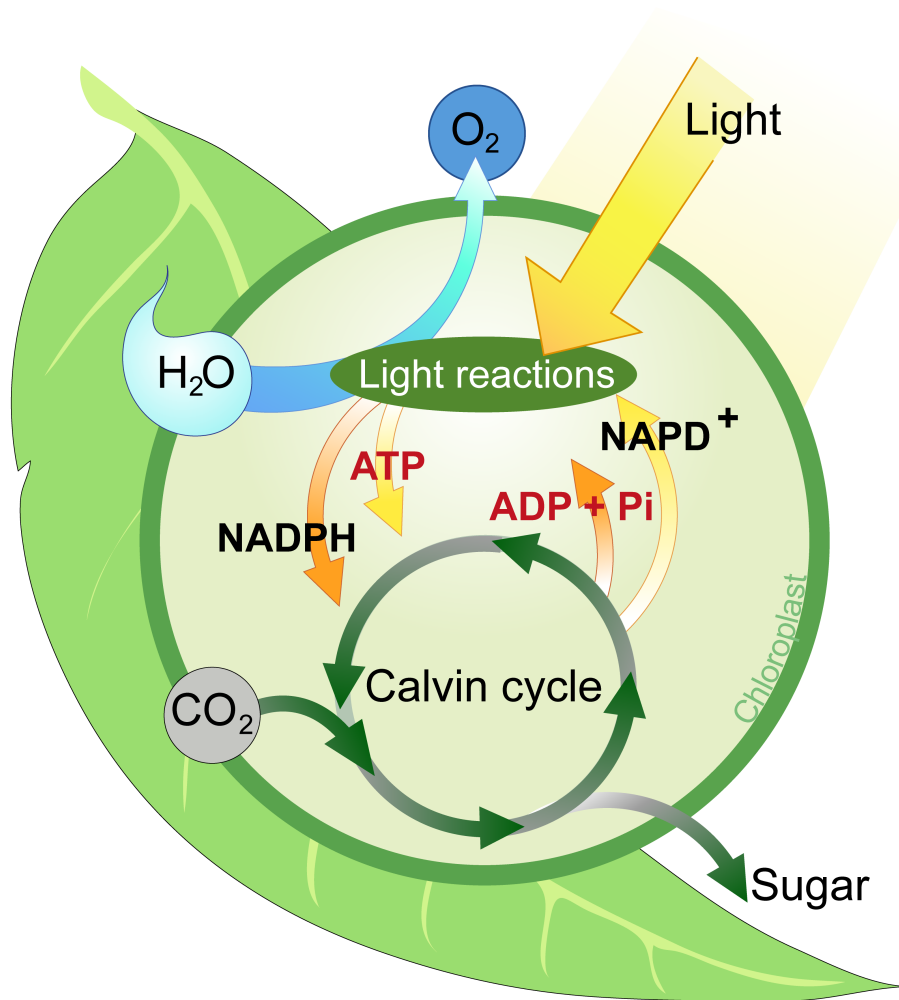
Discussion

Point out that photosynthesis is how cells of certain bacteria, plants, and some other organisms use light energy to make food and that the process releases oxygen. Discuss how the evolution of photosynthesis led to the addition of oxygen to Earth's atmosphere, which in turn allowed the evolution of cellular respiration. Explain that cellular respiration is a very efficient way of getting energy from food and it requires oxygen. Add that cellular respiration allowed more complex life forms to evolve. On the board, write the following equations for cellular respiration and photosynthesis, respectively. Ask students to identify which equation represents each process.

sugar (glucose) + oxygen (O₂) → carbon dioxide (CO₂) + water (H₂O) + energy

carbon dioxide (CO₂) + water (H₂O) + energy → sugar (glucose) + oxygen (O₂)

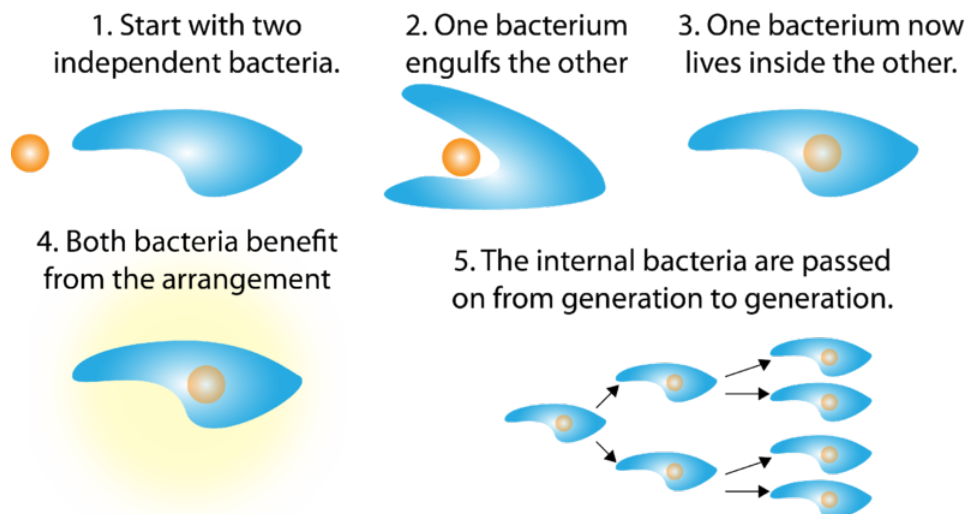
With the help of students, create a diagram like the one below that shows how the two processes are related.



Discussion

Discuss endosymbiotic theory, which is the theory that eukaryotes evolved from symbiotic relationships between prokaryotes. Use the simple diagram below to help students understand the theory. Describe evidence supports the theory. You can learn more at this URL: <http://evolution.berkeley.edu/evosite/history/endosym.shtml>.

Endosymbiosis



Differentiated Instruction

Do a think-pair-share activity to help students understand the most important lesson ideas. Ask students to think about the questions listed below. Then divide the class into pairs, and have partners discuss the questions.

1. What were the earliest continents like, and what happened to them?
2. When and how did the supercontinent Rodinia form?
3. How did the earliest simple cells evolve?
4. What is photosynthesis? How did it change Earth's atmosphere?

Enrichment

Ask one or more students to create a crossword puzzle using at least 15 of the lesson vocabulary terms. Make copies of the puzzle and distribute them to the rest of the class to complete as a review of lesson vocabulary.

Science Inquiry

Discuss the Miller-Urey experiment, which is described in the FlexBook® lesson. Call on students to describe the experiment and its results. Then guide students in interpreting the results of the experiment.

Question: What is an implicit assumption the researchers made in their experiment?

Answer: They assumed the simulation closely represented conditions on early Earth.

Question: What hypothesis is supported by the results of the experiment?

Answer: Organic molecules can form spontaneously under conditions thought to represent conditions on early Earth.

Make sure students realize that the results of Miller and Urey's experiment do not prove that the earliest organic molecules formed as simulated in the experiment.

Chemistry Connection

Students can learn more about the RNA world hypothesis as it is currently being investigated by biochemists in Scott Lab at the University of California at Santa Cruz. Lab scientists are carrying out investigations that they hope will clarify the role of RNA in the origin of life. At the following URL, students can read about highlights of the research and some of the specific problems the scientists are investigating.

<http://scottlab.ucsc.edu/scottlab/origins.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 12.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 12.2 in *CK-12 HS Earth Science*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 12.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What would life be like on Earth if there were no free oxygen?

- Why did it take so long for eukaryotes or multicellular organisms to evolve?

How did the evolution of life affect the non-biological parts of the planet?

12.4 Lesson 12.3: Phanerozoic Earth History

Key Concepts

- Geology of the Paleozoic era
- Geology of the Mesozoic era
- Geology of the Cenozoic era

Lesson Objectives

- The Phanerozoic is divided into the Paleozoic, Mesozoic, and Cenozoic.
- Marine transgressions and regressions were common during the Paleozoic and Mesozoic.

Lesson Vocabulary

- **facies:** characteristic sedimentary rock layers that indicate the processes and environments in which they formed
- **marine regression:** falling of sea level so seas no longer cover the continents
- **marine transgression:** rising of sea level over the continents
- **orogeny:** mountain-building event

Teaching Strategies

Introducing the Lesson

Ask students to recall from the previous lesson (“The Precambrian”) the time span covered by the Precambrian Eon (4.6 billion to about 570 million years ago). Remind them that the following (and current) eon is the Phanerozoic Eon. Point out that in terms of Earth’s total history, the Phanerozoic Eon is short—only about half a billion years (this is apparent in the geologic time scale format shown at the URL below). However, important geological events and most biological evolution occurred during this eon. Tell students they will read about the geological changes of the Phanerozoic in this lesson and they will read about the evolutionary changes of the Phanerozoic in the following lesson.

<http://palaeos.com/timescale/geotimescale.html>

Using Visuals

Help students understand the rock evidence for Paleozoic marine transgressions and regressions. Refer them to the figure in the FlexBook® lesson that shows the Grand Canyon’s three sets of rocks. Have them focus on the

layered Paleozoic rocks. Explain how the sedimentary rock sequences provide evidence of marine transgressions and regressions during the Paleozoic. For example, point out how the Tonto Group toward the bottom of the diagram (around 515 million years ago) represents a marine regression because it has the sequence sandstone, shale, and limestone, all of which were laid down during the Cambrian Period.

Question: Why do sandstones indicate that water depth was low?

Answer: Sandstones form from sand and other coarse-grained sediments, which are deposited in high-energy water that is relatively shallow.

Question: Why do limestones indicate that water depth was high?

Answer: Limestones form from very fine-grained sediments, which are deposited in low-energy water that is relatively deep.

Demonstration

You may want to use the interactive timeline at the following URL when you teach students about plate tectonics and climate change during the Phanerozoic. It demonstrates how Earth's continents moved from the Eocene through the Pleistocene. You can stop the motion at fixed points throughout the eon.

http://nature.ca/discover/exf/clmtpst/index_e.cfm

Differentiated Instruction

Have students make a table comparing and contrasting the eras of the Phanerozoic Eon: the Paleozoic, Mesozoic, and Cenozoic. Tell them to include for each era the time span, important geologic events, and climate. Have students leave a blank column for evolutionary events. They can fill in this column of the table when they read the next lesson. Suggest that they save their table in their science notebook.

Enrichment

Ask for volunteers to make a diorama illustrating life during the Pleistocene glaciations in North America. They should include typical flora and fauna of the period. Display their diorama in a prominent place in the classroom.

Science Inquiry

Students can further explore the Ice Ages with the inquiry activity at the URL below. By doing the activity, students will understand what causes ice ages, learn about organisms that lived during the Pleistocene Ice Ages, and understand why certain ice-age animals went extinct. With the take-home activity sheet, "Giving a Scientific Opinion," students will try to apply what they have learned about the Ice Ages to modern times.

<http://www.discoveryeducation.com/teachers/free-lesson-plans/the-ice-age.cfm>

Overcoming Misconceptions

A common misconception is that the "Ice Ages" happened in the past and are now over. Make students aware that we are still within the most recent ice age, which started about 2.58 million years ago during the late Pliocene. Since then, the world has seen four cycles of glaciation, with ice sheets repeatedly advancing (glacial periods) and retreating (interglacial periods). Explain that Earth is currently in an interglacial period and that the last glacial period ended about 10,000 years ago. All that remains of the continental ice sheets from the last glacial are the Greenland and Antarctic ice sheets and smaller glaciers such as on Baffin Island. Some scientists think that the

current interglacial may last another 50,000 years. However, the effect that global warming will have on the cycle is uncertain.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 12.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 12.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 12.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How did the paleogeography of the planet affect the evolution of life?

How did climate affect the evolution of life?

How was human evolution related to major climatic events?

12.5 Lesson 12.4: History of Earth's Complex Life Forms

Key Concepts

- Adaptation and evolution of organisms
- Ediacara fauna
- Evolution of life forms during the Phanerozoic eon

Lesson Objectives

- Describe how adaptations develop.
- Explain how the fossil record shows us that species evolve over time.
- Describe the general development of Earth's life forms over the last 540 million years.

Lesson Vocabulary

- **adaptation:** inherited trait that helps an organism survive or reproduce in a given environment
- **adaptive radiation:** process in which many new species quickly evolve to fill available niches, often following a mass extinction
- **amniote egg:** egg that contains all the nutrients needed for the developing embryo and is protected by a shell
- **evolution:** change in the genetic makeup of a population or species over time
- **mutation:** random change in a gene, which can be beneficial, harmful, or neutral in its effects on the organism's fitness
- **natural selection:** mechanism of evolution; process in which inherited traits in a population or species change in frequency as individuals with certain traits are better able to survive and reproduce than individuals without the traits
- **paleontologist:** scientist who finds and studies fossils to learn about the history of life
- **tropical:** type of climate that is warm year-round and may be wet
- **variation:** difference in an inherited trait in a population

Teaching Strategies

Introducing the Lesson

Grab students' attention by sharing the amazing fact that there may be as many as 100 million species in existence on Earth today. Then tell students that because of human actions, species are going extinct at an alarming rate, with as many as 100,000 species going extinct each year. Explain that the current wave of extinctions is the sixth of a series of mass extinctions that occurred during the Phanerozoic Eon. Tell students they will learn about these mass extinctions, as well as the bursts of evolution that followed them, when they read this lesson.

Activity

Most descriptions of animal evolution in the Phanerozoic focus on vertebrates. Students can explore what invertebrate life was like in Mesozoic oceans with the interactive activity “Large Invertebrates” at this URL: http://nature.ca/discover/exf/lrgnvtbrts/index_e.cfm.

Building Science Skills

In the interactive activity at the following URL, students can investigate the hypothesis that dinosaurs were already in decline before their extinction at the K/T boundary. They will observe fossils in rock layers as a snapshot of life at that time and decide whether it supports the hypothesis. Make sure they watch the short video by Dr. Kirk Johnson, who explains why all animals larger than housecats went extinct at the K/T boundary.

http://nature.ca/discover/exf/dclnngdvrsty/index_e.cfm

Differentiated Instruction

How natural selection works to bring about adaptations at the level of the population may be difficult for some students to conceptualize. Have them do one of the hands-on simulations of natural selection at the URLs below. They will see first-hand how a trait increases or decreases in a population through predation pressure. This is a good activity for less proficient readers and English language learners.

http://www.ucmp.berkeley.edu/education/lessons/candy_dish.html

<http://www.accessexcellence.org/AE/AEPC/WWC/1995/beansbirds.html>

Enrichment

Suggest that interested students explore the effects of volcanism on the Cretaceous mass extinction. The interactive activity at the URL below investigates the Deccan volcanic eruption that occurred around the time of the Cretaceous mass extinction and what role it may have played in the extinction.

http://nature.ca/discover/exf/vlcnsmdextncton/index_e.cfm

Science Inquiry

Continuing the dinosaur extinction theme, you can use the activity described at the following URL to have students practice scientific reasoning. They will read and discuss articles presenting two alternative models about the extinction of dinosaurs. Then they will use the same criteria that scientists use to choose the “best” solution.

<http://www.indiana.edu/ensiweb/lessons/theor.ch.html>

Overcoming Misconceptions

Misconceptions about evolution are very common. The URL below lists and debunks 17 of the most widespread misconceptions about evolutionary theory. It should be required reading by all of your students.

<http://sciencebasedlife.wordpress.com/2011/09/04/understanding-evolution-17-misconceptions-and-their-responses/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 12.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 12.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 12.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How did life on Earth change from one period of geologic time to the next?

How did climate affect the evolution of life?

Evolution is well documented in the fossil record. Why is it so controversial?

CHAPTER **13** HS TE Earth's Fresh Water

Chapter Outline

- 13.1** CHAPTER 13: EARTH'S FRESH WATER
 - 13.2** LESSON 13.1: WATER ON EARTH
 - 13.3** LESSON 13.2: SURFACE WATER
 - 13.4** LESSON 13.3: GROUNDWATER
-

13.1 Chapter 13: Earth's Fresh Water

Chapter Overview

This chapter describes the water cycle and sources of Earth's fresh water, including streams, lakes, wetlands, and groundwater.

Online Resources

See the following Web sites for appropriate laboratory activities:

In the investigation at the following URL, students will create a model of a wetland to observe how it absorbs and filters water from the environment. They will also learn characteristics of wetland organisms and match various organisms to different types of wetlands.

- <http://www.state.nj.us/education/21cclc/casp/lsc/unit2/Lesson8.pdf>

Students will investigate groundwater with the lab at the URL below. They will describe the movement of the water table, locate saturation zones, and identify their function. <http://www.wef.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2535>

These Web sites may also be helpful:

You can find water-related activities suitable for high school students at this URL: <http://thewaterproject.org/community/student-resources/water-related-education-materials-for-high-school/>.

You can access many teaching resources from the USGS Water Science School at this URL: <http://ga.water.usgs.gov/edu/>.

The following URL has numerous teaching resources and lesson plans about water.

- <http://www.epa.gov/students/teachers.html#epawater>

Pacing the Lessons

TABLE 13.1: short caption

Lesson	Class Period(s) (60 min)
13.1 Water on Earth	1.5
13.2 Surface Water	2.0
13.3 Groundwater	1.5

13.2 Lesson 13.1: Water on Earth

Key Concepts

- Distribution of Earth's water
- The hydrologic cycle

Lesson Objectives

- Describe how water is distributed on Earth.
- Describe what powers the water cycle and how water moves through this cycle.

Lesson Vocabulary

- **condensation:** process in which a gas changes to a liquid
- **evaporation:** process in which a liquid changes to a gas
- **fresh water:** water with a low concentration of salts, found in streams, lakes, ice, the ground, and the atmosphere
- **groundwater:** fresh water that moves through pore spaces in soil and fractures in rock beneath Earth's surface
- **hydrologic (water) cycle:** continuous movement of water around Earth between reservoirs, such as oceans, other bodies of surface water, the atmosphere, ice, and groundwater
- **precipitation:** water that falls from clouds to the ground as rain, snow, sleet, or hail
- **reservoir:** storage location for a substance such as water
- **residence time:** average amount of time a substance remains in a reservoir
- **sublimation:** process in which a solid changes directly to a gas without going through the liquid state
- **transpiration:** release of water vapor into the atmosphere from the leaves of plants
- **water vapor:** gaseous state of water

Teaching Strategies

Introducing the Lesson

Introduce the water cycle by playing the water cycle rap at the following URL. Tell students they will learn about the nature of water and the water cycle in this lesson.

<http://www.educationalrap.com/song/water-cycle/>

Discussion

Tell students that many of Earth's most interesting features are due to the unique properties of water and to the planet having the right environmental conditions for water to be present in all three states. Explain and discuss the properties of water with the class, including the following:

- Water is a polar molecule, having a slightly negative oxygen end and a slightly positive hydrogen end because oxygen attracts the shared electrons more strongly.
- Water molecules bind loosely together by weak hydrogen bonds that form between oppositely charged ends of water molecules. The hydrogen bonds require energy to break and they give water properties such as cohesion and high specific heat.
- Water molecules in ice form an open hexagonal framework. Unlike most substances, water is less dense as a solid than as a liquid, so ice floats on liquid water.

You (or your students) can find more information about water's unique properties at this URL: <http://www.chem1.com/acad/webtext/states/water.html>.

Differentiated Instruction

Pair less proficient readers and English language learners with other students, and ask partners to work together to make a simple cycle diagram of the water cycle. Tell them to include sketches to illustrate the steps in the cycle. Ask them to explain at least one way that water can travel through their cycle diagram. Suggest that students add their diagram to their science notebook.

Enrichment

Ask a small group of students to make a water cycle board game. Each player could be a molecule of water, and the object of the game might be to make one complete trip through the cycle. Players could draw cards or roll dice to determine what happens to them on each move, depending on their state of matter. For example, if a molecule of water is in the ocean, on the player's next turn a roll of the dice could decide whether the player remains as liquid water in the ocean or evaporates and enters the atmosphere as water vapor. After the students create and test their board game, encourage other students to play it.

Science Inquiry

Students can model the water cycle with the activity described in the PDF document below. In the activity, they will construct a model of the hydrologic cycle and explain how the hydrologic cycle works and why it is important. They will also compare the hydrologic cycle to other cycles in nature such as the nitrogen cycle and carbon cycle.

http://www.polytechnic.edu.na/academics/schools/engine_infotech/civil/libraries/water_resource_basics/Introduction_-_Water.pdf

Overcoming Misconceptions

Common misconceptions about water and its states are listed below. The correct conceptions are given in brackets. For each pair of statements, ask students to select the correct one and explain why it is correct. You can find additional misconceptions at this URL: <http://beyondpenguins.ehe.osu.edu/issue/water-ice-and-snow/common-misconceptions-about-states-and-changes-of-matter-and-the-water-cycle>

1. When water boils and bubbles, the bubbles are air. [Bubbles formed by boiling water consist of water vapor.]

2. Steam is hot air. [Steam is water vapor.]
3. When steam is no longer visible it becomes air. [When water vapor condenses in the air it is visible as tiny water droplets.]

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 13.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 13.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 13.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How does precipitation affect the topography of Earth?

What natural disasters are caused by the water cycle?

How might building dams disrupt the natural water cycle?

As Earth's temperature warms, how might the water cycle be altered?

13.3 Lesson 13.2: Surface Water

Key Concepts

- Streams and rivers
- Ponds and lakes
- Wetlands
- Floods

Lesson Objectives

- Compare streams and rivers and their importance.
- Describe what ponds and lakes are and why they are important.
- Explain why wetlands are significant in the water cycle, and describe their biodiversity.
- Describe the causes of floods and their effects.

Lesson Vocabulary

- **brackish:** relating to water that is a mixture of fresh water and salt water
- **confluence:** place where two streams merge
- **continental divide:** ridge that separates all the water basins that empty into different oceans
- **divide:** highest ridge that separates one water basin from another
- **estuary:** wetland containing brackish water that forms where a stream meets the ocean
- **flood:** event in which a stream or river overflows its banks
- **lake:** large body of fresh water drained by a stream
- **levee:** raised structure built on a stream bank to hold back the water in case of a flood
- **limnology:** study of freshwater bodies and the organisms that live in them
- **marsh:** wetland with grasses and reeds but no trees, containing water that may be fresh, salty, or brackish
- **mouth:** part of a stream where it enters a large body of still water such as a lake or an ocean
- **pond:** small body of fresh water not drained by a stream
- **pool:** deep, slow-moving part of a stream where the stream may be wider than in other places
- **stream:** any body of fresh water that constantly flows downhill within banks (sides) and a bed (bottom)
- **swamp:** wetland in which water moves very slowly, oxygen levels are low, and trees and vines are common
- **tributary:** smaller of two streams that merge to make a larger stream
- **wetland:** land that is wet for most or all of the year

Teaching Strategies

Introducing the Lesson

Introduce the lesson with the short wetlands video at the URL below. This interesting movie shows young adult hosts emerging from an algae-covered swamp, so it will be sure to grab students' attention and pique their interest in wetlands.

http://www.youtube.com/watch?v=ft_2nj96jLM

Discussion

Discuss how human actions—including building levees for flood protection—can actually increase flooding. You can learn more at this URL: http://www.nbcnews.com/id/3077314/ns/technology_and_science-science/t/floods-raise-scientific-dilemma/.

Differentiated Instruction

Pair students who need extra help with other students in the class, and ask partners to make and label a sketch of a river system. Their sketch should include a river, its source and mouth, tributaries, and divides to separate the river's watershed from that of other rivers. Post their sketches in the classroom.

Enrichment

Ask a small group of interested students to role-play a congressional hearing in which scientists testify before congress on the importance of wetlands and the need to protect them. Give the students a chance to present their role-play to the class.

Enrichment

Students who are interested in learning more about floods, such as their connection to El Niño and myths about floods, should read the articles at the following URLs. The National Geographic article includes a collection of excellent flood images.

<http://www.pbs.org/newshour/infocus/floods/science.html>

http://education.nationalgeographic.com/education/encyclopedia/flood/?ar_a=1

Science Inquiry

Have students do the estuary activity at the URL below. They will explain what an estuary is and why estuaries are important, build a model estuary, and examine how salinity affects aquatic plants.

<http://www.state.nj.us/education/21ccl/casp/lsc/unit2/Lesson7.pdf>

Biology Connection

With the activity at the following URL, students can identify the biotic and abiotic components of a freshwater ecosystem and create a freshwater ecosystem in a large plastic bottle. Then they can observe their mini-ecosystem

over time to see what changes occur.

<http://www.state.nj.us/education/21cclc/casp/lsc/unit2/Lesson3.pdf>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 13.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 13.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 13.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What types of streams have you seen in your area?

Why are bodies of water never really permanent?

Is it possible that your home could be flooded? What would you do if it were flooded?

13.4 Lesson 13.3: Groundwater

Key Concepts

- Characteristics of groundwater
- Aquifers
- Springs
- Wells

Lesson Objectives

- Define groundwater.
- Explain the location, use, and importance of aquifers.
- Define springs.
- Describe how wells work and why they are important.

Lesson Vocabulary

- **aquifer:** permeable layer of underground rock, sand, or gravel that rests on an impermeable layer of rock and is saturated with groundwater
- **capillary action:** movement of a liquid such as water through narrow spaces because of intermolecular forces between the liquid and surrounding surfaces
- **impermeable:** unable to be penetrated by water
- **permeability:** ability to be penetrated by water because of the interconnectedness of pores within a material
- **porosity:** condition in which a material contains many small holes, or pores
- **spring:** place where the water table meets the surface so groundwater bubbles onto the surface
- **subsidence:** sinking of the land surface because of the extraction of groundwater below it
- **water table:** upper surface of groundwater
- **well:** circular hole dug or drilled down into an aquifer to allow people to access groundwater

Teaching Strategies

Introducing the Lesson

Ask students if they know the source of the water that is piped into their home or school. Possible sources could include a reservoir, lake, or well. Identify any correct responses, and then explain to the class that many people get their water from under the ground. This water, called groundwater, is accessed by wells. Tell students they will learn more about groundwater and how it's obtained in this lesson.

Activity

Use one or more of the four aquifer activities at the following URL when you teach this lesson: <http://www.ngwa.org/fundamentals/teachers/pages/lesson-plans-from-ngwa.aspx>. The activities are:

- How Water Flows in Aquifers—This activity teaches students how water moves through an aquifer as well as how and why water storage in an aquifer changes over time.
- Making an Aquifer Model—As a follow-up to “How Water Flows in Aquifers,” this activity teaches students more in-depth knowledge of aquifers and how they are an important component of the hydrologic cycle.
- Measuring Water Storage in Aquifers—This activity builds on the previous two activities by determining the type of material that best contributes to aquifer water storage.
- Usability of Aquifer Water—In this activity, students will gain an appreciation for the importance of aquifers as drinking water sources and the reasons behind the need for water treatment.

Differentiated Instruction

Have less proficient readers and English language learners make a Frayer model for the term aquifer. They should draw a large box and divide it into quarters labeled “Definition,” “Drawing,” “Example,” and “Nonexample.” Then they should fill in each quarter with the relevant material.

Enrichment

Ask one or more students to learn about paving alternatives that may help reduce runoff and result in more water infiltrating the ground (see URLs below). Ask the students to summarize what they learn and share it with the rest of the class. This can introduce or follow up the science inquiry activity below.

<http://www.tompkins-co.org/planning/vct/tool/pavementalternatives.html>

<http://brgov.com/dept/planning/pdf/bulletins/bull45.pdf>

Science Inquiry

Challenge groups of students with the inquiry activity, “Groundwater—water we doing to our planet?” (see URL below). Students must solve the problem of how much runoff is created by an average shopping mall parking lot. The object is to determine how much water is lost that would otherwise have entered the groundwater system.

<http://www.geosociety.org/educate/lessonplans/Groundwater.pdf>

Overcoming Misconceptions

Some students may hold the misconception that groundwater and surface water are unconnected. Explain how surface water may become groundwater and vice-versa. Make sure students understand that both sources of water are part of the same global water cycle. To reinforce the correct conception, have students do the activity “What Goes on Down Under” at the following URL. They will identify sources for the recharge and discharge of groundwater and identify the connection between surface and groundwater.

<http://www.wef.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2534>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 13.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 13.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 13.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Is water from a river or from a well more likely to be clean to drink?

Why is overuse of groundwater a big concern?

What policies might people put in place to conserve water levels in lakes and aquifers?

CHAPTER

14

HS TE Earth's Oceans

Chapter Outline

- 14.1** CHAPTER 14: EARTH'S OCEANS
 - 14.2** LESSON 14.1: INTRODUCTION TO THE OCEANS
 - 14.3** LESSON 14.2: OCEAN MOVEMENTS
 - 14.4** LESSON 14.3: THE SEAFLOOR
 - 14.5** LESSON 14.4: OCEAN LIFE
-

14.1 Chapter 14: Earth's Oceans

Chapter Overview

This chapter describes how Earth's oceans formed, ocean water composition, and ocean water movements (waves, tides, and currents). It also describes the seafloor and types of ocean organisms.

Online Resources

See the following Web site for an appropriate laboratory activity:

With the lab at the URL below, students will observe the effects of the layering of warmer and colder water and of water that is more or less saline. They will recognize that differences in salinity and temperature are the cause of differences in density of ocean water and the underlying cause of deep ocean currents.

- http://oceanservice.noaa.gov/education/lessons/hot_cold_lesson.html

These Web sites may also be helpful:

You can find several excellent videos pertaining to Earth's oceans at this URL: http://climate.nasa.gov/climate_reel/

You can access NeMO Explorer at the URL below. NeMO Explorer allows students to explore the NeMO seafloor observatory at Axial Seamount either geographically or by subject matter.

- <http://www.pmel.noaa.gov/vents/nemo/explorer.html>

The URL below provides 165 lesson plans developed to bring entire classrooms “on board” for exploration and discovery of ocean-related topics, such as deep-sea hydrothermal vents and benthic creatures on the ocean floor.

- <http://oceanexplorer.noaa.gov/edu/welcome.html>

You can find excellent articles on Earth's oceans at the Oceans Alive! URL below.

- <http://legacy.mos.org/oceans/planet/index.html>

At the following URL, you can access many videos and interactives pertaining to the oceans and the atmosphere.

- http://www.teachersdomain.org/browse/?start=0&fq_hierarchy=k12.sci.ess.watcyc.asint
-

Pacing the Lessons

TABLE 14.1: short caption

Lesson	Class Period(s) (60 min)
14.1 Introduction to the Oceans	1.0
14.2 Ocean Movements	3.0
14.3 The Seafloor	1.0
14.4 Ocean Life	2.0

14.2 Lesson 14.1: Introduction to the Oceans

Key Concepts

- Significance of the oceans
- The continental margin
- Composition of ocean water
- The water column

Lesson Objectives

- Explain the significance of the oceans.
- Describe the composition of ocean water.
- Define the parts of the water column and oceanic divisions.

Lesson Vocabulary

- **aphotic zone:** ocean zone deeper than 200 meters where too little sunlight penetrates for photosynthesis to occur
- **biomass:** total mass of living organisms in a given area
- **intertidal zone:** ocean zone that is closest to shore, between the high and low tide marks
- **neritic zone:** ocean zone that lies over the continental shelf between the intertidal zone and the oceanic zone
- **oceanic zone:** ocean zone that consists of the open ocean farther from shore than the neritic zone
- **photic zone:** ocean zone in the top 200 meters of water that receives enough sunlight for photosynthesis to occur
- **salinity:** concentration of dissolved salts in salt water
- **water column:** vertical column of ocean water, which is divided into different zones according to depth

Teaching Strategies

Introducing the Lesson

Introduce Earth's oceans by asking students how ocean water differs from water in a pond or river. (Ocean water is salty; water in a pond or river is fresh water.)

Question: If I had a liter of ocean water, how much salt do you think it would contain?

Answer: Answers may vary. The correct answer is about 35 grams.

Tell students they will learn more about the composition of ocean water in this lesson.

Discussion

Discuss how vertical and horizontal ocean zones are related to the needs of living organisms. Point out that the main vertical ocean zones (photic and aphotic zones) differ in the amount of sunlight they receive, whereas horizontal ocean zones (intertidal, neritic, and oceanic zones) differ in the amount of nutrients they receive. Tell students that zones closer to shore have more nutrients available to living things.

Question: Why are there more nutrients near shore than out in the open ocean?

Answer: Most nutrients enter the ocean from the land. They are washed into the water by runoff and rivers that flow into the ocean.

Differentiated Instruction

Have students complete a KWL chart for the lesson. Before they read the lesson, they should list in the “Know” column anything they already know about the oceans and in the “Want to Know” column what they would like to know. After they read the lesson, they should list in the “Learned” column what they learned about the oceans from the lesson.

Enrichment

Ask interested students to investigate the amazing 1959 descent of the bathyscaphe Trieste with two crewmembers to the Challenger Deep, the deepest place on Earth in the Mariana Trench. This was the last time a submersible vehicle would travel to this depth until 2012, when the film director James Cameron made the trip alone in the submersible Deepsea Challenger. Have the students then create a Web page about the Trieste and its accomplishment. Urge other students in the class to visit the Web page.

Science Inquiry

Explain the concept of specific heat as the amount of heat (in calories) needed to raise the temperature of one gram of a substance by one degree Celsius. Tell students that one of water’s most significant properties is that it takes a lot of energy to make it get hot. Ocean water, for example, has to absorb about 0.9 calories of heat for the temperature of one gram of water to increase by one degree Celsius. The specific heat of soil is much lower. It takes only about 0.3 calories to raise the temperature of one gram of soil by one degree Celsius. At the URL below, students can watch an interactive simulation that demonstrates the different specific heats of water and land. Students will observe the temperature of a soil sample rising faster than the temperature of the same amount of water when both are exposed to the same heat sources. Following the simulation, challenge students to relate the differences in specific heat of land and water to differences in the temperatures of land and water between day and night and from one season to the next. Ask them to predict how the differences in temperature affect world and regional (coastal vs. continental) climates.

http://oceanservice.noaa.gov/education/pd/oceans_weather_climate/media/specific_heat.swf

Overcoming Misconceptions

In the article at the following URL, you can find a list of 110 misconceptions that have been documented in students. Discuss with your class the misconceptions that are especially germane to the content of this chapter.

http://www.tos.org/oceanography/archive/20-4_feller.pdf

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 14.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 14.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 14.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How do water motions such as tides and waves affect living creatures in and near the sea?

Is it possible to have a river in the middle of the ocean?

What factors affect the movement of ocean water? How do these factors affect the world's climate and the ocean's ecosystem?

14.3 Lesson 14.2: Ocean Movements

Key Concepts

- Waves
- Tides
- Surface currents
- Deep currents

Lesson Objectives

- Define waves and explain their formation.
- Describe what causes tides.
- Describe how surface currents form and how they affect the world's climate.
- Describe the causes of deep currents.
- Relate upwelling areas to the food chain.

Lesson Vocabulary

- **Coriolis effect:** apparent deflection of global winds and surface ocean currents because of Earth's rotation
- **downwelling:** sinking of higher density water from the top to the bottom of the ocean
- **gyre:** one of five major loops created by surface ocean currents
- **high tide:** highest water level in each tidal cycle
- **longshore current:** local surface current that moves along the shore in the same direction as the prevailing winds
- **low tide:** lowest water level in each tidal cycle
- **neap tide:** tide with the smallest range between high and low tide, which occurs twice in each lunar month during first and third quarters of the moon
- **rip current:** strong surface current that flows seaward from near the shore
- **spring tide:** tide with the largest range between high and low tides, which occurs twice in each lunar month during new and full moons
- **storm surge:** high water pushed ashore by storm winds
- **surface current:** ocean current caused mainly by winds that flows through the surface of the water
- **thermohaline circulation:** movement of ocean water in deep currents, which occur because of differences in temperature and salinity of the water
- **tidal range:** difference between high and low tide in a given tidal cycle
- **tide:** regular rise or fall of Earth's surface water twice a tidal day as a result of the moon's and sun's gravitational attraction and Earth's rotation
- **upwelling:** process in which nutrient-rich water rises from the deep ocean to the surface
- **wave:** transfer of energy through matter, such as the transfer of wind energy through water in an ocean wave

Teaching Strategies

Introducing the Lesson

Introduce currents and other ocean water motions with the fascinating animation at the URL below. The animation shows ocean surface currents from June 2005 to December 2007 based on data from NASA satellites. Students can observe how bigger currents like the Gulf Stream carry warm waters across thousands of miles at high speeds and how coastal currents like the Agulhas in the Southern Hemisphere move equatorial waters toward Earth's poles. They will also observe many other ocean currents that are confined to particular regions and form slow-moving, circular pools called eddies. Tell students they will learn why ocean water moves in these ways when they read this lesson.

<http://www.nasa.gov/topics/earth/features/perpetual-ocean.html>

Building Science Skills

With the activity “Ups and Downs” at the following URL, students can investigate the causes of tides. They will explain and model forces that cause and affect tides, analyze variations in tidal patterns and water levels in selected areas, and infer and discuss some conditions that may have influenced these variations. They will also explain how tides affect our lives and the importance of monitoring tides.

http://oceanservice.noaa.gov/education/lessons/ups_downs.html

Differentiated Instruction

Pair English language learners with other students, and ask partners to make a cycle diagram showing the monthly tide cycle. The diagram should show the phases of the moon and spring and neap tides. Suggest that students keep their cycle diagram in their science notebook.

Enrichment

Challenge students to predict how knowledge of waves might be important to surfers. Then have them investigate “surfology,” the application of knowledge about waves to the sport of surfing. (They can start with the URLs below.) They should learn more about waves, including how they differ depending on factors such as wind, fetch, swell period, and the ocean floor (bathymetry). They should also learn how to choose the best swells for surfing. Ask the students to create a poster to convey what they learn. Display their poster in the classroom.

- http://www.surfing-waves.com/waves/best_waves.htm
- <http://surfing.isport.com/surfing-guides/how-to-read-waves-for-surfing>
- <http://www.surfscience.com/topics/learn-to-surf/surfing-101/how-to-choose-a-good-wave/>

Science Inquiry

With the inquiry activity at the following URL, groups of students will try to answer the question: What factors drive water circulation in the Arctic Ocean? By doing the activity, they will be able to identify the primary driving forces for ocean currents. They will also be able to infer the type of water circulation to be expected in the Arctic Ocean, given information on temperature, salinity, and bathymetry.

http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_c_events.pdf

Overcoming Misconceptions

Students may think that the Coriolis effect is a force, like the force of gravity, and that it causes the actual deflection of global winds and surface currents. Use a globe and other items to create a three-dimensional model that demonstrates the Coriolis effect and shows that is only an apparent deflection of winds or currents. Explain how the Coriolis effect occurs because of Earth's rotation. Point out that Earth's surface moves, not the air or water.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 14.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 14.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 14.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Some scientists have hypothesized that if enough ice in Greenland melts, the Gulf Stream might be shut down. Why might this happen?

If the Gulf Stream shuts down, what would be the result on climate in Europe?

How do the movements of ocean water contribute to the ocean's life?

14.4 Lesson 14.3: The Seafloor

Key Concepts

- How scientists study the seafloor
- Features of the seafloor
- Ocean resources

Lesson Objectives

- Describe the methods scientists have for studying the seafloor.
- Describe the features of the seafloor.
- List the living and non-living resources that people use from the seafloor.

Lesson Vocabulary

- **bottom trawling:** fishing by dragging nets along the ocean floor
- **manganese nodule:** rock on the ocean floor that contains valuable minerals including manganese

Teaching Strategies

Introducing the Lesson

Generate student interest in the ocean floor by showing them one or more animated 3-D bathymetric maps of features of the ocean floor. You can find a collection of maps at the first URL below. <http://oceanexplorer.noaa.gov/gallery/maps/maps.html>

Activity

Students can take a virtual trip to the seafloor and explore the hydrothermal vents of the Magic Mountain Chimney Fields by clicking on the interactive map below. When they click on an area of the map, they will view a virtual fly-through and panorama of one of four sites. Ask students to describe what they observe. Discuss these features of the ocean floor with the class.

<http://oceanexplorer.noaa.gov/explorations/02fire/logs/magicmountain/welcome.html>

Building Science Skills

Students can build science skills with the sunken sub activity at the URL below. They will identify features of the ocean floor, draw an ocean floor profile using data points, and then use the profile to find a sunken submarine.

http://www.smithsonianeducation.org/educators/lesson_plans/ocean/acrobat/secret.pdf

Differentiated Instruction

Work with students to make a cluster map of ways to study the seafloor using an overhead transparency or the blackboard. Write “Studying the Seafloor” in a central circle. Four surrounding circles should be labeled “Mapping,” “Sampling Remotely,” “Submersibles, and “Remotely Operated Vehicles.” As you discuss each way of studying the seafloor, have students add important points or keywords to the appropriate circles.

Enrichment

Tell students that the growth of manganese nodule is thought to be one of the slowest of all geological phenomena. It takes several million years for a nodule to grow just a centimeter in diameter. Call on one or more volunteers to investigate the challenging topic of how manganese nodules grow, regarding which there are several current theories. Students can find information at the following URLs. Ask the student(s) to create a poster or PowerPoint presentation to explain the various geological processes that can increase nodule size. Then have them lead a class discussion of implications of the slow growth rate for the use of nodules as mineral resources.

<http://www.isa.org.jm/files/documents/EN/Brochures/ENG7.pdf>

http://www.currentscience.ac.in/Downloads/article_id_078_03_0300_0308_0.pdf

Science Inquiry

The activity at the following URL focuses on the use of robots in ocean floor exploration. The activity is designated for middle school students but it is also appropriate for high school students. The activity addresses the question: How can underwater robots be used to assist scientific explorations? Learning objectives include contrasting at least three types of underwater robots used for scientific explorations, discussing the advantages and disadvantages of using underwater robots in scientific explorations, and identifying robotic vehicles best suited to carry out a specific underwater exploration task.

http://oceanexplorer.noaa.gov/explorations/05lostcity/background/edu/media/lostcity05_i_robot.pdf

Overcoming Misconceptions

As a homework assignment have students use Internet sources, such as those below, to find at least one misconception about the seafloor. The next day, call on students to read their misconceptions and restate them as correct conceptions. Discuss each correct conception and evidence that supports it.

- http://www.tos.org/oceanography/archive/20-4_feller.pdf
- <http://beyondpenguins.ehe.osu.edu/issue/polar-oceans/common-misconceptions-about-oceans#misconceptions>
- <http://www.encorewiki.org/display/OSER/Ocean+Misconceptions>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 14.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 14.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 14.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If the seafloor is not well known, how much do you think is known about marine life?

What methods are needed to learn about organisms at the ocean surface, the mid-depths, or on the seafloor?

Are techniques that are used for understanding ocean physics, chemistry, and geology also useful for studying marine life?

14.5 Lesson 14.4: Ocean Life

Key Concepts

- Types of ocean organisms
- Interactions among ocean organisms

Lesson Objectives

- Describe the different types of ocean organisms.
- Describe the interactions among different ocean organisms.

Lesson Vocabulary

- **chemosynthesis:** process of using chemical energy to make food
- **hydrothermal vent:** fissure at a mid-ocean ridge where hot mineral water pours out
- **invertebrate:** animal that lacks a backbone
- **phytoplankton:** “plant-like” plankton such as algae that make food by photosynthesis
- **plankton:** diverse group of mainly microscopic marine organisms that are suspended in the photic zone and form the basis of most marine food chains; include phytoplankton and zooplankton
- **primary productivity:** creation of food energy by photosynthesis or chemosynthesis
- **reef:** large underwater structure created from the calcium carbonate skeletons of coral organisms
- **vertebrate:** animal that has a backbone
- **zooplankton:** “animal-like” plankton that consume phytoplankton

Teaching Strategies

Introducing the Lesson

Share the following facts and figures about living things in the ocean with your students as an introduction to ocean life.

- Life began in the seas as long ago as 3.8 billion years. The first land dwellers appeared far more recently, at just 400 million years ago.
- Today, as much as 80 percent of all life on Earth is found in the ocean.
- Tiny phytoplankton provide 50 percent of the oxygen in Earth’s atmosphere and form the basis of ocean food chains, all the way up to big fish, marine mammals, and humans.
- A study of a deep-sea community found almost 900 species from more than 100 families in an area about half the size of a tennis court. More than half of these species were unknown until this discovery.

- Coral reefs are the nurseries of the ocean and biodiversity hot spots. On some tropical coral reefs, there may be a thousand species per square meter!

Collaborative Learning

Students can work together to learn about marine food webs by doing the group activity and extension at the URL below. Groups will distinguish between different trophic levels, describe examples of food chains in different major marine ecosystems, and order organisms in a food chain by trophic level. With the extension activity, groups will try to fit their food chains together to create a single marine food web.

http://education.nationalgeographic.com/education/activity/marine-food-chains-and-biodiversity/?ar_a=1

Differentiated Instruction

Have students make a Venn diagram comparing and contrasting what are arguably the most important organisms in the oceans: phytoplankton and zooplankton. Discuss with students why these organisms are so important. Have them sketch a simple marine food chain that contains both types of plankton.

Enrichment

Ask a few students to learn more about hydrothermal vent ecosystems and then teach the topic to the rest of the class. Suggest that they start with the URLs below. They should include images of, and interesting facts about, vent organisms in their presentation. They should also spend some time discussing threats to hydrothermal vent communities posed by mining.

- <http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/hydrothermal.html>
- <http://www.botos.com/marine/vents01.html>
- <http://www.boundless.com/microbiology/microbial-ecology/microbial-symbioses/hydrothermal-vent-microbial-ecosystems/>

Science Inquiry

Challenge students with the questions: Why are coral reefs important, and what can be done to protect them from major threats? Then have them do the inquiry activity below. In the activity, they will identify how coral reefs benefit human beings, major threats to coral reefs, and major components of the Coral Reef Early Warning System. They will also obtain and analyze several types of oceanographic data from remote-sensing satellites. Finally, they will identify and discuss actions that can be taken to reduce or eliminate threats to coral reefs.

http://oceanservice.noaa.gov/education/lessons/keep_watch.html

Overcoming Misconceptions

Students may assume incorrectly that coral reefs are found in all oceans. Explain that corals are typically found only in tropical and subtropical waters because coral organisms have very specific needs in terms of temperature, water salinity, and light.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 14.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 14.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 14.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How does the ocean interact with the atmosphere?

How is energy transferred around the planet and how does this affect life on Earth?

What would be the effect of pollution on the oceans?

CHAPTER **15** HS TE Earth's Atmosphere

Chapter Outline

- 15.1 CHAPTER 15: EARTH'S ATMOSPHERE
 - 15.2 LESSON 15.1: THE ATMOSPHERE
 - 15.3 LESSON 15.2: ATMOSPHERIC LAYERS
 - 15.4 LESSON 15.3: ENERGY IN THE ATMOSPHERE
 - 15.5 LESSON 15.4: AIR MOVEMENT
-

15.1 Chapter 15: Earth's Atmosphere

Chapter Overview

This chapter describes the properties, significance, and layers of Earth's atmosphere. It also explains how energy is transferred in the atmosphere and how air circulates through the atmosphere and flows over Earth's surface as wind.

Online Resources

See the following Web sites for appropriate laboratory activities:

Students can learn how heat is transferred in the atmosphere by doing the heat transfer lab at the URL below. They will observe the three main heat transfer methods (radiation, conduction, and convection). The complete lab can be downloaded after free registration at the Web site.

- <http://betterlesson.com/lesson/5214/04-heat-transfer-lab>

With the lab at the following URL, students will analyze and graph weather data to investigate the formation of a thermal circulation cell and land and sea breezes.

- <http://kingfish.coastal.edu/marine/risingtide/breeze/index.html>

These Web sites may also be helpful:

You can find many common student misconceptions about the atmosphere at this URL: <http://www.csulb.edu/lhenriqu/NARST2000.htm>.

The following URL is a video clip in which Bill Nye the Science Guy explains the layers of the atmosphere in his usual entertaining fashion.

- <http://www.watchknowlearn.org/Video.aspx?VideoID=25695&CategoryID=2666>

This excellent video, "The Precious Envelope," from the University of Maryland introduces students to the atmosphere and its importance as well as how human actions are changing it.

- <http://www.watchknowlearn.org/Video.aspx?VideoID=18356&CategoryID=2666>

You can find a set of useful slides covering the information in the lesson "Air Movement" at this URL: <http://www.slideshare.net/cpelfrey/global-and-local-winds>.

Pacing the Lessons

TABLE 15.1: short caption

Lesson	Class Period(s) (60 min)
15.1 The Atmosphere	1.5
15.2 Atmospheric Layers	1.5
15.3 Energy in the Atmosphere	2.0
15.4 Air Movement	2.0

15.2 Lesson 15.1: The Atmosphere

Key Concepts

- Significance of the atmosphere
- Composition of the atmosphere
- Air pressure and density

Lesson Objectives

- Describe the importance of the atmosphere to our planet and its life.
- Outline the role of the atmosphere in the water cycle.
- List the major components of the atmosphere and their functions.
- Describe how atmospheric pressure changes with altitude.

Lesson Vocabulary

- **air pressure:** force of air pressing on a given area
- **altitude:** height above sea level
- **atmosphere:** layer of gases that surround a planet
- **greenhouse gas:** gas such as carbon dioxide or methane that absorbs and holds heat that is re-radiated from the surface of the planet into the atmosphere
- **humidity:** amount of water vapor in the atmosphere
- **ozone:** gas consisting of molecules of three oxygen atoms each (O_3), which is a pollutant in the lower atmosphere but in the upper atmosphere absorbs and protects living things from ultraviolet radiation
- **respiration:** process in which organisms convert sugar into useful energy, using oxygen and releasing carbon dioxide
- **ultraviolet (UV) radiation:** high-energy radiation from the sun that can be harmful to organisms on Earth
- **water vapor:** gaseous form of water
- **weather:** temporary state of the atmosphere in a given area, such as its temperature and humidity

Teaching Strategies

Introducing the Lesson

Introduce the atmosphere by placing it in context as one of Earth's four geospheres: lithosphere (solid rocky Earth), biosphere (living things on Earth), hydrosphere (Earth's waters), and atmosphere (body of air surrounding the planet). Tell students they will learn about Earth's atmosphere in this chapter.

Demonstration

Demonstrate air pressure with a simple but effective activity. Do demonstration #26, “Stubborn Paper Wad,” at the following URL. In the demonstration, you will place a bottle on its side on a table, put a pea-sized wad of paper just inside the mouth of the bottle, and blow hard and fast into the bottle. The paper wad should fly out of the bottle toward you (adjust wad placement and degree of blowing if necessary). Ask students to explain why this happens. (It occurs because the rapidly moving air goes past the wad and strikes the bottom and sides of the bottle, increasing air pressure inside the bottle. Air suddenly rushes out of the bottle to equalize the pressure, and it pushes the wad out with it.)

http://www.colorado.edu/geolsci/courses/DEMOS/seicontribution/101_lowtech_earth_science%20demos.pdf

Differentiated Instruction

Have students make a cluster diagram of the significance of the atmosphere. It should include the following ways the atmosphere is important:

- Atmospheric gases are needed by living organisms for photosynthesis and respiration.
- The atmosphere is a crucial part of the water cycle.
- The ozone layer protects living things from harmful UV radiation.
- The atmosphere keeps Earth's temperature moderate.
- Gases in the atmosphere carry sound waves and allow us to hear.

Enrichment

Suggest that curious students do a Web quest to answer these questions: What is the “Goldilocks principle”? How does this principle apply to Earth's atmosphere? Some useful references are supplied below. They should share their answers with the class.

- <http://curiosity.discovery.com/question/what-is-goldilocks-principle>
- <http://www.windows2universe.org/earth/interior/Goldilocks.html>

Science Inquiry

With the teacher-developed inquiry activity at the URL below, students will construct a cumulative graph and then draw connections between the amounts of atmospheric gases and changes in life patterns on Earth.

<http://betterlesson.com/lesson/5027/02-atmosphere-and-living-things>

Overcoming Misconceptions

Studies have identified several student misconceptions about air pressure, a few of which are listed below. Think of a counter-example for each misconception that shows the misconception is false.

- Air exerts pressure only when it is flowing (as in wind).
- Gases flow just like liquids, so they can be unevenly distributed in a container.
- Gases exert pressure only if they undergo a force or are heated.
- Gases exert pressure in only one direction (usually down).
- Air pressure is not the same in all directions.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 15.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 15.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 15.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How would Earth be different if it did not have an atmosphere?

What are the most important components of the atmosphere?

How does the atmosphere vary with altitude?

15.3 Lesson 15.2: Atmospheric Layers

Key Concepts

- Air temperature
- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere
- Ionosphere
- Magnetosphere
- Exosphere

Lesson Objectives

- List the major layers of the atmosphere and their temperatures.
- Discuss why all weather takes place in the troposphere.
- Discuss how the ozone layer protects the surface from harmful radiation.

Lesson Vocabulary

- **aurora:** spectacular light display that occurs in the ionosphere near the poles when charged particles from solar storms energize oxygen and nitrogen molecules in the atmosphere
- **exosphere:** outermost layer of the atmosphere where gas molecules are extremely far apart
- **inversion:** situation in which warm air lies above cold air
- **ionosphere:** layer of ions within the thermosphere
- **magnetosphere:** charged particles beyond the atmosphere that are held in place by Earth's magnetic field
- **mesosphere:** layer of the atmosphere that lies between the stratosphere and the thermosphere and where temperature decreases with increasing altitude
- **ozone layer:** layer within the stratosphere where ozone gas is concentrated
- **solar wind:** high-speed protons and electrons traveling through the solar system from the sun and extending millions of kilometers out into space
- **stratosphere:** layer of the atmosphere that lies between the troposphere and the mesosphere and where temperature increases with increasing altitude because of the concentration of ozone in this layer
- **temperature gradient:** change in temperature with distance
- **thermosphere:** layer of the atmosphere that lies between the mesosphere and exosphere and where temperature increases with increasing altitude
- **troposphere:** lowest layer of the atmosphere that lies between Earth's surface and the thermosphere and where temperature decreases with increasing altitude

Teaching Strategies

Introducing the Lesson

Use the teacher-made rap at the URL below to introduce layers of the atmosphere. The rap uses a familiar tune from Kanye West. It repeats the names of the layers in the refrain and describes a few features of each layer in the verses.

<http://www.watchknowlearn.org/Video.aspx?VideoID=26842&CategoryID=2666>

Activity

Have students do the very informative interactive activity at the following URL to learn about the layers of the atmosphere.

<http://www.watchknowlearn.org/Video.aspx?VideoID=46675&CategoryID=2666>

Differentiated Instruction

Suggest that students make a compare/contrast table for atmospheric layers. Have them use the following table headings: Name of Layer, Temperature Gradient, and Distinguishing Feature(s). For example, for the troposphere, temperature decreases and a distinguishing feature is that all weather takes place in this layer.

Enrichment

Ask a few students to investigate the effects of the hole in the stratospheric ozone layer on living things. They can start with the URL below. Ask them to make a poster or Web page to illustrate the concepts.

- <http://www.epa.gov/ozone/science/effects/>
- <http://www.eco-action.org/dt/ozone.html>
- <http://www.theozonehole.com/askthescientist.htm>

Science Inquiry

Show students how changing air temperature affects air pressure with the simple demonstration “The Collapsing Bottle” (demonstration #37 at the URL below). You will half fill a plastic bottle with hot water, empty the bottle, and then immediately place the cap on it. Students will observe that the bottle soon collapses. Challenge them to explain why this happens. (The hot water heats the air inside the bottle. After the bottle is emptied and capped, the air inside cools, takes up less space, and exerts less pressure on the inside of the bottle. The greater air pressure outside the bottle causes it to collapse.) Challenge students to relate their observations and explanation to the behavior of air in the atmosphere when it is heated or cooled.

http://www.colorado.edu/geosci/courses/DEMOS/seicontribution/101_lowtech_earth_science%20demos.pdf

Real-World Connection

Tell the class about the Montreal Protocol, a 1987 international agreement with the intention of limiting production of CFCs, the major cause of depletion of the stratospheric ozone layer. You (or your students) can learn more, including how CFCs deplete ozone and how effective the agreement has been, at the following URLs.

- http://ozone.unep.org/new_site/en/montreal_protocol.php
- <http://www.environment.gov.au/atmosphere/ozone/legislation/montp.html>
- <http://www.theozonehole.com/montreal.htm>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 15.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 15.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 15.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How does solar energy create the atmosphere's layers?

How does solar energy create the weather?

What would happen to life on Earth if there was less ozone in the ozone layer?

15.4 Lesson 15.3: Energy in the Atmosphere

Key Concepts

- Energy, temperature, and heat
- Energy from the sun
- Seasons on Earth
- Heat transfer in the atmosphere
- Heat at Earth's surface
- Greenhouse effect

Lesson Objectives

- Describe how energy is transmitted.
- Describe Earth's heat budget and what happens to the sun's energy.
- Discuss the importance of convection in the atmosphere.
- Describe how a planet's heat budget can be balanced.
- Describe the greenhouse effect and why it is so important for life on Earth.

Lesson Vocabulary

- **albedo:** measure of the amount of light that reflects off a surface
- **electromagnetic wave:** wave with both electric and magnetic properties that can travel through space by radiation
- **greenhouse effect:** trapping of heat in Earth's atmosphere by greenhouse gases, which absorb heat that radiates from Earth's surface
- **insolation:** amount of solar radiation striking a given area over a given period of time
- **insulation:** material that inhibits conduction of heat or electricity
- **latent heat:** energy absorbed or released when a substance changes state
- **reflection:** change in direction of a wave at the surface of a new medium so that the wave travels back through the original medium
- **specific heat:** amount of heat needed to raise the temperature of one gram of a substance by one degree Celsius
- **temperature:** measure of the hotness of a material, which reflects how quickly its atoms are vibrating

Teaching Strategies

Introducing the Lesson

Before students read about energy in the atmosphere, help them recall what they already know about energy.

Question: What is energy?

Answer: Energy is the ability to do work or change matter.

Question: What are some different forms that energy may take?

Answer: Forms of energy include light, sound, electrical energy, and chemical energy.

Question: What is heat?

Answer: Heat is energy associated with the movement of atoms or molecules.

Tell students they will learn in this lesson where the atmosphere gets heat energy and how heat moves through the atmosphere.

Building Science Skills

Students can build their observation skills and see how the angle of the sun's rays affect their strength if you do a simple demonstration (demonstration # 36, "Comb Beams," at the URL below). Using a light source, comb, and piece of white cardboard, you will demonstrate how light rays can be spread out or concentrated to cover more or less area by changing the angle at which the rays strike the surface. Have students relate the demonstration to rays of sunlight striking Earth's surface at different angles during different times of the year. Discuss how these differences in light energy are related to the seasons.

http://www.colorado.edu/geosci/courses/DEMOS/seicontribution/101_lowtech_earth_science%20demos.pdf

Differentiated Instruction

Have students make a concept map of lesson content. Their concept map should include such concepts as energy, temperature, heat, radiation, conduction, convection, and greenhouse effect.

Enrichment

Many students erroneously think that greenhouse gases in Earth's atmosphere trap energy directly from the sun and thereby make Earth warmer than it would otherwise be. Ask one or more students to teach the class how greenhouse gases in the atmosphere actually moderate Earth's temperature (i.e., by absorbing heat that is re-radiated from Earth's surface and preventing it from escaping into space).

Science Inquiry

Have students do the first inquiry activity (Lab 1: "Heating from Below") at the following URL to investigate how convection transfers heat in the atmosphere. The activity involves increasing the temperature of water and observing the motion of a dye caused by changes in temperature and density of the water.

<http://www.woodrow.org/teachers/esi/2001/princeton/project/zerba/activities/activities.htm>

Overcoming Misconceptions

Many people think that the seasons are caused by changes in the distance of Earth to the sun. In fact, the seasons are mostly due to changes in the tilt of Earth on its axis. As explained at the following URL, misconceptions like this one, which seem logical and reasonable, are often the most difficult to correct. The URL also explains a way to demonstrate the fallacy of this particular misconception.

<http://www.badastronomy.com/bad/misc/seasons.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 15.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 15.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 15.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How does the difference in solar radiation that reaches the lower and upper latitudes explain the way the atmosphere circulates?

How does the atmosphere protect life on Earth from harmful radiation and from extreme temperatures?

What would the consequences be if Earth's overall heat budget were not balanced?

15.5 Lesson 15.4: Air Movement

Key Concepts

- Air pressure and winds
- Local winds
- Atmospheric circulation
- Global wind belts
- Polar fronts and jet streams

Lesson Objectives

- List the properties of the air currents within a convection cell.
- Describe how high and low pressure cells create local winds and explain how several types of local winds form.
- Discuss how global convection cells lead to the global wind belts.

Lesson Vocabulary

- **advection:** horizontal movement of fluid, such as the horizontal flow of air in the troposphere
- **Chinook wind (Foehn wind):** wind that blows when low pressure draws air over a mountain range
- **haboob:** desert sandstorm that forms in the downdrafts at the front of a thunderstorm
- **high pressure zone:** region where relatively cool, dense air is sinking to the surface
- **jet stream:** fast-flowing “river” of air at the top of the troposphere where air masses with very different temperatures and humidities move past each other
- **katabatic wind:** wind that flows down a slope
- **land breeze:** local wind that blows from land to sea in the winter when the land is cooler than the sea
- **low pressure zone:** region where relatively warm, light air is rising above the surface
- **monsoon:** local wind that blows from sea to land in summer and from land to sea in winter where very hot lands are located next to the sea
- **mountain breeze:** wind that blows from a mountain to a valley at night when mountain air cools off more quickly than air in the valley
- **polar front:** boundary between cold continental air and warmer subtropical air that occurs at about 50 °N and 50 °S latitude
- **rain shadow:** location on the leeward side of a mountain range where very little rain falls due to dry descending air
- **Santa Ana wind:** hot, dry wind that blows east to west across Southern California in the fall and winter
- **sea breeze:** local wind that blows from sea to land in the summer when the sea is cooler than the land
- **valley breeze:** uphill flow of air that occurs when warm air rises and draws cool air up from a valley

Teaching Strategies

Introducing the Lesson

Generate student interest in the lesson with a simple demonstration (demonstration #22, “Pop Top” at the URL below). You will place a wet cap upside down on top of an empty plastic pop bottle and then simply hold the bottle. The cap will eventually “jump” off the bottle because the heat of your hands will warm the air in the bottle, causing it to expand and knock off the bottle cap. Challenge students to explain what happens. Accept all reasonable responses at this point, and then tell students they will learn the correct explanation when they read this lesson.

http://www.colorado.edu/geolsci/courses/DEMOS/seicontribution/101_lowtech_earth_science%20demos.pdf

Activity

The high-speed winds of jet streams, found near the top of the troposphere, play a major role in guiding weather systems. Many factors, including Earth’s rotation and the sun’s uneven heating of Earth’s surface, contribute to the formation of the powerful eastward flows of the jet streams. In this interactive resource from NOVA Online, students can learn about the factors that create these powerful meteorological forces.

<http://www.watchknowlearn.org/Video.aspx?VideoID=18356&CategoryID=2666>

Differentiated Instruction

Have students make a table comparing and contrasting the different types of local winds described in the lesson. They should include the time, season, or other conditions when each wind blows and its direction.

Enrichment

Suggest that students watch the interesting video below to see how NASA is using special rockets to learn about ultra-high, super-fast winds in a part of the atmosphere that is little known and hard to study.

<http://www.watchknowlearn.org/Video.aspx?VideoID=51029&CategoryID=2666>

Science Inquiry

Use the inquiry activity at the following URL to guide students through a better understanding of global wind patterns and why they occur. The activity has both hands-on and kinesthetic components during which students will learn how winds move in global patterns and from high to low pressure systems.

http://teachingboxes.org/jsp/teachingboxes/weatherEssentials/wind/sequence/lesson4_activity1.jsp

Overcoming Misconceptions

Students may think that all air movements are from areas of higher pressure to areas of lower pressure. Make sure students understand that this principle applies only to surface winds. Explain that high-altitude winds and vertical air movements are caused by convection in the atmosphere.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 15.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 15.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 15.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How do local winds affect the weather in an area?

How do the global wind belts affect the climate in an area?

What are the main principles that control how the atmosphere circulates?

CHAPTER **16**

HS TE Weather

Chapter Outline

- 16.1 CHAPTER 16: WEATHER
 - 16.2 LESSON 16.1: WEATHER AND ATMOSPHERIC WATER
 - 16.3 LESSON 16.2: CHANGING WEATHER
 - 16.4 LESSON 16.3: STORMS
 - 16.5 LESSON 16.4: WEATHER FORECASTING
-

16.1 Chapter 16: Weather

Chapter Overview

This chapter describes weather and weather factors, such as types of clouds and precipitation and movement of air masses. It also explains how different types of storms develop and how meteorologists forecast weather, including the use of various tools, maps, and models.

Online Resources

See the following Web site for an appropriate laboratory activity:

With the online Weather Lab at the following URL, students can create their own weather instruments and then use them to gather weather data in several different experiments. A weather data sheet is included so students can record data for all of their experiments.

- http://teacher.scholastic.com/activities/wwatch/gather_data/

These Web sites may also be helpful:

At the following URL, you can connect with five lessons plans to teach weather-related topics to your student. Included are classroom activities and real-time data investigations to study factors that affect weather.

- <http://ciese.org/curriculum/weatherproj2/en/index.shtml>

You can find a large collection of weather-related games and simulations at this URL: <http://spark.ucar.edu/longcontent/games-sims-weather-climate-atmosphere>.

The URL below provides 10 satellite meteorology learning modules for middle and high school students that include exciting activities and hands-on tools for investigation, inquiry, and analysis.

- <http://cimss.ssec.wisc.edu/satmet/index.html>

Go to this URL for a wide variety of teaching resources relating to weather and the atmosphere: http://www.education.noaa.gov/Weather_and_Atmosphere/.

At the following URLs, you can access lesson plans and activities in the National Weather Service's Jetstream Online Weather School.

- <http://www.srh.noaa.gov/jetstream/append/lessonplans.htm>
- http://www.srh.noaa.gov/jetstream/append/coolstuff_matrix.htm

Pacing the Lessons

TABLE 16.1: short caption

Lesson	Class Period(s) (60 min)
16.1 Weather and Atmospheric Water	1.5
16.2 Changing Weather	1.5
16.3 Storms	2.5
	16.4 Weather Forecasting 2.0

16.2 Lesson 16.1: Weather and Atmospheric Water

Key Concepts

- Weather vs. climate
- Clouds
- Fog
- Precipitation

Lesson Objectives

- Discuss the difference between weather and climate.
- Describe the relationship between air temperature and humidity, including the concept of dew point.
- List the basics of the different cloud types and what they indicate about current and future weather.
- Explain how the different types of precipitation form.

Lesson Vocabulary

- **cloud:** cluster of water droplets or ice crystals that have condensed in the atmosphere
- **dew point:** temperature at which air is saturated with water so it has 100 percent relative humidity
- **relative humidity:** amount of water vapor in the air relative to the maximum amount of water vapor that air could hold at that temperature

Teaching Strategies

Introducing the Lesson

Introduce weather by astounding students with a description of the largest hailstone ever recovered in the United States. The monster hailstone fell in Aurora, Nebraska, in June of 2003. It measured 17.8 cm (7 in) in diameter, making it almost as large as a soccer ball. The hailstone is now at the National Center for Atmospheric Research in Boulder, Colorado, where it will be preserved indefinitely. Tell students they will learn how hailstones form when they read this lesson.

Activity

In the activity at the following URL, students will produce a cloud in a jar and observe the effect of adding a small amount of nuclei (smoke) on the formation of the cloud.

http://www.srh.noaa.gov/jetstream/clouds/ll_smoke.htm

Demonstration

Show the class the ability of the wind to suspend rain and hail in clouds by doing the simple demonstration described at the URL below. You will suspend a ping pong ball in the stream of air supplied by a hair dryer to demonstrate how hail is supported in thunderstorms.

http://www.srh.noaa.gov/jetstream/tstorms/ll_updrafts.htm

Differentiated Instruction

Humidity may be a difficult concept for some students to grasp because it measures something that is invisible: water vapor. Tell students to make a Frayer model for the concept of humidity. They should draw a large box and divide it into four parts, labeled “Definition,” “Drawing,” “Example,” and “Non-example.” Then they should fill in each part of the box for humidity. Ask pairs of students to compare and discuss each other’s Frayer models.

Enrichment

Suggest that interested students learn more about fog with a Web quest. Have them use the Internet to find answers to the three questions listed below. Ask them to share what they learn with the class.

1. What conditions lead to the formation of fog?
2. Where are some of the foggiest places in the world?
3. How does fog cause problems for people?

Science Inquiry

Divide the class into groups, and assign a different type of cloud to each group. Have students within each group collaborate to make a three-dimensional model of their assigned cloud type. They might use materials such as cotton puffs or tissue paper for their models. Urge them to be creative while accurately representing basic features of their cloud type. Give groups a chance to show their models to the class, and then put the models on display in the classroom. Students can refer to them as they continue to learn about weather in this chapter.

Overcoming Misconceptions

Students may have misconceptions about humidity. Two are listed below. Discuss with the class why each misconception is false.

- Humidity is moisture (i.e., liquid water) in the air. [No; humidity is the amount of water vapor in the air.]
- Humid air is denser (heavier) than dry air. [No; humid air is actually less dense than dry air because the molecular weight of water is less than the molecular weight of dry air.]

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 16.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 16.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 16.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

When thinking about the weather, what factors do you consider important?

How do air temperature, humidity, and pressure differences create different weather?

Think about the types of weather described in this lesson. Imagine types of weather that you have not experienced; look at photos, and ask friends and relatives who've lived in other places what their weather is like.

16.3 Lesson 16.2: Changing Weather

Key Concepts

- Air mass formation and movement
- Types of fronts

Lesson Objectives

- Describe the characteristics of air masses and how they get those characteristics.
- Discuss what happens when air masses meet.
- List the differences between stationary, cold, warm, and occluded fronts.

Lesson Vocabulary

- **air mass:** large body of air with about the same temperature and humidity throughout
- **cold front:** boundary between two air masses in which a cold air mass pushes a warm air mass upward
- **front:** boundary that forms where two air masses with different characteristics meet
- **occluded front:** front that forms when a cold front overtakes a warm front, so a warm air mass is trapped between two cold air masses
- **squall line:** line of thunderstorms that forms at the edge of a cold front
- **stationary front:** boundary between air masses that are stalled in the same place
- **warm front:** boundary between two air masses in which a warm air mass replaces a cold air mass

Teaching Strategies

Introducing the Lesson

Show the class an example of a weather map that shows one or more fronts. The last figure in this FlexBook® lesson is a good example. Point out the front lines on the map, and ask students if they know what they represent. As necessary, explain that the lines represent fronts, which are boundaries where large masses of air meet. Tell students they will learn about air masses and fronts and why they are important when they read this lesson.

Cooperative Learning

Students can work collaboratively to learn about the four different types of fronts. Divide the class into groups of four students each, and have each student in the group research a different type of front. Students should learn how

their front forms, the type of weather associated with it, and how it is represented on a weather map. After they collect the information, have students meet again as a group and share what they learned with group members.

Differentiated Instruction

Pair English language learners and less-proficient readers with other students, and ask partners to make a Venn diagram comparing and contrasting warm and cold fronts. Have pairs of students exchange and compare Venn diagrams with other pairs.

Enrichment

Students can learn more about the movement of air masses by investigating how the jet stream is related to the movement of air masses across North America. Before they start their research, have them use their current knowledge of weather and the atmosphere to develop a hypothesis for how the jet stream and air mass movement are related. You could do this step as a class or group brainstorming session. Then have students do online research to see if their hypothesis is correct. Students should write a summary of what they discover in their investigation.

Science Inquiry

Use the activity at the following URL when students learn about cold and warm fronts. In the activity, they will infer the location of cold and warm fronts on a map plotted with weather observations.

http://www.srh.noaa.gov/jetstream/synoptic/ll_analyze.htm

Overcoming Misconceptions

A relatively common misconception is that a front is a thin wall of weather. This idea may come from the way fronts are indicated by lines on weather maps. Point out that the line on a weather map that represents a front shows only the boundary between two air masses, whereas the weather associated with the front may actually extend over many miles on either side of the frontal boundary.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 16.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 16.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 16.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How do the various types of fronts lead to different types of weather?

Why are some regions prone to certain types of weather fronts and other regions prone to other types of weather fronts?

Why does the weather sometimes change so rapidly and sometimes remain very similar for many days?

16.4 Lesson 16.3: Storms

Key Concepts

- Thunderstorms
- Tornadoes
- Cyclones
- Hurricanes
- Blizzards and lake-effect snow
- Heat waves

Lesson Objectives

- Describe how atmospheric circulation patterns cause storms to form and travel.
- Understand the weather patterns that lead to tornadoes, and identify the different types of cyclones.
- Know what causes a hurricane to form, what causes it to disappear, and what sorts of damage it can do.
- Know the damage that heat waves and droughts can cause.

Lesson Vocabulary

- **anticyclone:** wind system that rotates around a high-pressure center
- **blizzard:** large snowstorm with cold temperatures, high winds, and reduced visibility because of wind-blown snow
- **cyclone:** wind system that rotates around a low-pressure center
- **heat wave:** prolonged period of excessively hot weather for a given region
- **hurricane:** large storm with high winds and heavy rains that forms from a tropical cyclone
- **lake-effect snow:** heavy snowfall caused by the evaporation of water from a relatively warm lake into a cold front that then drops the moisture as snow on the leeward side of the lake
- **lightning:** huge discharge of static electricity that typically occurs during a thunderstorm
- **mid-latitude cyclone:** cyclone that forms in the middle latitudes at the polar front
- **nor'easter:** mid-latitude cyclone storm that strikes the northeastern United States
- **thunder:** loud noise produced by lightning because the discharge of electricity causes the air to heat and expand so quickly that it explodes
- **thunderstorm:** storm caused by upwelling air and characterized by cumulonimbus clouds, lightning, and thunder
- **tornado:** rotating funnel cloud with extremely high winds that grows downward from a cumulonimbus cloud
- **tropical depression:** low-pressure cell that rises in the tropics and from which thunderstorms develop

Teaching Strategies

Introducing the Lesson

Share these facts and figures about lightning with your class to pique student interest in storms:

- At any given time, almost 2000 lightning storms are occurring in Earth’s atmosphere.
- Over the course of a year, millions of lightning storms occur.
- Each flash of lightning contains millions of volts of electricity.
- Lightning can reach temperatures as high as 54,000 °C (97,232 °F).
- Lightning can travel at the “lightning-fast” speed of 60,000 m/s (130,000 mph).

Tell students they will learn more about lightning storms and other kinds of storms when they read this lesson.

Activity

In the learning module at the following URL, students will use hands-on applets to learn about storms, including thunderstorms, hurricanes, tornadoes, and blizzards. They will also learn the role of satellites in tracking severe weather, and they will identify key features for each type of storm using satellite images.

http://cimss.ssec.wisc.edu/satmet/modules/8_wild_weather/ww-1.html

Building Science Skills

Use the learning module at the URL below to help students become better consumers of weather information and learn more about hurricanes. The Web site provides dynamic graphics, animations, and science content about remote sensing, satellite imagery, and hurricanes. As part of the module, students will apply what they’ve learned by exploring recent hurricanes through satellite imagery. After completing the module, they should be able to view satellite imagery in a typical weather forecast and recognize the importance of certain features.

<http://www.comet.ucar.edu/nsflab/web/index.htm>

Differentiated Instruction

Work with students to create a flow chart, diagram, or sketch showing how lake-effect snow occurs. It should show wind:

1. blowing across a warm lake,
2. warming and picking up water vapor,
3. cooling and producing snow when it reaches land on the leeward side of the lake.

Enrichment

Ask two or more students to collaborate on making a crossword puzzle that incorporates all of the lesson vocabulary terms. Tell them to write the clues in such a way that each missing term consists of a single word. They can make the crossword puzzle by hand or use a free online puzzle maker (see URL below). Make copies of their puzzle and hand them out to other students to complete as a review of lesson vocabulary.

<http://www.discoveryeducation.com/free-puzzlemaker/?CFID=265931&CFTOKEN=42971909>

Science Inquiry

In the activity “Severe Weather: Hurricanes!” at the URL below, teams of students will review the action of Hurricane Andrew (1992) in preparation for tracking, analyzing, and predicting the course of a new hurricane that may threaten North America this school year. Teams will check radio, television, and newspapers for reports of the next hurricane to threaten the United States. Then they will use a series of remote-sensing images from NOAA weather satellites to determine the forward speed of a current hurricane, track its course, and predict where and when it will come ashore. This activity is best done during the late summer or early fall when hurricane season is at its peak.

<http://www.cotf.edu/ete/modules/sevweath/sevweath.html>

Real-World Connection

At the following URL, students can use the National Weather Service’s (NWS) Hotseat Warning Simulator to gain an appreciation of the meteorology of severe weather events and the decision-making process that goes into NWS warnings. They will learn more about severe weather and also become more informed consumers of NWS warnings in the process.

<http://www.srh.noaa.gov/ffc/?n=hotseat>

Overcoming Misconceptions

Many people believe the misconception that lightning never strikes the same place twice. Explain to students that the most likely place for lightning to strike is the highest point in the area. Therefore, a tall building or tree is more likely to be struck—and struck again—than a low-lying point such as a ditch. Tell students that the 381-meter (1250-foot) tall Empire State Building in New York City is struck by lightning about 100 times each year. In fact, it was constructed in part to act as a lightning rod for the surrounding area.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 16.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 16.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students’ mastery of the lesson with Lesson 16.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why is predicting where tornadoes will go and how strong they will be so difficult?

How would the damage done by hurricane Katrina have been different if the storm had taken place 100 years ago?

What knowledge do meteorologists need to better understand storms?

16.5 Lesson 16.4: Weather Forecasting

Key Concepts

- Tools for collecting weather data
- Numerical weather prediction
- Weather maps

Lesson Objectives

- List some of the instruments that meteorologists use to collect weather data.
- Describe how these instruments are used to collect weather data from many geographic locations and many altitudes.
- Discuss the role of satellites and computers in modern weather forecasting.
- Describe how meteorologists develop accurate weather forecasts.

Lesson Vocabulary

- **barometer:** weather instrument that measures air pressure
- **isobar:** line on a weather map that connects points with the same air pressure
- **isotach:** line on a weather map that connects points with the same wind speed
- **isotherm:** line on a weather map that connects points with the same temperature
- **radar:** radio detection and ranging device that emits radio waves and receives them after they reflect from the nearest surface, including water droplets in the atmosphere
- **radiosonde:** group of instruments that measure atmospheric characteristics, such as temperature and humidity, as they move through the air
- **thermometer:** instrument that measures temperature
- **weather map:** map showing weather conditions over a particular area at a given time

Teaching Strategies

Introducing the Lesson

List the following weather factors on the board, and call on students to name the device that is used to measure each factor:

- temperature (thermometer)
- air pressure (barometer)

- humidity (hygrometer)
- wind speed (anemometer)
- wind direction (wind vane)
- amount of rain (rain gauge)

Students are unlikely to be able to name all of the measuring devices. Tell them they will learn the names of the other weather instruments when they read this lesson.

Demonstration

Show students the video “NEXRAD: Eye to the Sky” at the URL below. From the video, they will learn how the NEXRAD Doppler radar system works and how its data are used.

<http://www.norman.noaa.gov/2007/10/nexrad-eye-to-the-sky/>

Cooperative Learning

With the activity at the following URL, students will design and construct a rain gauge, barometer, anemometer, psychrometer, and wind vane using the materials of their choice. Assign each instrument to a different group of students to construct. Have each group use their weather instrument to monitor weather conditions at school for at least a week. At the end of the week, ask groups to explain to the class how their devices work and to share the weather data they collected.

<http://school.discoveryeducation.com/lessonplans/activities/weatherstation/>

Differentiated Instruction

Suggest that less proficient readers make a main ideas/details chart for the lesson. It will help them focus on the most important information in the lesson. They can divide a sheet of paper in half and on the left side write the main ideas and on the right side write the details supporting each main idea.

Enrichment

Tell students there are many proverbs that have long been used to help predict the weather. Some of them include:

- When dew is on the grass, rain will not come to pass.
- A morning fog that hides the sun’s ray means the coming of a clear day.
- Mackerel sky (i.e., high-level cumulus clouds), 12 hours dry.
- A wind from the west means weather’s fair; a wind from the east means foul weather’s near.
- Red sky at night, sailors delight; red sky at morning, sailors take warning.

Ask each student to select one of these proverbs and investigate the science that explains why it applies. Then have students try to come up with some of their own weather-prediction proverbs. Their proverbs can be about everyday weather, storms, or other weather phenomena. Share the following ideas with students to help them develop their proverbs:

- Air always moves from an area of high pressure to an area of low pressure.
- A bright reflection from clouds north of the sun may mean colder weather is coming, while a bright reflection from clouds south of the sun may mean warmer weather is coming.
- If air pressure is rising, fair weather is likely to be approaching; if air pressure is falling, stormy weather may be on its way.
- Warm, humid air in early spring or late fall may indicate storms will form.

Science Inquiry

Students can monitor the weather and make weather predictions with the activity “Weather or Not,” which is described at the URL below. They will pick an outdoor event, such as a sporting event, that is scheduled to take place today or within the next few days. They will use real-time images and other resources in the monitoring area to come up with a prediction of the weather, which they will share with other students. Then they will find out if their prediction was right by looking for the weather report in the locale where the event took place. They might check the weather map in a newspaper or satellite images on a TV weather report. If the event was televised, they might be able to observe for themselves what the weather was like.

<http://www.cotf.edu/ete/modules/weathernot/weathernot.html>

Overcoming Misconceptions

Students may have the misconception that weather forecasting is an exact science, or that a single exact formula or method may be used to forecast weather accurately. Have students read the article at the following URL. They will learn that weather forecasting is at best an inexact science and never easy. Because weather is so complex and variable, it requires skill, experience, and even a bit of luck to forecast the weather accurately.

<http://www.theweatherprediction.com/philosophy/conception/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 16.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 16.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students’ mastery of the lesson with Lesson 16.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

With so much advanced technology available, what is the role of meteorologists in creating accurate weather forecasts?

With so much advanced technology available, why are weather forecasts so often wrong?

What advances do you think will be necessary for meteorologists to create accurate weather forecasts one to two weeks in advance of a major weather event?

CHAPTER **17**

HS TE Climate

Chapter Outline

- 17.1 CHAPTER 17: CLIMATE
 - 17.2 LESSON 17.1: CLIMATE AND ITS CAUSES
 - 17.3 LESSON 17.2: WORLD CLIMATES
 - 17.4 LESSON 17.3: CLIMATE CHANGE
-

17.1 Chapter 17: Climate

Chapter Overview

This chapter describes factors that affect climate, the different climates found worldwide, and the causes and effects of climate change.

Online Resources

See the following Web sites for appropriate laboratory activities:

In the “Paleoclimate Reconstruction Lab” at the following URL, students will reconstruct past climates using lake varves as a proxy for temperature. They will use the data to explore and interpret long-term climate patterns and to understand annual sediment deposition as it relates to weather and climate patterns.

- <http://www.ei.lehigh.edu/eli/cc/sequence/day13.html>

With the gold-star simulation lab at the URL below, students can explore the greenhouse effect and its impact on recent climate change. Specifically, using the simulation, students will investigate how atmospheric changes affect global temperature, examine how clouds contribute to the greenhouse effect, and predict how changing greenhouse gas levels affect global temperature.

- <http://phet.colorado.edu/en/contributions/view/3092>

In the STEM lab “Exploring the Relationship between CO₂ and Temperature Using Brassica Plants,” students directly investigate the relationships between temperature and CO₂ over a period of 21 days. During days 8-14 of the experiment, students will insert a large amount of CO₂ into the system and then measure the effect this added CO₂ has on temperature. The lab requires students to develop a hypothesis about the relationship between CO₂ and temperature, analyze the data they collect, and use the data to support their conclusion in a formal report. An assessment rubric is provided.

- <http://osep.northwestern.edu/sites/default/files/ClimateChange/CO2AndTemperature.pdf>

These Web sites may also be helpful:

The URL below is one of the best online climate change resources for teachers. It includes a variety of materials for teaching about climate, climate change, and sustainability across the curriculum. You can explore tips, advice, and ideas for teaching this potentially controversial and misunderstood topic, addressing misconceptions, making interdisciplinary connections, and making the topics relevant to students’ lives.

- http://serc.carleton.edu/teachearth/site_guides/climate.html

At the following URL, you can download a climate change guide that contains information and activities relating to climate change that are suitable for grades 7–12.

- <http://dnr.wi.gov/org/caer/ce/eeek/teacher/climatechangeguide.htm>

You can access many climate change resources for teachers and students at this URL: <http://www.globalsystemsscience.org/uptodate/cc>.

At the URL below, you can find links to numerous games and simulations relating to climate.

- <http://spark.ucar.edu/longcontent/games-sims-weather-climate-atmosphere>

This guide points K-12 educators to the best sites for teaching about climate change: several that offer first-rate background material, and others that include detailed lesson plans and experiments. It begins with the top ten things people need to know about global warming and why there is so much controversy surrounding this issue.

- <http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm>

Explore best practices for teaching global climate change to high school students with these free, self-paced modules for teachers. Each module includes STEM resources that will increase your knowledge of climate change concepts and can be used directly with students.

- http://climate.nasa.gov/education/pbs_modules

Pacing the Lessons

TABLE 17.1: short caption

Lesson	Class Period(s) (60 min)
17.1 Climate and Its Causes	1.5
17.2 World Climates	2.5
17.3 Climate Change	2.5

17.2 Lesson 17.1: Climate and Its Causes

Key Concepts

- Definition of climate
- Latitude and climate
- Relationship of atmospheric circulation cells to climate
- Continental position and climate
- Ocean currents and climate
- Effects of altitude and mountain ranges on climate

Lesson Objectives

- Describe the effect of latitude on climate.
- Diagram the Hadley, Ferrell, and Polar atmospheric circulation cells, and show how they influence the climate of various locations.
- Discuss other important factors that influence a location's climate: position in the global wind belts, proximity to a large water body, position relative to a mountain range, and others.

Lesson Vocabulary

- **continental climate:** climate with extreme temperature differences due to location within a continent
- **Intertropical Convergence Zone (ITCZ):** low-pressure area at the equator where the northern and southern Hadley cells meet
- **maritime climate:** moderate climate influenced by a nearby ocean

Teaching Strategies

Introducing the Lesson

Write the following quote from American humorist Mark Twain on the board or an overhead:

Climate is what we expect, weather is what we get.

Lead the class in a discussion of how climate differs from weather starting with the quote. (“Weather is what we get” because weather consists of the actual conditions of the atmosphere on any given day. “Climate is what we expect” because climate refers to the expected weather conditions for that day and expectations are based on average weather over many years.) Tell students they will learn more about climate and how it differs from weather when they read this chapter.

Demonstration

Demonstrate atmospheric circulation cells with one or more of the animations at the following URLs.

- http://www.informmotion.biz/EarthLabs/Moving_Heat.html
- <http://higheredbcs.wiley.com/legacy/college/strahler/0471417416/animations/ch05/page6.mov>
- <http://www.geography.hunter.cuny.edu/tbw/wc.notes/7.circ.atm/animations/GlobalWind.html>
- http://kisdwebs.katyisd.org/campuses/MRHS/teacherweb/hallk/Teacher%20Documents/AP%20Biology%20Materials/Ecology/Tropical%20Atmospheric%20Circulation/50_A01s.swf
- <http://www.youtube.com/watch?v=DHrapzHPCSA>

Discussion

Discuss the relationship between atmospheric circulation cells and precipitation. Review how warm, moist air rises at the ITCZ and how cool, dry air sinks at a Hadley-Ferrell Cell boundary. Have students find these latitudes on a world rainfall map (see URL below) and identify the average annual precipitation that is found at each latitude. Call on volunteers to explain how atmospheric circulation is related to the precipitation levels.

<http://www.climate-charts.com/World-Climate-Maps.html#rain>

Differentiated Instruction

Divide the class into pairs that partner any differential learners with other students. Have each pair make a Venn diagram comparing and contrasting maritime and continental climates. Ask partners to discuss with each other why the climates differ. Then have each pair of students exchange and discuss their Venn diagrams with another pair.

Enrichment

Ask students to predict several locations in the world where they think deserts might occur because of rain shadow effect. Then have them find rainfall data for the locations to see if their predictions were correct. They should write a paragraph summarizing their predictions, the reasons for them, and whether they were supported by the data.

Science Inquiry

Have students do the inquiry activity “Local Geography and Climate” at the following URL. In the activity, students will first compare actual temperature data from coastal and inland cities in Peru. Then they will do a hands-on experiment to compare the heat capacity of soil and water. Finally, they will apply their experimental results to explain the temperature data. Links to real-time temperature data and ideas for homework extensions of the activity are included.

<http://www.ciese.org/curriculum/weatherproj2/en/activityC4.shtml>

Economics Connection

Discuss possible relationships between climate and economics with your class. Tell students that people have long observed that nations with tropical climates are generally less economically successful than those with temperate climates. Recent research offers two possible explanations for this relationship. The researchers argue that areas that have a cold winter season with annual hard frosts have an advantage for two reasons. Frost helps farmers increase agricultural productivity because it results in a buildup of organic matter in soil and produces adequate spring moisture for crops. Frost also helps control diseases, particularly malaria, because insect vectors die off in

the winter. You and/or your students can learn more by reading the summary of the research at this URL: http://www.scienceagogo.com/news/20010817233944data_trunc_sys.shtml.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 17.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 17.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 17.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Describe how two cities at the same latitude can have very different climates. For example, Tucson, Arizona, has a hot, dry desert climate and New Orleans, Louisiana, has a warm, muggy climate even though both cities are at approximately the same latitude.

How does climate influence the plants and animals that live in a particular place?

Would you expect climate at similar latitudes to be the same or different on the opposite side of the equator. For example, how would the climate of a city at 45 °N be similar or different to one at 45 °S latitude?

17.3 Lesson 17.2: World Climates

Key Concepts

- Climate zones and biomes
- Tropical moist climates
- Dry climates
- Moist subtropical mid-latitude climates
- Continental climates
- Subpolar climates
- Polar climates
- Microclimates

Lesson Objectives

- Describe the relationship between climate zones and the factors that influence climate.
- Discuss the relationship between climate zones and biomes.
- Discuss the different biomes based on a general description.

Lesson Vocabulary

- **biodiversity:** measure of the number of different species of organisms in a region
- **biome:** major climate type and the organisms that live there
- **chaparral:** scrubby, woody vegetation that grows in a Mediterranean climate
- **desert:** very dry climate with low precipitation, high evaporation, and sparse vegetation
- **ice cap:** thick layer of permanent ice found mainly in Greenland and Antarctica
- **microclimate:** local climate that differs from the major climate type of the region where it is located
- **permafrost:** sub-surface layer of permanently frozen ground in an area with a polar climate
- **savanna:** tropical wet and dry biome characterized by grasses and widely scattered deciduous trees
- **steppe:** mid-latitude, semi-arid desert biome characterized by bunch grasses, scattered low bushes, and sagebrush
- **taiga:** coniferous forest that grows in a subpolar continental climate
- **tropical rainforest:** wet tropical biome characterized by abundant broadleaf evergreen trees and great biodiversity
- **tundra:** polar climate biome characterized by small plants such as mosses and no trees

Teaching Strategies

Introducing the Lesson

Introduce types of world climates by asking students what type of climate they have in their area. (Students might identify their climate as temperate, rainy, or in some other descriptive way but are unlikely to know their climate's classification). Give students the name of the type of climate where they live and tell them they will learn more about this and other types of climates when they read this lesson.

Cooperative Learning

Divide the class into five groups, and assign each group one of the major world climates described in the FlexBook® lesson: tropical moist climate, dry climate, moist subtropical mid-latitude climate, continental climate, and polar climate. Ask students in each group to collaborate on researching and creating a poster or brochure about their climate type. They should include climate sub-types, locations, typical organisms, and average weather conditions for their major climate type. Schedule a block of class time for groups to present their work to the rest of the class.

Using Visuals

When you discuss tropical moist (group A) climates with the class, call their attention to the images in the FlexBook® lesson that illustrate the diversity of climates within this group. Point out the tropical rainforest and African savanna pictures in the text. Call on students to explain why the biomes are so different when they are both located at or very near the equator. (The main difference is the amount and timing of precipitation.) Use this example as a way to make the point that all of the major climate groups have climate sub-types that may be quite variable.

Differentiated Instruction

The sheer amount of detail, with the descriptions of all the climate sub-types in this lesson, may be overwhelming for some students. Work with them to make a compare/contrast table for just the major climate groups (groups A–E). They should compare the climate groups with regard to temperature, precipitation, typical vegetation, and location.

Enrichment

Define microclimate and then challenge students to think about and write answers to these questions:

1. How small is a microclimate? (Microclimates can be as small as a few square centimeters or as large as several square kilometers.)
2. What is an example of a small microclimate? (*Sample answer:* A small area on the north side of rock that is usually shaded may have a cooler microclimate than an area just a few centimeters away.)
3. Would you expect to find microclimates in cities? (Cities can produce a wide variety of microclimates due to concrete acting as a heat sink and tall buildings creating wind tunnels.)

Science Inquiry

Hold a class discussion of the value of classification in scientific inquiry. Begin the discussion by asking students why they think it is important for scientists to classify climate. Then extend the discussion to classification in general. Points that might be made include the following:

- When scientists classify things, whether it is organisms or climates, they group similar things together.
- Scientists use classification to organize information and objects.
- Classification systems help scientists make sense of the world around them. (The world would be a chaotic place if we didn't have a way of organizing things.)
- When things are sorted into groups, it makes them easier to understand.
- Classifying things also makes it easier to see the relationships between them.

Overcoming Misconceptions

Many students may have the misconception that all deserts are hot. They have probably seen pictures of deserts such as the Sahara Desert, which is hot as well as very dry and sandy because it is relatively close to the equator. In actuality, deserts do not have to be in hot climates. An area is classified as a desert based on the amount of precipitation it receives. Deserts are also located at higher latitudes, and these deserts are not hot, at least not all of the time, and may be quite cold at times, especially at night.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 17.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 17.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 17.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why aren't biomes always determined by latitude? What geographic features or other factors affect the climate?

Climate zones and biomes depend on many climate features. If climate changes, which of these features changes too?

If global warming is increasing average global temperatures, how would you expect biomes to be affected?

17.4 Lesson 17.3: Climate Change

Key Concepts

- Climate change in Earth's history
- Short-term climate changes
- Causes of long-term climate change
- Global warming

Lesson Objectives

- Describe some ways that climate change has been an important part of Earth history.
- Discuss what factors can cause climate to change and which of these can be exacerbated by human activities.
- Discuss the consequences of rising greenhouse gas levels in the atmosphere, the impacts that are already being measured, and the impacts that are likely to occur in the future.

Lesson Vocabulary

- **El Niño:** natural, short-term climate variation in which the trade winds weaken or reverse directions and warm water accumulates on the surface of the Pacific Ocean off South America
- **global warming:** recent increase in Earth's average atmospheric temperature mainly due to human actions, especially the burning of fossil fuels
- **La Niña:** natural, short-term climate variation in which the trade winds are stronger than normal and cold water comes to the surface of the Pacific Ocean off South America
- **Milankovitch cycle:** 100,000-year cyclic change in Earth's position relative to the sun that affects Earth's global climate
- **slash-and-burn agriculture:** method of clearing land for farming, in which trees are cut and burned on the ground to make way for planting crops; occurs commonly in tropical rainforests
- **sunspot:** cool, dark area on the sun's surface that has a lower temperature than surrounding areas

Teaching Strategies

Introducing the Lesson

Providing students with some facts about recent and projected global climate trends and their predicted consequences is a good way to engage students in issues relating to climate change. First tell students that scientists predict that Earth's average temperature will rise from 2 to 4 degrees Celsius in the current century. Explain that a temperature increase of this magnitude may seem insignificant, but it would actually have catastrophic consequences. For example:

- Island states such as the Maldives would suffer major storm surges and rising sea levels that could cause many of the islands to disappear.
- Millions more people could experience coastal flooding each year.
- Some kinds of food productivity would decrease at low latitudes, and growing numbers of people in the poorest countries would suffer from malnutrition and serious diseases.
- Up to 30 per cent of all species would be at increasing risk of extinction.
- Water supplies to hundreds of millions of people would be in jeopardy.
- Climate^[U+2010]related natural disasters—such as serious floods, droughts, and hurricanes—would increase in number and severity, affecting hundreds of millions of people.
- The amount of money required to deal with climate^[U+2010]related disasters would skyrocket.

Tell students they will learn more about these and other consequences of climate change, as well as the causes of climate change, when they read this lesson.

Building Science Skills

Have students do the activity “Track Your School’s Climate Impact” at the URL below. With the activity, students can investigate the link between everyday actions at their high school, greenhouse gas emissions, and climate change. Using EPA’s Climate Change Emission Calculator Kit (Climate CHECK), students can learn about climate change, estimate their school’s greenhouse gas emissions, and identify ways to mitigate their school’s climate impact. Students will gain detailed understandings of climate-change drivers, impacts, and science; and produce an emission inventory and action plan. They can even submit the results of their emission inventory to their school district. In addition, they can compare the energy use of their school with other schools nationwide, and they can earn the ENERGY STAR for their school if it qualifies as a top performer.

<http://www.epa.gov/climatechange/wycd/school.html>

Activity

Students can learn more about El Niño with the data-based activity at the following URL. In the activity, they will read an article, gather and analyze online data, and make predictions about the occurrence and economic impacts of El Niño based on their data.

<http://www.oar.noaa.gov/k12/html/elnino2.html>

Differentiated Instruction

Suggest that students outline the lesson to organize the information and focus on the most important points. They can use the headings in the lesson as their main outline entries and then add important details under each heading.

Enrichment

Challenge your more advanced students with the activity at the URL below. The activity is designed to give students an understanding of carbon capture and sequestration (CCS). Students will read three articles from which they will extract information on CCS and the pros and cons of different techniques. In the activity assessment, students will be presented with a conflicting viewpoint passage, similar to those found on college-admissions tests such as the ACT. The summation of the activity is a writing assignment in which students will present their own opinion on CCS and support it with information from the assigned articles or their own research.

<http://osep.northwestern.edu/sites/default/files/ClimateChange/CarbonCaptureAndSequestration.pdf>

Enrichment

If students are interested in learning more about global climate change, and especially about climate change research, direct them to the excellent and well-illustrated article at this URL: <http://www.exploratorium.edu/climate/index.html>.

Science Inquiry

The document below provides a set of three inquiry activities that allow students to investigate the chemistry of climate change. The focus is on the effects of pollution on the greenhouse effect and global climate change. Students will identify sources of air pollution and solutions to air pollution. They will also distinguish between natural and human-caused sources of air pollution. In addition, students will calculate the weight of various pollutants and visualize the amount of air pollution emitted by a car each year.

<http://dnr.wi.gov/org/caer/ce/eek/teacher/Climateguide/pdf/02-2629-chemistry.pdf>

Overcoming Misconceptions

People commonly think that weather anomalies can be used as evidence for or against climate change. Explain to your class that there is a link between climate change and weather, but any particular weather event cannot “prove” that climate change is happening. Instead, an important source of evidence for climate change comes from observations that average weather has changed for a region. You can find additional misconceptions about climate change at these URLs:

- <http://cires.colorado.edu/education/outreach/climateCommunication/CC%20Misconceptions%20Handout.pdf>
- <http://www.c2es.org/publications/realities-vs-misconceptions-about-science-climate-change>

Real World Connection

Have students do the activity “Climate Change Causes and Alternative Energy Solutions,” which you can access at the following URL. The main goal of the activity is to help students better understand the current energy crisis and options available to help mitigate the problem. Students will learn why curbing and controlling the damage is so difficult financially and socially. Also, by studying the causes and effects of climate change, students will realize changes they can make in their own lives, no matter how small, to help decrease their carbon footprint.

<http://osep.northwestern.edu/sites/default/files/ClimateChange/AlternativeEnergyProject.pdf>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 17.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 17.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 17.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Nearly all climate scientists agree that human activities are causing the accelerated warming of the planet that we see today. Why do you think that the media are still talking about the controversy about this idea when scientists are almost entirely in agreement?

If greenhouse gas emissions must be lowered to avoid some of the more serious consequences of global warming, why have humans not done something to lower these emissions instead of letting them increase?

In what ways can progress be made in reducing greenhouse gas emissions? Think about this on a variety of scales: for individuals, local communities, nations, and the global community.

CHAPTER

18

HS TE Ecosystems and Human Populations

Chapter Outline

- 18.1 CHAPTER 18: ECOSYSTEMS AND HUMAN POPULATIONS
 - 18.2 LESSON 18.1: ECOSYSTEMS
 - 18.3 LESSON 18.2: THE CARBON CYCLE AND THE NITROGEN CYCLE
 - 18.4 LESSON 18.3: HUMAN POPULATIONS
-

18.1 Chapter 18: Ecosystems and Human Populations

Chapter Overview

This chapter describes ecosystems and explains how matter and energy flow through ecosystems. It also describe how the human population has grown and how it affects our global ecosystem

Online Resources

See the following Web sites for appropriate laboratory activities:

In the lab “Night Creatures of the Kalahari” (see URL below), students will investigate predator-prey relationships in spiders and fruit flies. They will create a set of food chain chambers (one control chamber and three chambers in which variables have been altered). Then they will make predictions and record observations for each chamber. After the lab, students will relate the chambers to real-life situations.

- http://www.pbs.org/wgbh/nova/education/activities/2501_kalahari.html

When students learn about the carbon cycle in Lesson 18.2, “Cycles of Matter,” have them do the lab “The Oceans: Carbon Sink or Carbon Source?” at the following URL. First, students will learn how the oceans "absorb" carbon by biological and physical processes. Then, they will focus on biological processes by investigating the role of phytoplankton in the carbon cycle and analyzing conditions and locations for the growth of phytoplankton. They will also view seasonal and decadal changes in phytoplankton populations using a visualization from the NASA SeaWiFS satellite program. After completing the lab, students should be able to describe the biological and physical processes that make the ocean a carbon sink, describe the role of phytoplankton in maintaining the ocean biological carbon pump, and use systems thinking to predict the causal effects of warmer water on the biological carbon pump.

- <http://serc.carleton.edu/eslabs/carbon/lab6.html>

These Web sites may also be helpful:

At this URL, you can find a large collection of teacher-approved videos about ecosystems, biomes, and populations.

- <http://www.neok12.com/Ecosystems.htm>

For more information and many links on ecosystems, biomes, and habitats, go to this URL: <http://www.fi.edu/tfi/units/life/habitat/>.

A more sophisticated overview of cycles of matter, including some cycles not covered in the chapter, is available here:

- <http://www.lenntech.com/matter-cycles.htm>

You can find an excellent educator’s guide to cycles of matter and the flow of energy through ecosystems at the following URL.

- <http://astroventure.arc.nasa.gov/teachers/pdf/AV-Biolesson-6.pdf>

At these URLs, you can access high school activities relating to the human population:

- http://www.worldof7billion.org/teacher_resources
- http://education.nationalgeographic.com/education/collections/population-7-billion/?ar_a=1

Pacing the Lessons

TABLE 18.1: short caption

Lesson	Class Period(s) (60 min)
18.1 Ecosystems	2.0
18.2 Cycles of Matter	2.0
18.3 Human Populations	2.5

18.2 Lesson 18.1: Ecosystems

Key Concepts

- Ecosystems and communities
- Roles in ecosystems
- Flow of energy in ecosystems
- Flow of matter in ecosystems

Lesson Objectives

- Discuss the importance of chemical and physical factors to living organisms.
- Describe the role of different species in an ecosystem.
- Describe the function of an ecosystem, and how different species fill different roles in different ecosystems.
- Describe energy transfer from the lowest to the highest trophic level in a food chain, including energy loss at every trophic level.
- Discuss how materials are cycled between trophic levels and how they can enter or leave a food web at any time.

Lesson Vocabulary

- **abiotic factor:** nonliving feature of an ecosystem, such as space, air, or water
- **biotic factor:** living feature of an ecosystem, such as a plant or an animal
- **carnivore:** type of consumer that eats only animals
- **commensalism:** relationship between organisms of different species in which one organism benefits and the other organism neither benefits nor is harmed
- **community:** all the populations of all the species in a particular ecosystem
- **competition:** relationship between organisms of different species that are both trying to obtain the same resources
- **consumer:** type of organism that uses other organisms for food
- **decomposer:** type of organism that breaks down the tissues of dead organisms or the wastes of living things and releases their nutrients to the environment
- **ecosystem:** community of living things and their environment
- **food chain:** simple model showing one pathway of energy through an ecosystem that includes a producer and one or more consumers
- **food web:** complex model that shows intersecting pathways of energy through an ecosystem
- **habitat:** place where a given organism is best suited to live
- **herbivore:** type of consumer that eats only plants
- **mutualism:** relationship between organisms of different species in which both organisms benefit
- **niche:** a species' particular "job" in an ecosystem
- **nutrient:** nonliving matter that organisms need to live and grow

- **omnivore:** type of consumer that eats both plants and animals
- **parasitism:** relationship between organisms of different species in which one organism benefits and the other organism is harmed.
- **population:** all the individuals of a species that live in the same place at the same time
- **predator:** animal that kills and eats other animals called prey
- **prey:** animal that is killed and eaten by a predator
- **producer:** type of organism that uses energy to make food for itself and other organisms by photosynthesis or chemosynthesis
- **scavenger:** type of consumer that eats animals that are already dead
- **species:** unique group of organisms that can interbreed and produce fertile offspring together but not with members of other such groups
- **symbiosis:** any relationship between organisms of different species in which at least one of the organisms benefits; mutualism, commensalism, or parasitism
- **trophic level:** energy level in a food chain or food web, such as producer, primary consumer, or secondary consumer

Teaching Strategies

Introducing the Lesson

The term ecosystem is likely to be familiar to most if not all of your students from previous science classes. Introduce ecosystems with a word association game. Call on each student in turn to say the first word that comes to mind when they hear the term ecosystem. Continue around the room until no new words are forthcoming. (Possible words might include species, niche, environment, and food chain.) Tell students they will learn about ecosystems and related concepts when they read this lesson.

Building Science Skills

The activity at the following URL is a good one for introducing students to communities and ecosystems. Students will list familiar organisms found in several different communities, distinguish between producer and consumer organisms in their list, and then examine and identify as many organisms as possible in a soil community.

<http://mypages.iit.edu/~smile/bi9115.html>

Activity

With the interactive animation at the URL below, students can explore symbiotic relationships in a coral reef ecosystem.

<http://www.pbs.org/wgbh/evolution/survival/coral/index.html>

Differentiated Instruction

Determining the meanings of unfamiliar words by analyzing word parts is an extremely helpful skill for students to develop. Point out that the word abiotic (“nonliving”) means the opposite of the word biotic (“living”). Ask students to infer the meaning of the prefix a- based on this example. (It means “not.”) Give students additional examples of words that are negated by adding the prefix a-. (e.g., moral/amoral, symmetric/asymmetric.)

Enrichment

Healthy ecosystems provide several important services, such as providing us with clean water and air and pollinating crops. Interested students can learn more about ecosystem services by reading the article at the first URL below. At the second URL below, you can find two student handouts to accompany the article. Assign one or both handouts. With the first handout, students will create a public service announcement about the importance of ecosystem services. With the second handout, they will investigate how ecosystems provide a particular service. Have students present their finished work to the class.

<http://www.actionbioscience.org/environment/esa.html>

<http://www.actionbioscience.org/environment/lessons/esalessons.pdf>

Science Inquiry

Students will analyze and graph population data for predators and prey in the activity at the following URL. The activity will give students a better understanding of the predator-prey relationship and how populations of predators and prey influence each other.

http://www.biologycorner.com/worksheets/predator_pre_graphing.html#.UcYhtoXD-M8

Overcoming Misconceptions

Misconceptions about ecosystems are common. Several are listed below (along with the correct conceptions in parentheses). Use the list as a true/false quiz, and discuss any of the misconceptions that students think are true. An effective way to dispel misconceptions is with examples that counter the misconceptions and show they are false.

1. Varying the population size of a species may not affect an ecosystem because some organisms are not important. (All organisms are important in an ecosystem. Varying a species' population size may not affect all other species equally, but it will affect the ecosystem as a whole.)
2. Ecosystems are not a functioning whole but simply a collection of organisms. (Ecosystems include not just the organisms but also the interactions between organisms and between the organisms and their physical environment.)
3. Ecosystems change little over time. (Ecosystems are always changing. They change to natural hazards, environmental changes, and human activity.)
4. Species coexist in ecosystems because of their compatible needs and behaviors; they need to get along. (Within an ecosystem, species compete for resources and feed on one another. Species live in the same ecosystem because of similar adaptations and environmental needs.)

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 18.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 18.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 18.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What happens if two species attempt to fill the same niche?

There is at least one exception to the rule that each ecosystem has producers, consumers, and decomposers. Excluding hydrothermal vents, what does the deep-sea ecosystem lack?

Where do humans fit into a food web?

Most humans are omnivores, but a lot of what we eat is at a high trophic level. Since ecosystems typically can support only a few top predators relative to the number of lower organisms, why are there so many people?

18.3 Lesson 18.2: The Carbon Cycle and the Nitrogen Cycle

Key Concepts

- Short-term cycling of carbon
- Long-term cycling of carbon
- Carbon sinks and carbon sources
- Human actions and the carbon cycle
- Importance of the carbon cycle
- The nitrogen cycle

Lesson Objectives

- Describe the short term cycling of carbon through the processes of photosynthesis and respiration.
- Identify carbon sinks and carbon sources.
- Describe short-term and long-term storage of carbon.
- Describe how human actions interfere with the natural carbon cycle.
- Describe the nitrogen cycle.

Lesson Vocabulary

- **carbohydrate:** organic compound that supplies energy to living things; sugar, starch, or cellulose
- **carbon sink:** reservoir for carbon that absorbs more carbon dioxide than it emits
- **carbon source:** reservoir for carbon that emits more carbon dioxide than it absorbs
- **deforestation:** cutting down and/or burning all of the trees in a forested area

Teaching Strategies

Introducing the Lesson

Introduce the carbon cycle by reviewing the element carbon and its properties. Show students the clever animated cartoon about carbon by NPR's Robert Krulwich at the following URL (Episode 1). Tell students they will learn more about carbon and how it cycles through ecosystems when they read this lesson.

<http://www.npr.org/news/specials/climate/video/>

Demonstration

Demonstrate the carbon cycle to your students by showing students the video “Keeping Up With Carbon” at the URL below. It provides a detailed overview of the carbon cycle and how it is being affected by human actions.

<http://www.neok12.com/php/watch.php?v=zX745f736f476a0b58005a5d&t=Carbon-Cycle>

Activity

For a deeper understanding of the carbon cycle, have students play the carbon cycle game described at the following URL. By rolling a die, students will simulate a molecule of carbon’s movement throughout various sinks and sources within the carbon cycle.

<http://www.ctenergyeducation.com/lesson.htm?id=muefmifp>

Cooperative Learning

In the "jigsaw" exercise at the URL below, each student is assigned one of five geochemical processes in the carbon cycle to research, fully understand, and then explain to others in groups of five. By the end of the activity, all of the students will know about each of the five processes and have an understanding of the entire carbon cycle.

<http://serc.carleton.edu/NAGTWorkshops/climatechange/activities/15162.html>

Differentiated Instruction

Pair students who need extra help with other students, and have partners work together to create a simple cycle diagram of the nitrogen cycle. Suggest to students that they keep their cycle diagram in their science notebook.

Enrichment

Direct students who need enrichment to the nitrogen cycle learning module at the URL below. It presents lesson content at a more advanced level and includes a self-scoring quiz that students can take for assessment.

http://www.visionlearning.com/library/module_viewer.php?mid=98&mcid=&l=

Science Inquiry

The activity described in the PDF document below is an inquiry-based approach to investigating the nitrogen cycle in a simplified desktop ecosystem involving aquaria and hydroponically grown plants. Specific learning objectives include identifying biotic and abiotic environmental components, understanding nitrogen cycling, measuring and graphing nutrient levels and plant growth, and generating hypotheses about the impact of nutrients on plant growth.

http://csip.cornell.edu/Curriculum_Resources/CEIRP/Aquaponics.pdf

Language Arts Connection

The activity at the URL below uses creative writing to improve student understanding of the nitrogen cycle. Students begin by self-assessing their knowledge of the nitrogen cycle by drawing a diagram to represent it. Then they research one nitrogen cycle component and choose three or four facts of interest about their component to report to the rest of the class. Small groups of students then use a set of small objects and cards to model a possible nitrogen

cycle, with arrows showing how nitrogen moves through the cycle. Finally, students write a limerick, haiku, or other poem to relate facts about their component of the nitrogen cycle and then share their poem with the class.

<http://serc.carleton.edu/NAGTWorkshops/health04/activities/21756.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 18.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 18.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 18.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

18.4 Lesson 18.3: Human Populations

Key Concepts

- Population carrying capacity
- Limits on population growth
- Human population growth
- Humans and the environment

Lesson Objectives

- Describe how changes in a limiting factor can alter the carrying capacity of a habitat.
- Discuss how humans have increased the carrying capacity of Earth for our species and how we may have exceeded it.
- Discuss how human activities such as agriculture and urbanization have impacted the planet.
- Describe sustainable development.

Lesson Vocabulary

- **carrying capacity:** number of individuals of a given species that a particular environment can support
- **Green Revolution:** changes in the way food is produced since World War II that have resulted in enormous increases in production
- **Industrial Revolution:** time when mass production and fossil fuel use started to grow explosively, beginning in the late 1700s in Western Europe
- **invasive species:** species of organism that spreads in an area where it is not native
- **limiting factor:** factor such as a nutrient, water, or space that limits the size of a population in an area
- **over-consumption:** use of resources to a degree that is unsustainable in the long term
- **overpopulation:** situation in which the population of an area exceeds its carrying capacity or does long-term harm to resource availability or the environment
- **pesticide:** chemical that kills a certain pest that would otherwise eat or harm plants that humans want to grow
- **sustainable development:** economic development that helps people out of poverty, uses resources at a rate at which they can be replaced, and protects the environment

Teaching Strategies

Introducing the Lesson

Have students look at the human population graph in the FlexBook® lesson, showing the size of the human population from 10,000 BC through 2000 AD. Challenge students to suggest reasons why the human population

started to increase so dramatically in the recent past. Accept all reasonable responses at this point, and then tell students they will learn how and why the human population has grown when they read this lesson.

Building Science Skills

Carbon emissions from the burning of fossil fuels contribute to global warming. Population growth, along with rapid industrialization over the past two centuries, has increased the world's carbon emissions significantly. By doing the activity at the URL below, students will be able to analyze an online simulation of carbon emissions and population change. They will also graph historical data for global population growth and carbon dioxide emissions. They will discuss the relationship between population growth and carbon dioxide emissions as well as the future implications and responsibilities that come with growing affluence around the world.

http://www.worldof7billion.org/images/uploads/generating_heat.pdf

Activity

In the interactive animation at the following URL, world maps reveal the human footprint on Earth's water, air, climate, forests, and animal habitats. The maps allow students to examine geographical connections between population growth and environmental degradation across the globe in order to answer the question: How do consumption and rapid population growth affect our planet's natural resources?

<http://www.pbs.org/wgbh/nova/earth/earth-peril.html>

Differentiated Instruction

Suggest that students make a main ideas/details chart for this lesson. Tell them to write at least one main idea for each of the lesson headings. They can write the main ideas on the left side of a sheet of paper, leaving room to fill in important details for each main idea on the right side of the paper.

Enrichment

Challenge one or more students who are especially interested in the issue of human overpopulation to read and write a book review of one of the following books on the issue:

- *Life on the Brink: Environmentalists Confront Overpopulation* (2012), by Philip Cafaro and Eileen Crist
- *Too Many People?: Population, Immigration, and the Environmental Crisis* (2011), by Ian Angus et al.
- *Full Planet, Empty Plates: The New Geopolitics of Food Scarcity* (2012), Lester R. Brown

Science Inquiry

With the activity at the following URLs, students will use the “trendalyzer” program from www.GapMinder.org to construct and interpret dynamic graphs and discuss differences in life expectancy, fertility rates, health, economics, and total population among several different countries. Examining some of the factors related to a country's economic development will help students see connections between population trends and social, environmental, and economic trends throughout the world over time.

http://www.worldof7billion.org/images/uploads/Development_in_Motion1.pdf

Overcoming Misconceptions

As a homework assignment, have students read the article about human population myths at the following URL. The next day, discuss the myths with the class. The article provides numerous examples to counter the myths and explains the faulty reasoning behind them.

<http://www.developmenteeducation.ie/blog/2012/07/5-myths-about-the-worlds-population/>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 18.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 18.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 18. Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How much impact on the planet does an infant born in the United States have during its lifetime, compared with one born in Senegal?

How does consuming less impact global warming?

Can ordinary people really make a difference in changing society toward more sustainable living?

CHAPTER **19** HS TE Human Actions and the Land

Chapter Outline

19.1 CHAPTER 19: HUMAN ACTIONS AND THE LAND

19.2 LESSON 19.1: LOSS OF SOILS

19.3 LESSON 19.2: POLLUTION OF THE LAND

19.1 Chapter 19: Human Actions and the Land

Chapter Overview

This chapter discusses how human actions have caused soil erosion and pollution of the land surface, as well as how these problems can be prevented.

Online Resources

See the following Web sites for appropriate laboratory activities:

In the soil erosion lab at the URL below, students will investigate the effect of vegetation removal on soil fertility, analyze common agricultural practices to determine their impact on soil and the environment, and predict possible effects of soil mismanagement.

- <http://www.learnnc.org/lp/pages/3701>

This lab activity will help students understand how Superfund sites are created. They will learn what activities produce hazardous waste and how contaminants are released into the environment. They will also learn what types of pollution can be cleaned up using Superfund authority and what types are addressed through other laws. In the experimental part of the lab, students will construct a model to observe how contaminants in soil enter and move through groundwater.

- http://www.epa.gov/superfund/students/clas_act/haz-ed/act02.htm

These Web sites may also be helpful:

At the following URL from the Soil Science Society of America, you can find a collection of high school teaching resources pertaining to soil.

- <http://www.soils.org/about-soils/lessons/resources>

You can find excellent photos and videos of soil erosion, including historical images from the Dust Bowl, at this URL: http://www.soilerosion.net/doc/photos_videos.html.

Two additional soil erosion videos are available here: <http://www.ewg.org/losingground/index.html>.

At the following URL, you can access Hazed teaching materials from the EPA. The materials include interdisciplinary activities that focus on scientific, technical, and policy issues relating to hazardous waste sites and the Superfund. The materials are designed to help middle and high school students develop skills in critical thinking, problem solving, and decision making. They also increase environmental awareness and encourage an environmental ethic in students.

- http://www.epa.gov/superfund/students/clas_act/haz-ed/hazindex.htm

The EPA's Environmental Response Team Video education program (see URL below) offers eight video-based modules to high school teachers. The free videos highlight real-world environmental clean-up efforts.

- <http://www.ertvideo.org/home.html>

Pacing the Lessons

TABLE 19.1: short caption

Lesson	Class Period(s) (60 min)
19.1 Loss of Soils	1.5
19.2 Pollution of the Land	1.5

19.2 Lesson 19.1: Loss of Soils

Key Concepts

- The Dust Bowl
- Causes of soil erosion
- Preventing soil erosion

Lesson Objectives

- Explain how human actions accelerate soil erosion.
- Describe ways that we can prevent soil erosion.

Lesson Vocabulary

- **leaf litter:** layer of organic debris such as dead leaves, bark, and branches that accumulate on a forest floor

Teaching Strategies

Introducing the Lesson

Bring a small sample of soil to class in a closed brown paper bag. Tell students you will give them clues about the material in the bag and they should try to identify it with as few clues as possible. Then read these clues until students correctly identify soil:

- It can take a thousand years to grow an inch.
- There are more than 70,000 kinds of it in the U.S.
- It usually consists of about 25 percent air.
- Its particles come in a range of sizes.
- Five tons of it spread over an acre forms a layer only as thick as a dime.
- Five to ten tons of animal life can live in one acre of it.
- Earthworms eat it.

Tell students they will learn why soil is being lost and how soil loss can be prevented when they read this lesson.

Activity

With the activity at the following URL, students will learn how damaging soil erosion can be to agriculture and the environment. They will also learn how to estimate the rate of soil loss in a field using the universal soil loss equation.

<http://www.edu.pe.ca/agriculture/erosion.pdf>

Differentiated Instruction

Have students do a think-pair-share activity to help them focus on the most important points in the lesson. First ask them to think about the five questions listed below. Then pair students who need extra help with other students, and ask partners to share and discuss their answers to the questions.

1. What was the Dust Bowl?
2. What caused the Dust Bowl?
3. What are the agents of soil erosion?
4. What human activities increase the chances that soil will be eroded?
5. What can people do to prevent soil erosion?

Enrichment

Ask a small group of students to do the demonstration described at the URL below. They will construct an apparatus to simulate soil erosion by water. Have them use the apparatus to demonstrate how the use of mulch reduces soil erosion. Set aside at least 10 minutes of class time for the students to present the demonstration to the class.

<http://soils.usda.gov/education/resources/lessons/experiments/erosion/>

Science Inquiry

Do the class demonstration activity in the lesson plan below. Objectives are to demonstrate that less disturbed soils contain more “soil glue” (such as the protein glomalin) so they hold together better than disturbed soils. Students will observe how well different soil samples hold together in water and make inferences about soil type and erosion. They will also conclude why it is important to disturb soil as little as possible.

http://soils.usda.gov/sqi/publications/files/soil_glue_lesson_plan.pdf

Overcoming Misconceptions

Students commonly think that all soil erosion is caused by human actions. To counter this misconception, describe examples or show photos of soil erosion due to natural causes. Explain that the soil lost due to natural erosion is balanced by the natural formation of new soil. However, human activities have increased the rate of soil erosion and thrown the natural system out of balance. You and/or your students can read more about natural causes of soil erosion and human impacts on the causes at this URL: <http://www.scienceclarified.com/EI-Ex/Erosion.html#ixzz2XY2mVtW3>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 19.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 19.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 19. Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why should soil be considered a renewable resource? Why should it be considered a non-renewable resource?

Could humans live without soil?

What can you do to help to conserve soil?

19.3 Lesson 19.2: Pollution of the Land

Key Concepts

- Love Canal
- Defining hazardous waste
- Impacts of hazardous waste
- Preventing hazardous waste pollution

Lesson Objectives

- Define hazardous waste and describe its sources.
- Describe some of the impacts of hazardous waste on human health and on the environment.
- Detail some ways that people can control hazardous wastes.

Lesson Vocabulary

- **Superfund Act:** law passed by the U.S. Congress in 1980 that holds companies responsible for cleaning up any sites they have polluted with hazardous wastes
- **Superfund site:** site where hazardous waste has been spilled and that must be cleaned up in accordance with the Superfund Act

Teaching Strategies

Introducing the Lesson

Use the two-part video at the URLs below to introduce the lesson. It is a moving and chilling history of the Love Canal disaster, which opens this FlexBook® lesson.

- <http://www.youtube.com/watch?v=PKUyOLXtUsQ>
- <http://www.youtube.com/watch?v=MXSE9kcBQCI>

Activity

Use the exercise described at the following URL when you teach your students about hazardous wastes. Students will collect reports from various media about local and national hazardous waste issues. The activity will help students appreciate the magnitude of the hazardous waste problem. A follow-up discussion allows students to explore how hazardous waste issues affect their community.

http://www.epa.gov/superfund/students/clas_act/haz-ed/news.htm

Building Science Skills

Have students do the activity “The Numbers Game” at the URL below. From the activity, they will gain an appreciation for the parts-per-million and parts-per-billion units that are used to measure contaminant concentrations in the environment. They will learn how to calculate these ratios and then apply them to a sample chemical spill to determine if cleanup action is necessary.

http://www.epa.gov/superfund/students/clas_act/haz-ed/numbers.htm

Differentiated Instruction

Suggest that students make a compare/contrast table of the different types of hazardous wastes (toxic, chemically active, corrosive, and flammable). Tell students to define, and include examples of, each type of hazardous waste in their table.

Enrichment

Have a group of students collaborate to do the role-playing activity at the following URL. They will take on roles and act out a situation that illustrates the process of decision making as it relates to cleaning up a Superfund site. Students will identify the participants in the Superfund decision-making process, make judgments about the potential effect of site cleanup on the characters they portray, and learn that different people have different perspectives on the same cleanup issues. In addition, they will practice writing statements, formulating questions, and articulating their views in a public-meeting setting. Set aside class time for a mock public meeting in which the students present their points of view and role-play the decision-making process.

http://www.epa.gov/superfund/students/clas_act/haz-ed/act09.htm

Science Inquiry

The inquiry activity at the following URL will help students understand some of the reasoning and science involved in choosing technologies for cleaning up hazardous waste sites. Students will analyze the pros and cons of different clean-up methods for specific hazardous waste problems. In their analysis, they will weigh such factors as contaminant-specific requirements, technological limitations, reliability, and cleanup time and cost.

[http://www.epa.gov/superfund/students/clas_act/haz-ed/act08.htm http://www.epa.gov/superfund/students/clas_act/haz-ed/act08.htm]

Real-World Connection

Have students do real-world research to identify and locate potential sources of hazardous waste in their neighborhood or community. In the process, they will learn what hazardous waste is and identify the potential threats it poses. The URL below outlines in detail how students should proceed with this real-world activity.

http://www.epa.gov/superfund/students/clas_act/haz-ed/act01.htm

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 19.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 19.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 19.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What are the best ways to either prevent or safely dispose of hazardous materials?

What is the effect of hazardous wastes on other living things?

Is it important for each generation to leave the world a safe place? If one generation doesn't do this, who pays the price?

CHAPTER **20** HS TE Human Actions and Earth's Resources

Chapter Outline

- 20.1** CHAPTER 20: HUMAN ACTIONS AND EARTH'S RESOURCES
 - 20.2** LESSON 20.1: USE AND CONSERVATION OF RESOURCES
 - 20.3** LESSON 20.2: ENERGY CONSERVATION
-

20.1 Chapter 20: Human Actions and Earth's Resources

Chapter Overview

This chapter describes the human use of renewable and nonrenewable natural resources, including energy resources. It also explains how resources can be conserved.

Online Resources

See the following Web sites for appropriate laboratory activities:

In the lab activity at the URL below, students will design and carry out a survey of shoppers to determine attitudes about recycling and the use of disposable products. Alternatively, students can use the table of survey results provided at the Web site to complete the lab exercise. The objective of the lab is to assess typical purchasing practices to determine the influence of packaging on consumer choices and whether consumers consider recycling and resource use when making purchasing decisions.

- <http://cwmi.css.cornell.edu/TrashGoesToSchool/HowDoOur.html>

This document provides specific experiments on bioenergy as well as a useful introduction on how to design and conduct effective science experiments.

- http://www1.eere.energy.gov/biomass/pdfs/highschool_projects.pdf

The lab “Measuring Wind Speed” on pages 168–175 in the following PDF document allows students to investigate the use of wind power for energy. Specifically, students will demonstrate an understanding of the feasibility of using wind as an energy source, construct a device to measure wind speed, calculate average wind speed, and determine whether wind provides sufficient energy to produce electricity in the local area.

- http://www.tvakids.com/teachers/pdf/renewable_high.pdf

These Web sites may also be helpful:

You can find a collection of teacher-reviewed educational games, videos, lessons, puzzles, and quizzes pertaining to natural resources at this URL: <http://www.neok12.com/Natural-Resources.htm>.

There are additional resources for teaching about natural resources at the URL below.

- <http://www.teachervision.fen.com/conservation/teacher-resources/55944.html>

For a selection of National Geographic educational content relating to natural resources, go to this URL: http://education.nationalgeographic.com/education/topics/natural-resources/?ar_a=1.

The following URL provides a collection of different types of resources relating to energy use and conservation for high school students and teachers. In addition to activities, the resources include fact sheets, a glossary, and a list of relevant Web sites for educators.

- http://www.tvakids.com/teachers/pdf/renewable_high.pdf

If you go to the URL below, you can download the U.S. Department of Energy's teachers' guide Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education.

- http://www1.eere.energy.gov/education/energy_literacy.html

The documents at the URLs below are the teacher and student pages, respectively, of 11 different activities for middle and high school students that teach students basic concepts of energy use and energy conservation. The hands-on activities allow students to explore energy sources and energy efficiency both at school and at home.

- <http://need.org/needpdf/Saving%20Energy%20Teacher%20Guide.pdf>
- <http://need.org/needpdf/Saving%20Energy%20Student%20Guide.pdf>

The teacher's "infobook" at the first URL below contains dozens of fact sheets about the major energy sources, electricity, energy efficiency, energy conservation, transportation, and emerging technologies. The second URL is a companion book of student activities that reinforce vocabulary, concepts, and facts about energy. Answer keys are provided.

- http://www.eere.energy.gov/education/pdfs/basics_secondaryenergyinfobook.pdf
- http://www.eere.energy.gov/education/pdfs/basics_secondaryenergyactivities.pdf

You can find several lesson plans on energy for high school students at this URL: <http://www.infinitepower.org/lessonplans.htm>.

Pacing the Lessons

TABLE 20.1: short caption

Lesson	Class Period(s) (60 min)
20.1 Use and Conservation of Resources	2.0
20.2 Energy Conservation	1.5

20.2 Lesson 20.1: Use and Conservation of Resources

Key Concepts

- Renewable versus nonrenewable resources
- Common materials we use from Earth
- Resource availability

Lesson Objectives

- Discuss some natural resources used to make common objects.
- Describe some ways to conserve natural resources.

Lesson Vocabulary

- **conserve:** to reduce the use of a natural resource so it will last longer
- **export:** to send a resource or product to another country
- **import:** to receive a resource or product from another country
- **timber:** trees that are cut for wood to be used for building or other purposes

Teaching Strategies

Introducing the Lesson

Introduce resource use by asking students to brainstorm a list of natural resources they typically use each day. Ask a volunteer to record their responses on the board. Tell students they will learn in this lesson how they can use fewer resources in their daily lives.

Activity

With the activity at the URL below, students will learn about the limited supply of natural resources in the world and, by role playing, understand some of the equity issues related to the use of natural resources. Specifically, they will compare lifestyles and consumption habits of rich, middle income, and poor people around the globe.

<http://www.uni.edu/ceee/sites/default/files/Education/knowresources.pdf>

Discussion

Use the lesson plan outlined at the following URL to teach students about sustainable forestry. Through a combination of lecture, questioning, and class discussion, students will learn the importance of forests as a natural resource, what silviculture is, and how it is used to sustain forests. The Web site includes lecture material and a student worksheet for assessment.

<http://ecosystems.psu.edu/youth/sftrc/lesson-plans/forestry/9-12/sustainability>

Differentiated Instruction

Suggest that students make a main ideas/details chart to help them focus on the most important ideas and supporting details in the lesson. They should draw a line down the center of a sheet of paper. On the left side of the paper, they should list the main ideas in the lesson, leaving space between each main idea to record supporting details on the right side of the paper. Tell students to include at least one main idea for each heading in the lesson. Caution them against including too many details and show them with an example how to select details that support a main idea.

Enrichment

Challenge a few students to brainstorm unique and creative ways to recycle items that are commonly thrown in the trash. Ask the students to share their ideas with the class.

Science Inquiry

The inquiry activity described below encourages students to think about where the natural resources we use come from and the processes by which these resources are extracted. Students will also consider the environmental, cultural, and human rights issues that are frequently associated with the extraction of natural resources. They will conduct Internet research on specific resources and create presentations to showcase what they have learned.

http://education.nationalgeographic.com/archive/xpeditions/lessons/16/g912/wherefrom.html?ar_a=1

Real-World Connection

Have students write a list of what they ate at their most recent meal. Then have them list the resources that went into making that meal. They should trace each item back to the original resources. For example, for a hamburger, they should trace the meat all the way back to the soil that grew the grass that was eaten by the cow. Students should include any nonfood items used in their lunch, such as paper napkins or aluminum foil wrappers, and identify resources used to make these items as well. After students write their own resource list, have them evaluate as a class which meal used the least amount of resources and which used the most. Wrap up by discussing ways to lessen the impact of food consumption on the environment.

Real-World Connection

In the lesson plan at the URL below, students will examine controversies over the use of public natural areas for economic activities (such as ranching and logging) and efforts to protect natural areas from development for future generations. Students will complete a research project on resource consumption and form their own opinions on the issue.

http://www.pbs.org/americanfieldguide/teachers/natural_areas/natural_areas_sum.html

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 20.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 20.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 20.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Could a renewable resource ever become nonrenewable?

What are some of the intangible values that a natural resource might have?

Do you think about the material and energy resources you use as you use them?

Which is more sustainable: using renewable resources or nonrenewable resources? Why?

20.3 Lesson 20.2: Energy Conservation

Key Concepts

- Obtaining energy
- Energy efficiency
- Energy conservation

Lesson Objectives

- Discuss why it takes energy to get energy and why some forms of energy are more useful than others.
- Describe some ways to conserve energy or to use energy more efficiently.

Lesson Vocabulary

- **energy efficiency:** amount of useful work that is done by a unit of energy
- **net energy:** amount of usable energy that is available from an energy resource
- **net-energy ratio:** ratio between the useful energy present in a fuel and the energy used to extract and process the fuel

Teaching Strategies

Introducing the Lesson

Ask students what the following natural resources have in common: fossil fuels, sunshine, and flowing water. (All of these natural resources can be used to produce energy.) Tell students they will learn more about energy resources when they read this lesson, including how to conserve them.

Activity

The document at the following URL is an educational guide to energy, electricity, consumption, and efficiency. The last page of the document is a home energy survey that students can use to analyze home energy use.

http://www1.eere.energy.gov/education/pdfs/power_to_the_plug_lesson.pdf

Building Science Skills

The teaching module at the URL below focuses on the science behind current and future energy technologies using an inquiry- and application-based framework. Through the use of innovative resource cards that students create themselves, students will weigh the costs and benefits of fossil fuel-based energy resources against those of alternative energy resources, including biomass, solar, geothermal, hydrogen fuel cell, and wind energy. For a final project, students will research an energy source and present it to their classmates. They will then use the information, plus all the content from class lectures and activities, to design a “Planned Community” that is an affordable and eco-friendly place to live. The overall objective is for students to develop a deep understanding not only of the conceptual science of energy but also of the technical and societal issues involved.

http://www1.eere.energy.gov/education/pdfs/acts_butterfield_energybasics_311.pdf

Differentiated Instruction

Suggest that students make an outline of the lesson. This will help them see the organization of the material and how the concepts are related. It will also help them identify the most important ideas and supporting details. Show them how to use the heading structure of the lesson for the main outline entries. They can fill in important details as they read the lesson.

Enrichment

Ask students to use online sources (such as the URLs below) to find the miles per gallon of fuel used by different means of transportation, including automobile, truck, train, plane, and boat transport. Have them make a compare/contrast table to present the results of their research to the class. Ask students to think about how they could use the information to reduce their use of energy when traveling or shipping goods.

- <http://truecostblog.com/2010/05/27/fuel-efficiency-modes-of-transportation-ranked-by-mpg/>
- http://en.wikipedia.org/wiki/Energy_efficiency_in_transportation

Science Inquiry

At the URL below, you can access inquiry activities in which students will compare two products that have the same function (in this case, providing light) but require different amounts of energy to do their job. Students will research and demonstrate energy efficiency in action and learn how it applies to different technologies. After the activities, students will understand how using less energy helps the environment and how compact fluorescent light bulbs and incandescent light bulbs differ in their efficiency and energy usage. They will also discuss other examples of energy-efficient technologies or energy-saving practices.

http://www1.eere.energy.gov/education/pdfs/efficiency_energyambassadors9-12.pdf

Overcoming Misconceptions

Students may think that the reason we are running out of energy is because energy is destroyed in many processes. Make sure students know that energy is never destroyed (or created); it only changes form. The best way to show students that energy is transformed without being lost is to have them track energy transformations in daily life. The lesson plan at the following URL allows students to track energy transformations in various modes of transportation as an example.

http://www.pbs.org/americanfieldguide/teachers/transportation/transportation_sum.html

Real-World Connection

With the activity at the URLs below, students will work in pairs or small groups to apply knowledge of energy-wise habits to evaluate energy use in their school and make recommendations for improved efficiency. Specifically, students will create an energy audit tool to collect data and present recommendations to their class. Taking their ideas to the school and district levels is encouraged.

- http://www1.eere.energy.gov/education/pdfs/efficiency_energywalkabout.pdf
- http://www.eere.energy.gov/education/pdfs/efficiency_energyauditchecklist.pdf

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 20.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 20.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 20.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If it takes energy to get energy, then what are the best choices for types of energy?

Put each of these actions in order from most to least important: choosing a sustainable form of energy, increasing energy efficiency, and conserving energy use. Explain the order you chose.

Could everyone in the world use as much energy as a person in the United States does each day? Why or why not?

CHAPTER **21** HS TE Human Actions and Earth's Water

Chapter Outline

- 21.1 CHAPTER 21: HUMAN ACTIONS AND EARTH'S WATER
 - 21.2 LESSON 21.1: HUMANS AND THE WATER SUPPLY
 - 21.3 LESSON 21.2: PROBLEMS WITH WATER DISTRIBUTION
 - 21.4 LESSON 21.3: WATER POLLUTION
 - 21.5 LESSON 21.4: PROTECTING THE WATER SUPPLY
-

21.1 Chapter 21: Human Actions and Earth's Water

Chapter Overview

This chapter describes how we use water and how water is distributed on Earth. It also outlines types and sources of water pollution and how to protect the water supply.

Online Resources

See the following Web sites for appropriate laboratory activities:

At the following URL, you can find both teacher and student lab manuals for testing water quality. Tests include temperature, pH, dissolved oxygen, phosphates, nitrates, and other indicators of water quality. Students may carry out one, some, or all of the testing procedures.

- <http://www.chebe.wsu.edu/modules/96modules/bennett/water.html>

The URL below provides several labs that allow students to explore water pollution and pollution prevention. For example, students can create and test a watershed model, determine sources of water pollution, test water quality for nutrients and nitrates, and search for nitrate pollution solutions, among other lab activities.

- <http://keec.ky.gov/NR/ronlyres/AE95BAB6-7A2D-46B9-B6CB-2248FBDAECD6/0/5WonderfulCommonwealthHS.pdf>

These Web sites may also be helpful:

This Web site provides background information on a wide variety of water topics. It also includes online activities, data tables, maps, and a glossary of terms.

- <http://ga.water.usgs.gov/edu/>

You can find a world map showing Earth's freshwater supplies by nation (as of 2000) at this URL: http://www.learner.org/courses/envsci/visual/visual.php?shortname=world_freshwater

At the following URL, you can find a variety of resources on water pollution and protection of the water supply.

- <http://www.nrdc.org/water/>

Pacing the Lessons

TABLE 21.1: short caption

Lesson	Class Period(s) (60 min)
21.1 Humans and the Water Supply	2.0
21.2 Problems with Water Distribution	1.0
21.3 Water Pollution	2.0
21.4 Protecting the Water Supply	1.0

21.2 Lesson 21.1: Humans and the Water Supply

Key Concepts

- Human uses of water
- California water resources

Lesson Objectives

- Discuss how much water is taken up by each water use.
- Explain the difference between consumptive and non-consumptive water uses.
- State the origin of California's fresh water supply.

Lesson Vocabulary

- **aquaculture:** farming in the sea or other body of water to raise fish, seafood, or aquatic plants
- **consumptive water use:** water use in which the water is lost to the ecosystem
- **drip irrigation:** using pipes and tubes with tiny holes in them to deliver small amounts of water directly to the soil at the roots of plants
- **non-consumptive water use:** water use that does not remove water from the ecosystem

Teaching Strategies

Introducing the Lesson

Introduce the lesson by leading the class in a brainstorming session of ways that people use water. Urge students to consider uses of water both inside and outside the home and also industrial and agricultural uses in addition to municipal uses. List their ideas on the board. When no new uses are forthcoming, tell students they will learn more about human uses of water in this lesson.

Activity

With the activity “Tragedy of the Water Commons” on pages 45–49 of the URL below, students will learn about the “tragedy of the commons” as it applies to the water supply. Then they will play a game to simulate use of a common water supply. Following the game, they will discuss how their experiences playing the game relate to how people use and share our common water supply.

<http://static.water.org/docs/curriculums/WaterOrg%20HighCurricFULL.pdf>

Differentiated Instruction

Have students set up and start filling in a KWL chart before they read the lesson. They should make a three-column chart with the headings “Know,” “Want to Know,” and “Learned.” Before reading, they should list things they know and want to know about humans and the water supply in the first two columns of the chart. As they read or after they complete the lesson, they should add items to the last column. Help students find any information they wanted to learn but didn’t learn when they read the lesson.

Enrichment

Suggest that interested students read and analyze the case study “Rising Tensions over the Nile River Basin: A Global Commons Case Study” on pages 38–44 of the following URL. Students will analyze the concept of a global commons as it applies to water by evaluating a primary source document describing a specific case.

<http://static.water.org/docs/curriculums/WaterOrg%20HighCurricFULL.pdf>

Science Inquiry

An important science inquiry skill is being able to identify possible biases in research literature. Raise students’ awareness of the issue by asking them to find online information about farmed vs. wild-caught fish. They might find articles on their nutritional differences, differences in contamination with toxins, and/or impacts on the environment. Tell students to try to find Web sites that present different points of view on the same issue. Then ask them to consider the sources of the information and what if any biases they might have. Use the two URLs below as examples to get them started.

- <http://www.paystolivegreen.com/2009/02/wild-salmon-vs-farmed-raised-which-is-better/>
- <http://www.salmonoftheamericas.com/oceanfarming/aquaculture.php>

Overcoming Misconceptions

Because water recycles through the water cycle, students may think that all water is “non-consumed.” Point out that consumptive and non-consumptive water use refers to the available water supply and not to all of the world’s water, most of which is not available for human use. Elaborate on the differences between consumptive and non-consumptive water use, and give students examples of each type of use to make the differences more concrete. Explain that consumptive water use occurs whenever water taken from the water supply is evaporated, transpired, lost to leakage, incorporated into products or crops, consumed by humans or livestock, transferred to another area, or otherwise removed from the immediate water source. For example, irrigation and livestock water uses are considered to be completely consumptive uses. All of the water withdrawn is evaporated or transpired, incorporated into crops, or consumed by livestock. Then explain that non-consumptive water use occurs whenever water is not removed from the water supply or is returned to the immediate water source unchanged and ready to be used again. For example, swimming and boating are completely non-consumptive uses of water. The water is neither withdrawn nor changed.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 21.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 21.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 21.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Is fresh water ever more valuable than gold or diamonds?

How can farmers and other people be encouraged to use more efficient irrigation methods?

With such abundant water resources, why do California's planners worry about the state's future water resources?

21.3 Lesson 21.2: Problems with Water Distribution

Key Concepts

- World water distribution and supply
- Scarcity of safe drinking water

Lesson Objectives

- Explain why water shortages are increasingly frequent throughout the world.
- Discuss why 1.1 billion people (one-fifth of the people on Earth) do not have access to safe drinking water.

Lesson Vocabulary

- **drought:** long period of lower-than-normal rainfall for a region
- **pathogen:** disease-causing organism

Teaching Strategies

Introducing the Lesson

Call on volunteers to describe a time when they were really thirsty, for example, when they were hiking or playing a sport on a hot day and ran out of water. How did it feel to be thirsty and not be able to quench their thirst? Point out that lack of water can quickly become a serious health issue. Then tell students they will learn in this lesson how common water scarcity is for people around the world.

Activity

Students can gain a deeper appreciation of the global water crisis by creating a “Water Awareness Portfolio” (see pages 23–25 of the PDF document below). Instructions for the activity include numerous sample prompts to guide students’ research, writing, and other portfolio entries. Completion of the portfolio will give students knowledge of current water conditions in developing nations, an increased awareness of the need for conservation practices, and a sense of the value of water as a shared global resource.

<http://static.water.org/docs/curriculums/WaterOrg%20MidCurricFULL.pdf>

Demonstration

When you discuss how water shortages are likely to increase in the future, show students projected freshwater stress areas in 2025 using the map at the following URL. This is similar to a figure in the FlexBook® lesson, but the figure at the URL also shows water stress areas in 1995 for comparison. Point out areas, such as the U.S., that will have to use a greater percentage of their freshwater resources in 2025 than they did in 1995. Discuss human actions that contribute to these changes.

http://www.learner.org/courses/envsci/visual/visual.php?shortname=freshwater_stress

Differentiated Instruction

Pair students with less proficient English language or reading skills with other students, and ask partners to do a think-pair-share activity about water scarcity. First tell individual students to think about and write tentative answers to the questions listed below. Then have partners share and discuss their answers to the questions.

1. How would you define water scarcity?
2. How big a problem is water scarcity worldwide?
3. What are some causes of water scarcity?
4. What are some possible effects of water scarcity?
5. How is water pollution related to water scarcity?

Enrichment

Point out that many rivers, or at least their drainage basins, cross national boundaries so they are located in more than one nation. Suggest that interested students learn about the Helsinki Rules that regulate the use of waters of international rivers. They can start with the URL below. Ask the students to summarize the rules and share their summary with the rest of the class.

http://www.unece.org/fileadmin/DAM/env/water/meetings/legal_board/2010/annexes_groundwater_paper/Annex_II_-_Helsinki_Rules_ILA.pdf

Science Inquiry

Divide the class into groups, and ask students within each group to discuss similarities and differences between the global distribution and use of energy on the one hand and the global distribution and use of water on the other hand. Have students debate which problem is worse, more widespread, or more difficult to solve: energy overconsumption and scarcity or water overconsumption and scarcity. After allowing time for in-group discussion, ask group members to share their ideas with the class.

Overcoming Misconceptions

Students may hold misconceptions about water scarcity, such as those listed below. Refer them to the water facts file from the World Health Organization at the following URL to overcome these and other misconceptions about water scarcity.

http://who.int/features/factfiles/water/water_facts/en/index.html

- Water scarcity occurs only in areas that receive very little rainfall.
- Water scarcity affects only a small percentage of the human population.
- Water scarcity occurs only where water is physically scarce.
- Water scarcity can be dealt with by teaching people how to waste less water.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 21.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 21.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 21.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What can we do to help the one-fifth of the people on Earth who do not have access to safe drinking water?

How can we reduce water shortages because of overuse, overpopulation, and drought?

Water is so valuable that wars have been fought over it throughout history. Could conserving fresh water now help avoid future wars?

21.4 Lesson 21.3: Water Pollution

Key Concepts

- Sources of water pollution
- Municipal water pollution
- Ocean pollution
- Thermal water pollution

Lesson Objectives

- Discuss the risks that water pollution poses to human and environmental health.
- Explain where freshwater and saltwater pollution come from.
- Discuss how pathogen-borne diseases are caused by water pollution.
- Describe why conserving water and protecting water quality is important to human health and the environment.
- Describe how water pollution reduces the amount of safe drinking water available.
- Discuss who is responsible for preventing and cleaning up water pollution.

Lesson Vocabulary

- **thermal pollution:** pollution that raises the temperature of water

Teaching Strategies

Introducing the Lesson

Introduce the class to water pollution with the following facts and figures about the health effects of drinking contaminated water.

- Diseases spread through contaminated water are one of the leading causes of disease and death in the world.
- At any given time, half of the world's hospital beds are occupied by patients suffering from water-related diseases.
- Every 15 seconds, a child dies from a water-related disease.

Tell students they will read more in this lesson about contamination of the water supply and ways to prevent it.

Activity

Students are likely to think that water pollution is caused only by direct discharge of substances into bodies of water. However, bodies of water can also be polluted by acid rain, which is a byproduct of sulfur pollution of the air, mainly by coal-burning power plants. In this activity, students will investigate how even a small input of acid rain can change the acidity of a body of water and negatively affect aquatic life.

http://earthecho.org/images/uploads/wpc_uploads/Acid_Rain_HS.pdf

Differentiated Instruction

Pair English language learners with native English speakers, and ask partners to work together to create a cluster diagram of water pollution. They should draw a circle in the center of a sheet of paper, labeled “Water Pollution,” and draw circles around it for each type or source of water pollution, including municipal, industrial, agricultural, ocean-water, and thermal pollution. To each of these surrounding circles, they should add a few key terms or facts about that type or source of pollution.

Enrichment

Have students read and write a book report on the award-winning nonfiction book “A Civil Action” by John Harr (1996). The book is a compelling true account of people in Woburn, Massachusetts, who sought justice when their children developed deadly cancers as a result of contamination of community groundwater resources by two local industries. Students will learn who was responsible for the contamination and how it was resolved in what has been called the “legal thriller of the decade.” You can find a summary of the book at this URL: http://serc.carleton.edu/woburn/ACA_summary.html.

Science Inquiry

The activity at the following URL presents student with a real-world problem to solve: the contamination of a fictitious town’s drinking water. In the activity, students will make a topographic map, use it to predict groundwater flow, and investigate the most likely source of groundwater contamination.

http://water.epa.gov/learn/kids/drinkingwater/upload/2009_04_29_kids_activity_grades_9-12_trackingpollution_teachersguide.pdf

Overcoming Misconceptions

A common misconception is that most of the pollution that enters water comes from industries dumping toxic wastes into water at a single point. Explain that this type of point-source pollution has been nearly eliminated by the Clean Water Act and other legislation. Instead, the majority of pollution that enters water now comes from non-point source pollution. This type of pollution is caused mainly by runoff rainwater.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 21.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 21.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 21.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

How does water pollution reduce the amount of drinking water available for people to use?

About 50 % of all infectious diseases are caused by water pollution. What can be done to reduce the number of pathogens that reach our freshwater supplies?

Ocean pollution harms some of the most productive sources of marine life. How can we change our behaviors to protect marine life?

21.5 Lesson 21.4: Protecting the Water Supply

Key Concepts

- Water treatment
- Reducing water pollution
- Controlling ocean pollution
- Conserving water

Lesson Objectives

- Describe several ways water can be conserved.
- Discuss how water is treated to eliminate harmful particles.
- State what governments and international organizations can do to reduce water pollution.

Lesson Vocabulary

- **sewage treatment:** any process that removes contaminants from sewage or wastewater
- **water purification:** any process used to produce safe drinking water by removing contaminants

Teaching Strategies

Introducing the Lesson

Show students the short video at the following URL about waterborne disease known as Guinea worm. The graphic descriptions and images will capture student interest and clearly make the point that the water supply must be protected. Point out in the video how filtering the water removes the Guinea worm. Tell students they will learn in this lesson about other ways water can be treated and purified to make it safe to drink.

<http://www.youtube.com/watch?v=BjsquiiYiRU>

Activity

Use the lesson at the URL below to raise students' awareness of the importance of water resources and the need to conserve them. In the lesson, students will begin with a water audit pre-lesson to determine their own personal water usage. They will then participate in a class activity to learn how water's physical properties and chemical composition are essential to life on Earth. Once they understand water's importance, they will debate water distribution issues, develop an understanding of the consequences of water scarcity, and come up with ways to conserve water in their own lives.

http://www.eeweek.org/assets/files/EDN%20Water%20Lessons/Amazing_Precious_9-12.pdf

Differentiated Instruction

Suggest that students create a concept map to organize and summarize important lesson concepts. The concept map should be titled “Protecting the Water Supply.” Concepts should include water treatment (including sewage treatment and water purification), reducing water pollution (including preventing water pollution and cleaning polluted water), controlling ocean pollution, and conserving water.

Enrichment

Ask a few students to interview a water treatment expert in their community, such as the community’s environmental services manager or water treatment plant chief operator. The students’ objective should be to learn how community water resources are treated and purified to make them safe for drinking. Before the interview, suggest that the students learn more about the processes involved in water treatment at the URL below. After the interview, have the students create a flow chart to show the steps used to treat the local water supply. Give them a chance to explain their flow chart to the rest of the class.

http://www.cdc.gov/healthywater/drinking/public/water_treatment.html

Science Inquiry

In the activity at the URL below, groups of students will use various materials to build a filter that they will then use to try to clean a sample of “wastewater.” Each group will try different materials to see which work best to cleanly and quickly filter a given volume of water. In each case, the filtrate will be tested to determine if the filter worked to remove odors, soap, and turbidity. The goal of the activity is to give students an idea of how difficult it is to clean dirty or polluted water.

<http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act14.pdf>

Real-World Connection

In 1989, an oil tanker ran aground in Narragansett Bay, Rhode Island, and spilled 200,000 gallons of fuel oil into the bay. Using that spill as a case study, the activity at the first URL below allows students to investigate how to clean up an oil spill. Before starting the activity, you will do a simple demonstration to show students the differences in density of oil and water. Then students will be given a small model of an oil spill and various materials to try to clean up the spill. They will also learn how wind affects oil spills. The document at the second URL is a student worksheet for the activity.

- <http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act13.pdf>
- <http://omp.gso.uri.edu/ompweb/doee/teacher/pdf/act13.wk.pdf>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 21.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 21.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 21.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Who is responsible for controlling water pollution?

What can governments and international organizations do to control pollution?

It is usually cheaper to dump polluted water without spending money to treat and purify the water. What incentives would convince industry to control water pollution?

CHAPTER **22** HS TE Human Actions and the Atmosphere

Chapter Outline

- 22.1** CHAPTER 22: HUMAN ACTIONS AND THE ATMOSPHERE
 - 22.2** LESSON 22.1: AIR POLLUTION
 - 22.3** LESSON 22.2: EFFECTS OF AIR POLLUTION
 - 22.4** LESSON 22.3: REDUCING AIR POLLUTION
-

22.1 Chapter 22: Human Actions and the Atmosphere

Chapter Overview

This chapter discusses types of air pollution, their causes and effects, and ways to reduce air pollution.

Online Resources

See the following Web sites for appropriate laboratory activities:

The lab at the following URL allows students to investigate exhaust emissions, class car use, and air quality.

- <http://www.sciencelearn.org.nz/Contexts/Enviro-imprints/Teaching-and-Learning-Approaches/Air-pollution-activities>

With the lab “There’s a Hole in My Umbrella” at the following URL, students will gain an understanding of acid deposition and acid rain and the environmental impacts they have both nationally and globally. In the lab, students will investigate the effects of acid deposition on plant growth, the corrosion of copper by acid, and the relationship between prevailing wind direction and areas that receive high levels of acid rain.

- <http://www.uni.edu/storm/downloads/highschool/There%27s%20a%20hole%20in%20my%20umbrella.pdf>

These Web sites may also be helpful:

This URL lists curriculum resources, activities, materials, and Web sites about air quality.

- <http://airnow.gov/index.cfm?action=learning.forteachers>

You may want to follow the lesson plan at the following URL when you teach this chapter. In the lesson, students will examine the topic of air pollution, its possible solutions, and the government agencies that are responsible for dealing with it. Specific topics addressed include: ingredients, causes, effects, and solutions of air pollution; individual actions to improve air quality; misuse of the atmosphere; federal laws and agencies that address air quality; stratospheric and tropospheric ozone; and criteria pollutants.

- <http://www.dnrec.state.de.us/DNREC2000/Divisions/AWM/aqm/education/airqualityLesson1.pdf>

You can find excellent air pollution images as well as background information on air pollution at this URL: http://education.nationalgeographic.com/education/encyclopedia/air-pollution/?ar_a=1.

Pacing the Lessons

TABLE 22.1: short caption

Lesson	Class Period(s) (60 min)
22.1 Air Pollution	2.0
22.2 Effects of Air Pollution	2.0
22.3 Reducing Air Pollution	1.5

22.2 Lesson 22.1: Air Pollution

Key Concepts

- Air quality
- The Clean Air Act
- Primary and secondary air pollutants
- Causes of air pollution

Lesson Objectives

- Describe the different types of air pollutants.
- Discuss what conditions lead some cities to become more polluted than others.
- Describe the sources of air pollutants.

Lesson Vocabulary

- **photochemical smog:** type of air pollution that results from a chemical reaction between certain air pollutants in the presence of sunshine
- **slash-and-burn agriculture:** form of agriculture in which trees are cut down and burned to clear the land for planting crops

Teaching Strategies

Introducing the Lesson

Introduce air pollution by showing the class images of serious air pollution, such as the images at the URLs below. Tell students they will learn about the causes and effects of air pollution, as well as ways it can be controlled, when they read this chapter.

- <http://commons.wikimedia.org/wiki/File:SmogNY.jpg>
- <http://geographyblog.eu/wp/wp-content/uploads/2011/11/Air-pollution-in-London-001-1.jpeg>
- http://www.momscleanairforce.org/files/2012/06/GWB_1973_2-580x377.jpg

Activity

Students can study particulates with the lesson plan at the following URL. Using a combination of teacher demonstration, discussion, online work, and hands-on activities, students will construct working definitions of criteria

pollutants and particulate matter, analyze real-time air quality data, and correlate particulate levels with health problems. The document includes background information, extension ideas, and a scoring rubric.

<http://www.uni.edu/storm/downloads/highschool/Particulates.pdf>

Demonstration

Use the animation at the first URL below to demonstrate to the class how low-level ozone forms. The animation at the second URL will give students more information on particulates.

<http://www.epa.gov/airnow/ozone/o3.html>

<http://www.epa.gov/airnow/pm/pm.html>

Differentiated Instruction

Suggest that students create an outline of the information in the lesson. Making an outline can help them organize the information in a reading passage so it is easier to see how concepts are related. It can also help them focus on the most important ideas. In addition, an outline is a very useful tool for reviewing and learning material from a reading passage. One of the main problems people have in writing outlines is writing too much. Tell students to read the following article first in order to learn how to avoid this problem when they create their outline.

<http://schooldestroyer.com/outlining-writing-book/>

Enrichment

Ask a few students to learn what the Air Quality Index (AQI) is, what it means, how it is calculated, and how it is related to human health. Then have them teach the information to the class. In addition, have the students find and report on the AQI for their local community each day for a week while the class is studying this chapter. At the end of the week, discuss how the AQI for their community affects the health of community members. Also discuss possible factors that contribute to the quality of air in their community.

- <http://www.airnow.gov/?action=aqibasics.aqi>
- <http://www.casadata.org/airqualityindex/aqi/aqicalculated.asp>
- <http://www.airnow.gov/>

Science Inquiry

Students can make an air pollution collector from simple materials, as described in the document below. The document also explains how to use the collector and interpret the results. Students will record observations of visible air pollution and link them with factors such as wind speed. Ask them to write a report on their project.

[<http://www.instesre.org/NSFWorkshop/HansenParticulateCollector.pdf> <http://www.instesre.org/NSFWorkshop/HansenParticulateCollector.pdf>]

Overcoming Misconceptions

Many people mistakenly think that the creation of ozone is a good thing because it helps repair the ozone hole. Make sure they are aware of the difference between ground-level and stratospheric ozone. The former is the most important secondary air pollutant and never a good thing. The latter protects living things from harmful UV radiation and is unrelated to ground-level ozone.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 22.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 22.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 22.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Despite the Clean Air Act, the air over many regions in the United States is still not clean. Why?

How do pollutants damage human health?

In what ways does air pollution harm the environment?

22.3 Lesson 22.2: Effects of Air Pollution

Key Concepts

- Smog effects on the environment
- Smog effects on human health
- Acid rain
- Ozone depletion

Lesson Objectives

- Describe the damage that is being done by smog.
- Discuss how acid rain is formed and the damage it does.
- Discuss how chlorofluorocarbons destroy the ozone layer.

Lesson Vocabulary

- **acid rain:** rain that has a pH of less than 5 that forms when nitrogen and sulfur oxides in the air dissolve in rainwater
- **alkaline:** having a pH of greater than 7; also called basic
- **bioaccumulation:** accumulation of toxic substances in organisms so that the concentration increases up the food web
- **ozone hole:** region in the stratosphere above Antarctica in which the ozone level is reduced in the spring because of the action of ozone-destroying chemicals
- **pH scale:** scale that measures the acidity of a solution, on which a pH value of 7 is neutral, values of less than 7 are acidic, and values of greater than 7 are basic
- **polar stratospheric clouds (PSC):** clouds that form in the stratosphere when it is especially cold and that are needed for the breakup of chlorofluorocarbon pollutants in the stratosphere

Teaching Strategies

Introducing the Lesson

Most students will be somewhat familiar with asthma and some of them are likely to have asthma themselves. Introduce human health effects of air pollution by focusing on this chronic lung disease. Tell students that asthma is a serious disease of the lungs that causes breathing problems due to a narrowing of the airways, which makes it difficult to get enough oxygen. Attacks are characterized by a tight feeling in the chest, coughing, and wheezing. State that asthma appears to be on the rise in the United States and many other countries. Its prevalence in the

United States, for example, has increased by more than 75 percent since 1980. Point out that children and certain racial groups, especially African Americans, have experienced relatively greater increases in asthma prevalence. Tell students that increases in asthma are just one of several effects of air pollution on human health and they will learn about others when they read this lesson.

Building Science Skills

With the activity “To Burn or Not to Burn” at the URL below, students will investigate the potential health effects of a proposed power plant in a community. They will calculate emissions of various pollutants from the proposed power plant and compare them with EPA air quality standards. Then they will use the data to make an informed decision about the power plant. The document includes teacher notes, links to data, and an assessment rubric.

<http://www.uni.edu/storm/downloads/highschool/To%20Burn%20or%20Not%20to%20Burn.pdf>

Activity

The purpose of the activity at the following URL is to raise awareness of the negative effects of air pollution, especially for people with asthma. Students will identify some of the sources of air pollution in their school and community and possible ways to improve air quality in these areas.

<http://learningtogive.org/lessons/unit483/lesson1.html>

Differentiated Instruction

Some students may be confused about ozone and whether it is good or bad. Help avoid this confusion by working with students to make a Venn diagram or compare/contrast table to distinguish the formation and health effects of low-level and stratospheric ozone. You can also have students watch the animation at the URL below.

<http://www.epa.gov/airnow/o3gb/o3gb.html>

Enrichment

A recent large-scale study documented a suspected link between exposure to air pollution in pregnant women and autism in their children. Refer interested students to one or more of the URLs below to learn about the research. Ask them to summarize the scope and findings of the research and present their summary to the class.

- <http://www.rsc.org/chemistryworld/2013/06/air-pollution-diesel-metals-autism>
- <http://www.bloomberg.com/news/2013-06-18/autism-tied-to-air-pollution-brain-wiring-disconnection.html>
- <http://www.livescience.com/37510-autism-air-pollution.html>

Science Inquiry

Use the lesson plan at the following URL so students can investigate the health effects of different air pollutants. This lesson contains three activities that focus on symptoms caused by specific pollutants. Students will engage in a game in which they analyze a series of case studies. The goal is to ask questions that clarify the patient’s symptoms and then deduce the probable cause of the symptoms. Seven such cases are included on “Symptom Scenario” cards. Although based on fictional characters, the cases are realistic examples of well-documented health effects of exposure to specific pollutants.

<http://www.dnrec.state.de.us/DNREC2000/Divisions/AWM/aqm/education/airqualityLesson7.pdf>

Overcoming Misconceptions

Students may think that people who are healthy and don't have asthma are not adversely affected by air pollution. Point out research that shows even a healthy person can suffer ill effects from air pollution. You can use the research described at the URL below or find other research to share with students.

<http://www.epa.gov/region07/air/quality/health.htm>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 22.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 22.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 22.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Since mercury bioaccumulates and coal-fired power plants continue to emit mercury into the atmosphere, what will be the consequence for people who like to eat tuna and other large predatory fish?

What are the possible causes of rising asthma rates in children?

A ban has been imposed on CFCs and some other ozone-depleting substances. How will the ozone hole change in response to this ban?

22.4 Lesson 22.3: Reducing Air Pollution

Key Concepts

- Reducing air pollution from vehicles
- Reducing industrial air pollution
- Reducing ozone destruction
- Reducing greenhouse gases

Lesson Objectives

- Describe the major ways that energy use can be reduced.
- Discuss new technologies that are being developed to reduce air pollutants, including greenhouse gases.
- Describe the difference between placing caps on emissions and reducing emissions.

Lesson Vocabulary

- **biofuel:** fuel made from living things, usually crop plants such as corn or soybeans
- **cap-and-trade:** system of caps, or upper limits, on carbon dioxide emissions in which nations can trade allowances for emissions
- **carbon sequestration:** removal of carbon dioxide from the atmosphere so it does not act as a greenhouse gas and contribute to global warming
- **carbon tax:** tax placed on energy sources that emit carbon dioxide when burned in order to discourage their use and to raise funds for researching alternative energy sources
- **catalyst:** substance that increases the rate of a chemical reaction but is not used up in the reaction
- **catalytic converter:** device on modern motor vehicles that uses a catalyst to break down pollutants in exhaust before they can leave the vehicle and enter the atmosphere
- **fuel cell:** energy cell in which chemical energy is converted to electrical energy
- **gasification:** technology that changes solid coal to a gas that burns more efficiently and produces fewer emissions than solid coal
- **hybrid vehicle:** very efficient vehicle that is powered by a combination of an internal combustion engine and an electric motor with a rechargeable battery

Teaching Strategies

Introducing the Lesson

Briefly explain to the class that an international agreement called the Montreal Protocol was signed by many nations, including the U.S., in 1987. The purpose of the agreement was to limit the production and use of CFCs, which break

down stratospheric ozone. Ask students if they think the Montreal Protocol was a success. Tell them they will find out when they read the lesson.

Activity

The activity at the URL below is designed to introduce students to the field of engineering with a focus on air pollution control. Students will learn basic information about one of the most commonly used air pollution control devices used in industry, known as the baghouse. Then they will use math to determine the efficiency of simulated baghouses they create using simple items available from a hardware store.

http://tbpmindset.org/modules/GatorTRAX/Environmental/Baghouse_Module.pdf

Differentiated Instruction

Have students make a KWL chart for the lesson to help them focus their reading. The three-column chart should have the headings “Know” (K), “Want to Know” (W), and “Learned” (L). Tell students to fill in the K and W columns before they read the lesson and the L column after they read the lesson. Discuss as a class anything students wanted to know but didn’t learn when they read the lesson.

Enrichment

Encourage interested students to learn more about fuel cell technology and fuel cell vehicles. They should find out how they work and why they don’t create air pollution. They should also learn about constraints on the design of fuel cell vehicles and problems in developing them for large-scale use. Suggest to the students that they start their research with this URL: <http://www.fueleconomy.gov/feg/fuelcell.shtml>.

Science Inquiry

Show the excellent film “Air—The Search for One Clean Breath” at the first URL below. Then use the lesson plan that accompanies the film (see second URL). In the lesson, students will solve an air pollution mystery using a variety of evidence. This will allow students to appreciate that many disciplines of study and areas of interest can contribute to solving a public health problem. It will also increase their awareness of past air pollution disasters. Students will learn that public awareness and activism can prevent or minimize air pollution tragedies.

<http://www.vcapcd.org/AirTheFilm/index.htm>

<http://www.vcapcd.org/AirTheFilm/pubs/AirPollutionTragedyLessonPlan.pdf>

Overcoming Misconceptions

Many people think that catalytic converters solve all the air pollution problems created by motor vehicles by removing pollutants from the exhaust before they exit the tail pipe. This is incorrect for two reasons. Point out that a catalytic converter works only when it is very hot. The heat comes from the exhaust and until the car engine heats up, the exhaust is too cool for the converter to work. This means that the car releases air pollutants from the tail pipe at the start of each trip until the car warms up. Also explain that a catalytic converter changes air pollutants other gases. One of these other gases is carbon dioxide. Although carbon dioxide is harmless to human health, it is a significant cause of global warming.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 22.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 22.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 22.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why is it important to reduce air pollution?

What can you do in your own life to reduce your impact on the atmosphere?

Why is a worldwide effort needed to reduce the threat of global climate change?

CHAPTER 23**HS TE Observing and Exploring Space****Chapter Outline**

- 23.1** CHAPTER 23: OBSERVING AND EXPLORING SPACE
 - 23.2** LESSON 23.1: TELESCOPES
 - 23.3** LESSON 23.2: EARLY SPACE EXPLORATION
 - 23.4** LESSON 23.3: RECENT SPACE EXPLORATION
-

23.1 Chapter 23: Observing and Exploring Space

Chapter Overview

This chapter begins with a discussion of electromagnetic radiation, types of telescopes, and ways of gathering information from our universe. It provides information about early space exploration and concludes with a description of recent and current space exploration.

Online Resources

See the following Web sites for appropriate laboratory activities:

The virtual space travel lab at the following URL (Lesson 4) will help students appreciate the difficulties involved in human exploration of space. It will also develop their technological design skills. In the lab, students will design helmets to protect space travelers on different planets, including Mars, Saturn, and Pluto. Each helmet must address different conditions and meet different requirements. The document includes design sheets adapted from NASA.

- <http://www.msncucleus.org/membership/html/jh/earth/spaceexplore/jhspaceexpl.pdf>

Another technological design lab can be found at the URL below. In the lab, students will demonstrate how reaction wheels (also known as momentum wheels) take advantage of Newton's third law to control a spacecraft's orientation. This is an important function, especially when an orbiting spacecraft is collecting data from a planet or other celestial body.

- http://saturn.jpl.nasa.gov/files/Spinning_World.pdf

These Web sites may also be helpful:

The following interactive Web site provides an in-depth exploration of the telescope, including its history and the science behind it. The site is a useful adjunct to the first lesson in this chapter for you and/or your students.

- <http://amazing-space.stsci.edu/resources/explorations/groundup/>

Students can explore space and take telescopic images with the Harvard-Smithsonian Center for Astrophysics' MicroObservatory network of automated telescopes. The telescopes can be controlled over the Internet. You can learn more about the program at this URL: <http://mo-www.harvard.edu/OWN/about.html>

At the URL below, you can find links to a wide variety of educational resources on astronomy.

- <http://www.astrosociety.org/education/educational-resources/>

This URL has links to many Web sites that offer information and activities relating to multi-wavelength astronomy.

- http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_astronomy/activities.html

You can find a detailed interactive space exploration timeline at the following URL. It covers space exploration for the 50-year period 1957–2007.

- <http://science.nationalgeographic.com/science/space/space-exploration-timeline/>

Go the URL below for a collection of space exploration videos.

- <http://www.neok12.com/Space-Exploration.htm>

Pacing the Lessons

TABLE 23.1: short caption

Lesson	Class Period(s) (60 min)
23.1 Telescopes	2.5
23.2 Early Space Exploration	2.0
23.3 Recent Space Exploration	2.0

23.2 Lesson 23.1: Telescopes

Key Concepts

- Electromagnetic radiation and the speed of light
- Optical, radio, and space telescopes
- Observations made with telescopes

Lesson Objectives

- Explain how astronomers use the whole electromagnetic spectrum to study the universe beyond Earth.
- Identify different types of telescopes.
- Describe historical and modern observations made with telescopes.

Lesson Vocabulary

- **astronomer:** scientist who studies the universe beyond Earth
- **catadioptric telescope:** type of optical telescope that uses a combination of mirrors and lenses to collect and focus light
- **constellation:** group of stars that appear from Earth to form a recognizable pattern
- **electromagnetic (EM) radiation:** energy transmitted through space as waves
- **electromagnetic spectrum:** full range of wavelengths of electromagnetic radiation
- **frequency:** number of waves that pass a given point each second
- **gamma ray:** penetrating type of electromagnetic radiation that has the shortest wavelengths
- **infrared light:** type of electromagnetic radiation with wavelengths between radio waves and visible light
- **light-year:** distance that light travels in one year; equal to 9.5 trillion kilometers
- **microwave:** type of radio waves with the shortest wavelengths
- **planet:** space object that orbits a star and has cleared its orbit of smaller objects
- **radio telescope:** type of telescope that collects radio waves
- **radio wave:** type of electromagnetic radiation that has the longest wavelengths
- **reflecting telescope:** type of optical telescope that uses mirrors to gather and focus visible light
- **refracting telescope:** type of optical telescope that uses convex lenses to gather and focus visible light
- **space telescope:** telescope that orbits Earth above Earth's atmosphere
- **spectrometer:** device that breaks light into different wavelengths, or colors
- **ultraviolet (UV) light:** type of electromagnetic radiation with wavelengths between visible light and X-rays that can harm living things
- **visible light:** type of electromagnetic radiation that has wavelengths between infrared and ultraviolet light and that can be detected by the human eye
- **wavelength:** horizontal distance between corresponding points on adjacent waves, such as the distance between two crests or two troughs
- **X-ray:** type of electromagnetic radiation with wavelengths between ultraviolet light and gamma rays

Teaching Strategies

Introducing the Lesson

Play a word association game with the class. Go around the room from one student to the next, and ask each student to say the first word that comes to mind when they hear the term space. After no new words are forthcoming, discuss how some of the most pertinent words are related to space or space exploration. Then tell students they will learn about space exploration in this chapter.

Activity

Students can use the telescope simulator at the following URL to better understand how a telescope works and how to use it to bring distant objects into focus.

<http://astro.unl.edu/classaction/animations/telescopes/telescope10.html>

Building Science Skills

Many students have trouble envisioning how relatively thin a layer Earth's atmosphere is and where space begins. Use the activity at the URL below to help them get a better idea of the relative sizes and locations of the atmosphere and space. In the activity, students will construct a scale model and use it to see where things such as airplane flights, the Hubble space telescope, and the beginning of space are located.

http://www.astrosociety.org/edu/activities/I11_How_High_Space.pdf

Activity

Students can explore the electromagnetic spectrum using a variety of interactive Internet resources and hands-on activities that are described at the following URL.

<http://can-do.com/uci/ssi2001/emspectrum.html>

Differentiated Instruction

Pair any differential learners with other students, and ask partners to make a Venn diagram comparing and contrasting refracting and reflecting telescopes.

Enrichment

Interested students can extend the Science Inquiry Activity below by learning how Galileo's discoveries with this telescope relate to the Copernican Revolution. Ask the students to create a PowerPoint presentation to share what they learn with the rest of the class.

Science Inquiry

In the inquiry activity at the URL below, students will undertake a simplified version of Galileo's pioneering observations of Jupiter's moons. Specifically, they will examine data showing the positions of Jupiter's moons over several nights. This will allow them to follow the motion of each moon and determine its orbital period around Jupiter. The focus of the activity is on the scientific process and the steps in that process.

<http://www.astrosociety.org/edu/slooh/footsteps.pdf>

Real-World Connection

Astronomy is an interesting subject to many people, and many companies take advantage of that interest by naming their products after astronomical objects. Have students make a list of such products (e.g., Mercury and Saturn cars, Milky Way candy bars, Starburst candies, Moon pies, Comet cleanser, and the Gemini roller coaster). Then have students think about other astronomy terms that might be used in the future to name new products. The activity will help students appreciate the influence of astronomy outside of science, increase their familiarity with astronomical terms, and develop their creative thinking skills.

<http://www.astrosociety.org/edu/publications/tnl/08/stars2.html>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 23.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 23.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 23.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Radio waves are used for communicating with spacecraft. A round-trip communication from Earth to Mars takes anywhere from 6 to 42 minutes. What challenges does this present for sending unmanned spacecraft and probes to Mars?

The Hubble space telescope is a very important source of data for astronomers. The fascinating and beautiful images from the Hubble also help to maintain public support for science. However, the Hubble is growing old. Missions to service and maintain the telescope are extremely expensive and put the lives of astronauts at risk. Do you think there should be another servicing mission to the Hubble?

23.3 Lesson 23.2: Early Space Exploration

Key Concepts

- Rockets
- Satellites
- The Space Race
- Reaching the moon
- Exploring other planets

Lesson Objectives

- Explain how a rocket works.
- Describe different types of satellites.
- Outline major events in early space exploration, including the Space Race.

Lesson Vocabulary

- **low-Earth orbit:** orbit of satellites that stay relatively close to Earth
- **orbit:** circular or elliptical path of one object around another
- **rocket:** vehicle propelled by high-speed gas particles flying out one end of it
- **satellite:** natural or human-made object that orbits another object
- **space probe:** spacecraft that is sent without a crew to collect data by flying near or landing on a distant object in space
- **thrust:** forward force produced by gases escaping from a rocket engine in the opposite direction

Teaching Strategies

Introducing the Lesson

Ask students if they have ever heard the expression, “It’s not rocket science.” Have them explain what the expression refers to and also what it infers about the actual science of rockets. (The expression refers to something that is not especially difficult. It infers that the actual science of rockets is very difficult.) Tell students that the basic science behind rockets is not as difficult as many people think, as they will learn when they read this lesson.

Activity

Students can apply basic principles of rocket science to build and launch a model transport rocket. You can find all the information needed for this project on pages 74–76 of the following document. Students will predict and then test how much weight their rocket can carry.

http://www.nasa.gov/pdf/265386main_Adventures_In_Rocket_Science.pdf

Differentiated Instruction

Have visual learners draw and label a sketch to show how a rocket works. Putting pencil to paper to create a labeled sketch will focus their knowledge of rocketry on the most crucial aspects of the rocket and the science behind it.

Enrichment

Have students who need extra challenges do the satellite image-interpretation activity at the URL below. The activity has three parts. Parts I and II provide—and then quiz students on—the basic information they need in order to interpret visible and infrared satellite images. Answers to the questions are provided. Part III asks students to apply this knowledge to a variety of actual satellite images and interpret what they see in the images.

<http://funnel.sfsu.edu/satlab/>

Science Inquiry

Students can use microsets of NASA satellite data to study the relationship between Earth’s surface temperature and tropospheric ozone levels. The purpose of the study is to analyze changes in tropospheric ozone and then hypothesize about the consequences of these changes. In the process, students will learn how to use satellite images and other data as well as gain an appreciation of the value of using satellites to gather data about Earth. The URL below provides a lesson plan for the activity. The Web site includes instructions for accessing the satellite data. The lesson plan itself includes background information, the procedure, and ideas for extension. Teacher notes are also provided.

http://mynasadata.larc.nasa.gov/lesson-plans/lesson-plans-hs-educators/?page_id=474?&passid=16

History Connection

Describe to students some of the social effects of the Space Race on people in the U.S. For example, shortly after the Soviet Union launched Sputnik 1, greater emphasis was placed on teaching math and science in schools, including greater government funding for math and science teacher training and public school math and science classes. You and/or your students can learn more by reading the excellent article at this URL: http://www.nebraskastudies.org/0900/frameset_reset.html?http://www.nebraskastudies.org/0900/stories/0901_0105.html.

Reinforce and Review

Lesson Worksheets=

Copy and distribute the Lesson 23.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 23.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 23.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

The Space Race and the United States' desire to get to the moon brought about many advances in science and technology. Can you think of any challenges we face today that are, could be, or should be a focus of science and technology?

If you were in charge of NASA, what new goals would you set for space exploration?

Do you think that a space program is a good use of government funding?

23.4 Lesson 23.3: Recent Space Exploration

Key Concepts

- Space stations
- Space shuttles
- Recent space missions

Lesson Objectives

- Outline the history of space stations and space shuttles.
- Describe recent developments in space exploration.

Lesson Vocabulary

- **orbiter:** main part of the space shuttle that has wings like an airplane
- **space shuttle:** reusable spacecraft capable of carrying large pieces of equipment or parts of a space station
- **space station:** large spacecraft that orbits Earth and on which humans can live for extended periods of time

Teaching Strategies

Introducing the Lesson

Show students some of the amazing images at the following URL. They are pictures of Saturn and its moons taken by the Cassini spacecraft. Tell students they will learn about the Cassini and other recent and current space missions when they read this lesson.

http://www.nasa.gov/mission_pages/cassini/multimedia/gallery/gallery-index.html

Discussion

Point out that research projects on the International Space Station (ISS) are projects that require the conditions of a low-Earth orbit, such as weightlessness. Have students brainstorm possible research questions that might be addressed in which weightlessness is a factor. Suggest that they think about research questions in human biology, space medicine, life science, physical science, astronomy, and/or meteorology. After students have come up with their own ideas, you can describe some of the research that actually takes place on the ISS. To learn more, go to these URLs:

- http://en.wikipedia.org/wiki/Scientific_research_on_the_International_Space_Station

- http://www.nasa.gov/mission_pages/station/research/experiments_category.html

Differentiated Instruction

Have students do a gallery walk for space shuttles and space stations. Post a large sheet of paper or poster board on two different walls of the classroom. Label one “Space Shuttles” and label the other “Space Stations.” Divide the class into several groups, including any differential learners in groups with other students. Give each group a chance to add notes to each poster, expressing what they know about each type of spacecraft. They should also add comments about the ideas expressed by other groups. After the activity, read aloud the most important points made by the groups, and identify and discuss any misconceptions.

Enrichment

If students want to learn more about NASA’s planned future missions, advise them to go to the Web site below. Encourage them to summarize what they learn and share it with the other students in class.

<http://science.nationalgeographic.com/science/space/space-exploration/future-spaceflight/>

Science Inquiry

Through Mars Exploration Student Data Teams (MESDT), students can get involved in authentic Mars research. As team members, they will work with scientists, mission planners, and educators on the collection and analysis of data as it is downloaded from instruments currently orbiting Mars. To see how your students can join this free program, go to this URL: <http://marsed.mars.asu.edu/mesdt-home>.

Overcoming Misconceptions

Many people think that there is no gravity in space. This misconception may come from the images people see of astronauts floating around in the International Space Station (ISS). Explain to students that neither the astronauts nor their spacecraft are ever free of gravity because there is gravity everywhere in the universe. In fact, for near-Earth missions like the ISS, astronauts are subject to a force of gravity that is almost as strong as it is on Earth’s surface. The only reason they seem weightless (and therefore not subject to gravity) is that they are falling around Earth at the same rate as the spacecraft is falling around Earth. This makes them weightless relative to the things around them.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 23.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 23.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 23.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

To date, a total of 22 people have died on space missions. In the two space shuttle disasters alone, 14 people died. However, space exploration and research have led to many great discoveries and new technologies. Do you think sending people into space is worth the risk? Why or why not?

In the past several years, private companies have been developing vehicles and launch systems that can take people into space. What applications can you think of for such vehicles? What advantages and disadvantages are there to private companies building and launching spacecraft?

CHAPTER

24**HS TE Earth, Moon, and Sun****Chapter Outline**

- 24.1** CHAPTER 24: EARTH, MOON, AND SUN
 - 24.2** LESSON 24.1: PLANET EARTH
 - 24.3** LESSON 24.2: EARTH'S MOON
 - 24.4** LESSON 24.3: THE SUN
 - 24.5** LESSON 24.4: THE SUN AND THE EARTH-MOON SYSTEM
-

24.1 Chapter 24: Earth, Moon, and Sun

Chapter Overview

This chapter describes the basic properties and motions of Earth, the moon, and the sun, including tides and eclipses. It also describes the sun's layers and solar activity.

Online Resources

See the following Web sites for appropriate laboratory activities:

Students can do the investigation “Impact Craters” (pages 61–70 in the document below) to learn more about the formation of craters on the lunar surface. They will experiment to determine the factors affecting the appearance of impact craters and ejecta. They will use marbles, ball bearings, or similar spheres as impactors dropped onto a prepared “lunar surface.” Using these materials, they will investigate how mass and velocity of the impactors affect crater size.

- http://www.nasa.gov/pdf/58199main_Exploring.The.Moon.pdf

In the classroom lab activity at the following URL, students will calculate the velocity and acceleration of a coronal mass ejection based on its position in a series of images taken by NASA's SOHO mission. This is a good lab to involve students in actual space research. It will develop both observational and mathematics skills.

- http://sohowww.nascom.nasa.gov/classroom/cme_activity.html

These Web sites may also be helpful:

At the following URL, you can access an excellent resource from NASA, “Exploring the Moon,” which is a teacher's guide with activities for Earth and space science for grades 4–12. In addition to the activities, the document includes extensive background information, fact sheets, and links to other resources.

- http://www.nasa.gov/pdf/58199main_Exploring.The.Moon.pdf

Another excellent resource from NASA is available at the URL below. It covers the SOHO mission, which is exploring the sun from space. You and/or your students can learn more about the sun and how it is being studied. The site also has wonderful solar images and a variety of educational materials.

- <http://sohowww.nascom.nasa.gov/home.html>

The following Web site provides a collection of multi-disciplinary, interactive exercises and activities based on the sun and solar science, most geared to grades 4-12.

- <http://solar-center.stanford.edu/teachers/>

At the URLs below, you can find a diversity of educational resources on solar eclipses, including teacher-reviewed videos.

- <http://www.exploratorium.edu/eclipse/index.html>
- <http://www.neok12.com/Eclipse.htm>

Pacing the Lessons

TABLE 24.1: short caption

Lesson	Class Period(s) (60 min)
24.1 Planet Earth	1.5
24.2 Earth's Moon	1.0
24.3 The Sun	1.5
24.4 The Sun and the Earth-Moon System	2.0

24.2 Lesson 24.1: Planet Earth

Key Concepts

- Earth's shape
- Earth's magnetism
- Earth's rotation
- Earth's revolution

Lesson Objectives

- Recognize that Earth is a modified sphere (oblate spheroid), and describe the evidence for this conclusion.
- Explain what causes Earth's magnetism and the effects that magnetism has on Earth.
- Describe Earth's rotation on its axis.
- Describe Earth's revolution around the sun.

Lesson Vocabulary

- **axis:** imaginary line that runs between the North and South Poles through the center of Earth
- **ellipse:** oval-like shape of the orbits of Earth and the other planets
- **hemisphere:** half of a sphere, such as half of planet Earth
- **revolution:** orbital movement of one object around another, such as the moon around Earth or Earth around the sun
- **rotation:** spinning of an object such as Earth on its axis

Teaching Strategies

Introducing the Lesson

Play a game to get students thinking about Earth the planet. Tell students you are going to give them clues about a natural object in space (Earth), and they have to try to guess the identity of the object with as few clues as possible. You can use these clues:

- It has a diameter of 12,756 km.
- It has a mass of 5.97×10^{24} kg.
- It formed 4.6 billion years ago.
- Its average distance from the sun is about 150 million km.
- The temperature at its center is about 5500 degrees Celsius.

- The temperature on its surface ranges from about -90 to 57 degrees Celsius.

After they guess, or you tell them, that the object is Earth, say they will learn more about our planet when they read this lesson.

Activity

Use the lesson “Foucault’s Pendulum” at the following URL so students can learn more about Foucault’s pendulum experiment and how it provided evidence for Earth’s rotation. By working through the lesson, they will have a better understanding of how Foucault used Newton’s first law of motion to prove that Earth spins on its axis. The activity includes links to related resources, a student worksheet, a written assessment, and ideas for extension.

<http://sciencenetlinks.com/lessons/foucaults-pendulum/>

Differentiated Instruction

Pair any students who are struggling with those who excel in science. Ask the students who excel to create an unlabeled diagram that shows how the tilt of Earth on its axis causes Earth’s seasons. Then have the other student in each pair correctly label the diagram. This is a good activity for visual and English language learners.

Enrichment

Ask interested students to learn more about Earth’s magnetic field and how it shields the planet from harmful solar radiation. The resources at the following URLs are useful for this purpose. Have the students explain this function of Earth’s magnetic field to the rest of the class. Tell them to include illustrations in their presentation. They should also explain and use the terms magnetosphere and Van Allen radiation belts.

- <http://www.universetoday.com/27005/earths-magnetic-field/>
- http://www.windows2universe.org/glossary/plasmaspheric_gain.html
- http://www.windows2universe.org/glossary/radiation_belts.html

Science Inquiry

Show the class the photograph of a partial lunar eclipse at the URL below. Tell students that the picture shows the moon passing through Earth’s shadow. Ask students to explain how this provides evidence for Earth’s spherical shape. (The curvature of Earth is apparent from the shape of the shadow it casts on the moon.)

[http://upload.wikimedia.org/wikipedia/commons/8/8e/Rhys400D_-_Lunar_Eclipse_Half_Moon_\(by\).jpg](http://upload.wikimedia.org/wikipedia/commons/8/8e/Rhys400D_-_Lunar_Eclipse_Half_Moon_(by).jpg)

Overcoming Misconceptions

Students are likely to have misconceptions about Earth’s magnetic field. For example, they are likely to think that the magnetic pole in the Northern Hemisphere is the north magnetic pole and that Earth’s magnetic alignment is always the same. Explain why each of these potential misconceptions is false. The north magnetic pole attracts the north pole of a bar magnet and so is in a physical sense actually a south magnetic pole. Also, the orientation of Earth’s magnetic field (and that of other planets) can flip, so that magnetic north becomes magnetic south and vice versa. This is known as geomagnetic reversal, and it has happened repeatedly throughout Earth’s geologic history.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 24.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 24.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 24.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What type of experiment could you create to prove that Earth is rotating on its axis?

If you lived at the equator, would you experience any effects because of Earth's tilted axis?

If Earth suddenly increased in mass, what might happen to its orbit around the sun?

Would life on Earth be impacted if Earth lost its magnetic field?

Why are the inner planets spherical?

24.3 Lesson 24.2: Earth's Moon

Key Concepts

- Lunar characteristics
- Surface of the moon
- Interior of the moon

Lesson Objectives

- Explain how scientists think the moon formed.
- Describe the features of the moon.

Lesson Vocabulary

- **crater:** bowl-shaped depression on the surface of the moon caused by the impact of a meteorite
- **lunar:** of or relating to the moon
- **maria:** dark-colored flat areas on the moon's surface that are made up of ancient basaltic lava
- **terrae:** light-colored highlands on the moon's surface

Teaching Strategies

Introducing the Lesson

At the URL below, you can find exciting new discoveries about the moon made by NASA's Lunar Reconnaissance Orbiter. Share some of the most interesting discoveries with students, and then tell them they will learn more about the moon when they read this lesson.

<http://www.space.com/21-10-coolest-moon-discoveries.html>

Activity

Students can learn more about the lunar surface and the Apollo Mission by doing the activity "Apollo Landing Sites" at the following URL (pages 43–46). In the activity, students will learn about the locations and geology of the six Apollo landing sites. The URL includes both student and teacher pages, with background information, an Apollo landing sites data chart, and ideas for extension.

http://www.nasa.gov/pdf/58199main_Exploring.The.Moon.pdf

Differentiated Instruction

Suggest that students make a Venn diagram to compare and contrast the near and far sides of the moon. They might compare them in terms of surface features, thickness of the crust, and visibility from Earth.

Enrichment

Encourage students to view and write a review of the award-winning science fiction film “Moon,” which was directed by Duncan Jones (2009). The movie is set on the moon. For the look of the lunar exteriors, the filmmakers relied on the amazing collection of NASA photos from the Apollo missions, which show the moon both from space and from its surface.

Science Inquiry

In the activity “Moon Anomalies” on pages 91–98 in the following document, students will develop hypotheses to explain four anomalies of the moon. They will be expected to prepare written and oral presentations. Then, using a forum format, students will debate the merits of each hypothesis.

http://www.nasa.gov/pdf/58199main_Exploring.The.Moon.pdf

Overcoming Misconceptions

There are several common misconceptions about the moon. Some of them are listed below. Read each misconception aloud, and call on students to state whether it is true or false. Call on other students to restate each misconception so it is true and then explain why each misconception is false. You can click on links to learn more about each misconception at this URL: <http://moon.nasa.gov/moonmisconceptions.cfm>

Misconception: The moon goes around Earth in a single day.

Reality: It takes about a month for the moon to orbit Earth (27.3 days to complete a revolution, but 29.5 days to change from new moon to new moon).

Misconception: The moon makes its own light (the same way the sun does).

Reality: The moon reflects the light of the sun, just as the planets do.

Misconception: The moon does not rotate.

Reality: The moon does rotate, completing a rotation once every 27.3 days. The confusion may be caused by the fact that it also takes about the same amount of time for the moon to orbit the Earth. As a result, the same side of the moon always faces Earth.

Misconception: The same half of the moon is in darkness all the time, that is, there is a dark side of the moon.

Reality: The moon has no side that is constantly dark. The moon's entire surface is eventually lit by the sun as the moon rotates on its axis. It's just that one side is always turned away from Earth. This side is more accurately called the far side because it is farther from Earth than the side we can see.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 24.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 24.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 24.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

What things would be different on Earth if Earth did not have a moon?

If the moon rotated on its axis once every 14 days, would we see anything different than we do now?

How do we know that the moon has been geologically inactive for billions of years?

24.4 Lesson 24.3: The Sun

Key Concepts

- Layers of the sun
- Sunspots, solar flares, and solar prominences
- Solar Dynamics Observatory

Lesson Objectives

- Describe the layers of the sun.
- Describe the surface features of the sun.

Lesson Vocabulary

- **chromosphere:** thin layer of the sun's atmosphere that lies directly above the photosphere and glows red
- **convection zone:** layer of the sun that surrounds the radiative zone and through which energy moves by convection
- **corona:** outermost layer of the sun's atmosphere that consists of plasma and extends millions of kilometers into space
- **nuclear fusion:** nuclear reaction in which nuclei of atoms fuse to form a heavier element and release a huge amount of energy; source of the sun's energy
- **photon:** particle of light
- **photosphere:** visible surface of the sun
- **plasma:** high-energy, high-temperature state of matter that consists of charged ions instead of atoms
- **radiative zone:** layer of the sun surrounding the core where energy moves slowly by electromagnetic waves away from the core
- **solar flare:** violent explosion on the sun's surface
- **solar prominence:** plasma loop flowing between sunspots

Teaching Strategies

Introducing the Lesson

Use the short video at the URL below to introduce students to the sun and how it has been studied, starting with ancient observations of sunspots and continuing through current NASA missions such as SOHO that are studying the sun from space. Tell students they will learn more about the sun and what scientists have learned about it when they read this lesson.

<http://www.jpl.nasa.gov/video/index.php?id=828>

Demonstration

Students will have a better understanding of how the sun's magnetic field creates surface features on the sun if they watch the brief animation at the following URL. Using actual images of the sun from the SOHO mission, the animation shows how the sun's magnetic field winds up and loops out.

http://sohowww.nascom.nasa.gov/gallery/Movies/dynamo/dynamo_snd.mov

Activity

With the activity at the URL below, students will acquire solar images and record coordinates of sunspots. They will calculate and plot the apparent movement of sunspots and describe their shapes. They will determine whether sunspots are features on the surface of the sun as Galileo proposed when he first discovered sunspots, or objects in orbit around it as the early German astronomer Christoph Scheiner claimed. The latter view was more consistent with religious ideas about the infallibility of God and his creations. This activity is a good way to expose students to relationships between science and society and how scientific interpretations may be biased by the belief systems of scientists.

<http://solar-center.stanford.edu/activities/galileo-sunspots.html>

Differentiated Instruction

Use the visuals in the FlexBook® lesson to teach important lesson concepts to students with limited English or reading proficiency. Call students' attention to the relevant images as you discuss the sun's layers, atmosphere, and surface features. You can find additional useful images for this purpose at this URL: <http://sohowww.nascom.nasa.gov/gallery/>.

Enrichment

Ask one or more students to learn about the relationships among solar wind, Earth's magnetosphere, and the aurora that can often be viewed from Earth's surface. Then have them present an explanation for the relationship to the class. The excellent NASA animation at the first URL below is a good visual for them use when they give their presentation.

<http://sohowww.nascom.nasa.gov/gallery/Movies/animation/Solarwind.mpg>

Science Inquiry

With the inquiry activity at the URL below, students can use real NASA images to observe and track sunspots. Then they can use the sunspot data to determine the rate of the sun's rotation.

<http://sohowww.nascom.nasa.gov/classroom/docs/Spotexerweb.pdf>

Overcoming Misconceptions

Some people think that recent global warming is caused by the sun. Tell the class that scientists know the sun is not responsible for global warming. How do they know? The output of energy from the sun has been monitored by satellites for thirty years and has not increased during this period of rapid global warming.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 24.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 24.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 24.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

If something were to suddenly cause nuclear fusion to stop in the sun, how would we know? When would we know?

Are there any types of dangerous energy from the sun? What might be affected by them?

If the sun is made of gases such as hydrogen and helium, how can it have layers?

24.5 Lesson 24.4: The Sun and the Earth-Moon System

Key Concepts

- Day-night cycle
- Earth's seasons
- Solar eclipses
- Lunar eclipses
- Phases of the moon
- Earth's tides

Lesson Objectives

- Describe how Earth's movements affect seasons and cause day and night.
- Explain solar and lunar eclipses.
- Describe the phases of the moon and explain why they occur.
- Explain how movements of Earth and the moon affect Earth's tides.

Lesson Vocabulary

- **crescent moon:** phase of the moon in which the near side of the moon appears to be less than half lit; occurs between the new moon and the first or third quarter
- **gibbous moon:** phase of the moon in which the near side of the moon appears to be more than half lit; occurs between the full moon and the first or third quarter
- **lunar eclipse:** event in which Earth casts a shadow on the moon so the moon cannot be seen from anywhere on Earth
- **penumbra:** outer part of a shadow where light is only partly blocked
- **shadow:** darkness that occurs where a light source is blocked
- **solar eclipse:** event in which the moon casts a shadow on Earth so the sun cannot be seen from the area on Earth's surface where the shadow falls
- **umbra:** inner part of a shadow where light is completely blocked

Teaching Strategies

Introducing the Lesson

Write the term harvest moon on the board, and ask students if they know what it means. (They are unlikely to know the precise definition if they have any idea at all of its meaning.) Explain that the harvest moon occurs each fall

and is defined as the full moon closest to the autumnal equinox. In the Northern Hemisphere, it usually occurs in September or sometimes in October. Add that around the time of the harvest moon, there is a shorter-than-usual time between moonrises for several days in succession. This means shorter periods of complete darkness between sunset and moonrise. The harvest moon no doubt gets its name from the days before artificial lighting when the light of the harvest moon helped farmers harvest their crops. Tell students they will learn more about the full moon and other phases of the moon when they read this lesson.

Demonstration

Use the teen-oriented video from NASA at the following URL to explain to students how solar eclipses occur.

<http://www.neok12.com/php/watch.php?v=zX767b534f7e076a05736267&t=Eclipse>

Differentiated Instruction

Use the short video at the first URL below to show students how a lunar eclipse occurs. This is a good way to explain the phenomenon to visual learners, less proficient readers, and English language learners. Following the video, have students label the interactive lunar eclipse diagram at the second URL to assess their comprehension.

<http://www.neok12.com/php/watch.php?v=zX027e52507b754877644063&t=Eclipse>

<http://www.neok12.com/diagram/Eclipse-01.htm>

Enrichment

Challenge a few creative students to make a three-dimensional model of the sun-Earth-moon system and use it to explain to the rest of the class what causes the monthly cycle of moon phases.

Science Inquiry

In the activity at the following URL, students will learn how the moon and the sun affect ocean tides. They will also use the Internet to gather current regional tidal information, graph the tidal data, and interpret the graphs.

<http://www.sitesalive.com/oil/tg/private/oiltgtides.html>

Overcoming Misconceptions

A common misconception is that the moon appears in different phases in different parts of the world on the same day. Explain to students that everyone on Earth sees the same phases of the moon at the same time. Draw a simple sketch on the board to be sure students understand why this is the case, or use the diagram at this URL: http://www.windows2universe.org/the_universe/uts/moon2.html.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 24.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 24.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 24.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Why don't eclipses occur every single month at the full and new moons?

The planet Mars has a tilt that is very similar to Earth's. What does this produce on Mars?

Venus comes between Earth and the sun. Why don't we see an eclipse when this happens?

CHAPTER

25

HS TE The Solar System

Chapter Outline

- 25.1 CHAPTER 25: THE SOLAR SYSTEM**
 - 25.2 LESSON 25.1: INTRODUCTION TO THE SOLAR SYSTEM**
 - 25.3 LESSON 25.2: INNER PLANETS**
 - 25.4 LESSON 25.3: OUTER PLANETS**
 - 25.5 LESSON 25.4: OTHER OBJECTS IN THE SOLAR SYSTEM**
-

25.1 Chapter 25: The Solar System

Chapter Overview

This chapter discusses the motion of the planets and the formation of the solar system. It also describes the inner and outer planets, dwarf planets, meteoroids, asteroids, and comets.

Online Resources

See the following Web sites for appropriate laboratory activities:

The simulation lab at the following URL focuses on gravity and planetary orbits. It is a virtual inquiry lab that will help students gain an intuitive understanding of how planetary orbits are affected by orbital velocity and the presence of other gravity-producing objects besides the sun.

- <http://phet.colorado.edu/en/contributions/view/3260>

In the lab “Looking Inside Planets” (see Lesson 3 in the PDF document below), students will make scale models of the interiors of the planets and compare them. They will see that the structures of the four inner planets are similar to each other, as are the structures of the four outer planets. They will also discover that the outer planets have rocky cores that are similar in size to Earth.

- http://solarsystem.nasa.gov/docs/modelingsolarsystem_20070112.pdf

In the lab at the following URL, students will observe the differences in thermal behavior between similar materials having different physical properties by making a series of temperature measurements and plotting the results. This will allow students to understand how scientists remotely determine the composition of an object in outer space, in particular how they learn about distant planets in the solar system through remote sensing of thermal properties.

- http://solarsystem.nasa.gov/educ/docs/Sand_Or_Rock.pdf

These Web sites may also be helpful:

The following URL is an excellent series of more than 80 PowerPoint slides that you can use throughout the teaching of this chapter. It covers all of the planets and other objects in the solar system.

- http://www.lpi.usra.edu/education/resources/s_system/solar_sys_overview.ppt

Links to several recommended videos about the solar system can be found at the first URL below. Links to several exceptional Web sites with information, images, and other resources about the solar system can be found at the second URL below. The third URL is a large collection of three-dimensional images of planets and moons that were taken from NASA spacecraft.

- http://www.lpi.usra.edu/education/skytellers/solar_system/audio_video.shtml

- http://www.lpi.usra.edu/education/skytellers/solar_system/web_sites.shtml
- http://www.lpi.usra.edu/publications/slidesets/3dsolarsystem/3d_index.shtml

You can find several solar system activities at this URL: http://hea-www.harvard.edu/ECT/the_book/Chap5/Chapter5.html.

You can access many teacher-reviewed videos about the solar system and individual planets at this URL: <http://www.neok12.com/Solar-System.htm>.

Pacing the Lessons

TABLE 25.1: short caption

Lesson	Class Period(s) (60 min)
25.1 Introduction to the Solar System	2.0
25.2 Inner Planets	2.0
25.3 Outer Planets	1.5
25.4 Other Objects in the Solar System	1.5

25.2 Lesson 25.1: Introduction to the Solar System

Key Concepts

- Geocentric and heliocentric models
- Exoplanets
- Planetary orbits
- Formation of the solar system

Lesson Objectives

- Describe historical views of the solar system.
- Name the planets, and describe their motion around the sun.
- Explain how the solar system formed.

Lesson Vocabulary

- **geocentric model:** early model of the universe that placed Earth at the center and placed other celestial bodies in spheres surrounding Earth
- **heliocentric model:** model proposed by Copernicus that placed the sun at the center of the solar system and placed Earth and the other planets in orbits around the sun
- **moon:** celestial object that orbits a planet
- **nebula:** interstellar cloud of gas and dust
- **nebular hypothesis:** hypothesis that the solar system formed from a spinning cloud of dust and gas
- **solar system:** star such as the sun and all of the planets and other objects that revolve around it due to gravity

Teaching Strategies

Introducing the Lesson

Introduce the solar system with the short video about the solar system at the following URL. After the video, tell students they will learn more about the solar system when they read this chapter.

<http://www.neok12.com/php/watch.php?v=zX54554e5c047a4e7d077d41&t=Solar-System>

Demonstration

Use the excellent series of PowerPoint slides at the URL below when you teach students about the formation of the solar system. It include vivid visuals from NASA and offers a detailed explanation of how the solar system formed.

http://www.lpi.usra.edu/education/resources/s_system/solar_sys_formation.ppt

Building Science Skills

The interactive animation at the following URL shows two important features of orbits: shape and size. Students will experiment with the shape and size of a hypothetical planet's orbit and in the process learn about ellipses, including eccentricity and semi-major axes.

http://www.windows2universe.org/physical_science/physics/mechanics/orbit/orbit_shape_interactive.html

Differentiated Instruction

Students can reinforce their knowledge of the names and order of planets in the solar system with the drag-and-drop activity at the following URL. This is a good exercise for kinesthetic and visual learners.

http://scoilnet.magicstudio.ie/interactive/view/11630?from=search&return_to=%2Frepository%2Fbrowse%3Fsearch_text%3Dsun

Enrichment

Students may be surprised to learn that ideas about extrasolar planets extend back to ancient Greece. They can learn more about the history of these ideas, as well as the long quest for extrasolar planets, with the interactive animated timeline at the first URL below. At the second URL, students can create their own extrasolar planet with the interactive activity "Extreme Planet Makeover."

<http://planetquest.jpl.nasa.gov/system/interactable/2/timeline.html>

<http://planetquest.jpl.nasa.gov/system/interactable/1/index.html>

Science Inquiry

Have students do the activity "Modeling Planets," which is Lesson 2 at the URL below. Students will learn the relative sizes and order of the planets while making a scale model of the solar system using common food items. They will also calculate gravity on planetary surfaces and determine the densities of planets. In addition, they will learn how the density of planets relates to the proportions of different components they contain.

http://solarsystem.nasa.gov/docs/modelingsolarsystem_20070112.pdf

Overcoming Misconceptions

Students commonly think that the solar system is crowded, that is, that planets are much closer together than they actually are. In fact, the distance between planets and between planets and the sun is tremendous. The best way to overcome this misconception is to relate interplanetary distances to distances with which students are familiar. Tell them, for example, that if Earth were the size of a baseball, the distance between Earth and the sun would be about half a mile.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 25.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 25.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

{{Todo | DANA - Comment from JB for question 6: The SE lesson says there are only three dwarf planets: Ceres, Pluto, and Eris.

Lesson Quiz

Check students' mastery of the lesson with Lesson 25.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Would you expect all the planets in the solar system to be made of similar materials? Why or why not?

The planets are often divided into two groups: the inner planets and the outer planets. Which planets do you think are in each of these two groups? What do members of each group have in common?

25.3 Lesson 25.2: Inner Planets

Key Concepts

- Earth
- Mercury
- Venus
- Mars

Lesson Objectives

- Describe key features of each of the inner planets.
- Compare each of the inner planets to Earth and to one another.

Lesson Vocabulary

- **day:** amount of time it takes for a planet to complete one rotation on its axis
- **inner planet:** one of the four planets closest to the sun; Mercury, Venus, Earth, or Mars
- **terrestrial planet:** Earth or any of the other three Earth-like planets (Mercury, Venus, or Mars) that are solid, dense, and rocky
- **year:** amount of time it takes for a planet to complete one revolution around the sun

Teaching Strategies

Introducing the Lesson

Introduce the inner, or terrestrial, planets by asking students to recall from the previous chapter (“Earth, Moon, and Sun”) some of the most salient characteristics of planet Earth. Encourage a diversity of responses and list on the board any characteristics they name that are shared with the other inner planets. Tell students they will learn in this lesson about the planets in the solar system that resemble Earth in these ways.

Cooperative Learning

Students can collaborate to learn more about the inner planets by creating an illustrated booklet about them. Divide the class into four groups and assign each group one of the four inner planets. Within groups, each student should assume responsibility for finding one category of information (e.g., size, mass, and distance from the sun; atmosphere and temperature range; interior layers and composition; surface features; unique properties; and so on), as well as related images, about that planet. Then students within the group should collaborate to assemble all of the

information and images and create their booklet. Arrange a display of the booklets in the classroom, and encourage students to examine the booklets created by other groups. Some suitable sources for information and images include:

- <http://nineplanets.org/>
- <http://www.neok12.com/Solar-System.htm>
- <http://airandspace.si.edu/research/resources/rpif/index.cfm>

Activity

Have students do the activity “Find that Planet!” at the URL below. By doing the activity, they will learn about the celestial coordinate system that astronomers use to identify the locations of objects in space. Students will use the instructions provided to determine the position of a planet at a certain time and date. Then they will plot that position on an appropriate sky map, choosing from a set provided. The final step is for students to actually find the planet in the night sky using the sky map.

<http://cse.ssl.berkeley.edu/SegwayEd/lessons/FindPlanets/Find-hmpg2.html>

Differentiated Instruction

The four inner planets share certain similarities, but they also differ from one another in many important ways. To help students sort out the similarities and differences, have them make a compare/contrast table for the inner planets. They might compare them in terms of size, mass, distance from the sun, moons, atmosphere, temperature, and other properties.

Enrichment

Mars has been the object of several space missions, in part because it seems to be the most suitable planet in our solar system for life to have evolved. Suggest that students who want to learn more about Mars missions go to the URL below. They will find a plethora of information about Mars and its exploration, ranging from Mars in pop culture to the technology behind the Mars rovers. Encourage them to share the most interesting information they learn from the site with the rest of the class in a brief oral report.

<http://mars.jpl.nasa.gov/>

Science Inquiry

Have students do the inquiry activity “Search for a Habitable Planet,” which is Lesson 4 in the following PDF document. Students will define the life requirements of a variety of organisms and learn that these relate to measurable characteristics of planets the organisms might inhabit. By evaluating these characteristics, students will discover that Earth is the only natural home for us in our solar system and that Mars is the next most likely home for life as we know it.

http://solarsystem.nasa.gov/docs/modelingsolarsystem_20070112.pdf

Overcoming Misconceptions

Students commonly think that planets are too far away or too dim to be visible from Earth without a telescope. In fact, five planets (other than Earth) are visible with the unaided eye: Mercury, Venus, Mars, Jupiter, and Saturn. These planets are visible in our sky because they reflect sunlight and shine with a steadier light than distant twinkling stars. In fact, the five planets tend to be quite bright. Tell students to read the article and view the images at the following URL to see how clearly visible the planets can be.

<http://earthsky.org/astronomy-essentials/visible-planets-tonight-mars-jupiter-venus-saturn-mercury#visible-planet>

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 25.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 25.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 25.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

The first humans may reach Mars sometime in the next few decades. What conditions will they face? Why do you think we are going to Mars instead of Mercury or Venus?

Why are the four inner planets called terrestrial planets? What might a planet be like if it weren't a terrestrial planet?

25.4 Lesson 25.3: Outer Planets

Key Concepts

- Jupiter
- Saturn
- Uranus
- Neptune

Lesson Objectives

- Describe key features of the outer planets and their moons.
- Compare the outer planets to each other and to Earth.

Lesson Vocabulary

- **Galilean moons:** Jupiter's four largest moons, which were discovered by Galileo
- **gas giant:** one of the four outer planets, which are composed mainly of the gases hydrogen and helium
- **Great Red Spot:** enormous, oval-shaped, long-lasting storm visible on Jupiter
- **outer planet:** one of the four planets that are located beyond the asteroid belt in the solar system; Jupiter, Saturn, Uranus, or Neptune
- **planetary ring:** ring of dust, rock, and/or other materials encircling a planet in a thin plane

Teaching Strategies

Introducing the Lesson

Introduce the outer planets by playing a guessing game called “Which planet am I?” Give students the following facts about Jupiter and challenge them to guess which planet it is. After the game, tell students they will learn more about Jupiter and the other outer planets when they read this lesson.

- I am the fastest-spinning planet in the solar system.
- I have rings that surround me.
- If you were to stand on my surface, you would weigh 14 times as much as you do on Earth.
- I have 63 moons, including one that is the largest moon in the solar system.
- I have been visited seven times by spacecraft from Earth.
- You can see me from Earth without a telescope.
- I am 2.5 times as massive as all of the other planets in the solar system combined.

Cooperative Learning

Have students do a collaborative, outer planets four-page Web site project to learn about the four planets that are farthest from the sun. Divide the class into four groups, and assign each group one of the four outer planets. Students within each group should work together to create an informative, illustrated Web page about their planet, including its unique features. These URLs are useful resources for this project:

- <http://nineplanets.org/>
- <http://www.neok12.com/Solar-System.htm>
- <http://airandspace.si.edu/research/resources/rpif/index.cfm>

Differentiated Instruction

Students will have a better understanding of what sets the outer planets apart from the inner planets if they make a Venn diagram comparing and contrasting the two sets of planets.

Enrichment

Suggest that students who are interested in space exploration learn about the Cassini Mission to Saturn. Cassini was designed to explore the Saturnian system from orbit: the planet and its atmosphere, rings and magnetosphere, and its moons, particularly Titan and the icy satellites. Cassini also carried Europe's Huygens probe to its rendezvous with Titan. Students can learn more about the Cassini Mission at the following URLs. After their research, ask them to share what they learn in a PowerPoint presentation to the class.

- <http://solarsystem.nasa.gov/missions/profile.cfm?MCode=Cassini>
- <http://solarsystem.nasa.gov/missions/profile.cfm?MCode=Cassini&Display=ReadMore>
- <http://saturn.jpl.nasa.gov/>

Science Inquiry

In the inquiry activity at the URL below (which was written for high school students in addition to middle school students), students will investigate how the density of Jupiter's moons is related to their diameter and their distance from Jupiter.

<http://lasp.colorado.edu/education/outerplanets/lessons/grades6-8/The%20Moons%20of%20Jupiter.pdf>

Science Inquiry

Another inquiry activity about Jupiter's moons is available at the following URL. In this activity, students will apply the scientific method and do a simplified version of Galileo's pioneering observations of Jupiter's moons. They will look at data showing the positions of the moons of Jupiter over nine nights and follow the motions of each moon to determine its orbital period around Jupiter.

<http://www.astrosociety.org/edu/slooh/footsteps.pdf>

Overcoming Misconceptions

Students may erroneously think that the gas giants are nothing but balls of gas so a spacecraft could fly right through them. Make sure students realize that the gas giants actually have rocky cores of heavier elements. Only their outer layers consist of gas. A good way to overcome the misconception is by sharing the diagram at the URL below, which

shows the layers of the gas giants. The diagram also shows how large the gas giants are compared with planet Earth (in the upper right corner of the diagram). Point out how the inner cores of the two largest gas giants are similar in size to Earth.

http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=166

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 25.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 25.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 25.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

The inner planets are small and rocky, while the outer planets are large and gaseous. Why might the planets have formed into these two groups?

We have discussed the sun, the planets, and the moons of the planets. What other objects can you think of that can be found in our solar system?

25.5 Lesson 25.4: Other Objects in the Solar System

Key Concepts

- Asteroids
- Meteoroids
- Comets
- Dwarf planets

Lesson Objectives

- Locate and describe the asteroid belt.
- Explain where comets come from and what causes their tails.
- Differentiate between meteors, meteoroids, and meteorites.

Lesson Vocabulary

- **asteroid:** small, irregularly shaped rocky body that orbits the sun, typically in a belt of asteroids located between the orbits of Mars and Jupiter
- **asteroid belt:** region between the orbits of Mars and Jupiter where the majority of asteroids are located
- **comet:** small icy, dusty object with a bright tail that orbits the sun
- **dwarf planet:** celestial body orbiting a star that meets all the criteria of a planet except that it has not cleared its orbit of other objects
- **Kuiper belt:** region of the solar system beyond the orbit of Neptune that contains millions of frozen objects
- **meteor:** chunk of rock from space that burns up as it passes through Earth's atmosphere
- **meteor shower:** event in which many meteors fall through the atmosphere because Earth passes through a cluster of meteoroids
- **meteoroid:** small rock in interplanetary space that has not entered Earth's atmosphere

Teaching Strategies

Introducing the Lesson

Show students the animation at the following URL without telling them what it represents. Ask them if they can identify what it shows. (They are likely to recognize the sun and the nearly circular orbit of a terrestrial planet such as Earth, but they may not recognize the highly elliptical orbit of the comet.) Point out the tail of the comet when it is close to the sun, and tell students this is a strong hint as to what it is. If need be, tell them that the object represents a comet orbiting the sun. Add that they will learn in this lesson about comets and other non-planetary objects that orbit the sun.

<http://www.st-andrews.ac.uk/bds2/ltsn/ljm/JAVA/COMETORB/orbit.gif>

Cooperative Learning

Divide the class into groups, and assign each group one of the non-planetary objects that orbits the sun: meteoroids, asteroids, comets, and the individual dwarf planets. Tell students within groups to become “experts” on their orbiting bodies. Then have each group create an illustrated poster to share their expert knowledge. Urge them to make their posters eye-catching and creative and to include information beyond what is found in the FlexBook® lesson. Give each group an opportunity to present its poster to the class, and then display the posters in the classroom.

Differentiated Instruction

Give students copies of a simple solar system diagram showing only the sun and planets (see URLs below for samples). Then ask students to add labeled sketches to the diagram to represent the following: asteroid belt (between Mars and Jupiter), Kuiper belt (beyond Neptune’s orbit), and Oort cloud (beyond the Kuiper belt). They should also add a few words to each sketch to indicate the type of orbiting bodies found there.

- http://upload.wikimedia.org/wikipedia/commons/0/0c/Quad-solarsystem_BD%E2%88%9222_5866.jpg
- <http://amazingspacepictures.info/diagram-of-the-solar-system.html>

Enrichment

Ask students who are especially interested in space exploration to learn about careers in space science. The following URLs are good sources of information. They should address such questions as: What are some specific careers in space science? What types of work do space scientists do? Where are space scientists employed? What educational background is required? Have the students choose the career that most interests them and report on it to the class. Ask them to explain why they are most interested in that career.

- <http://www.nasa.gov/audience/forstudents/postsecondary/career/>
- http://jobs.lovetoknow.com/Careers_in_Space_Science
- <http://sciencenetlinks.com/blog/snl-educator/careers-space-science-not-just-astronauts/>

Science Inquiry

Have students do the inquiry activity “Comparing Comets” at the following URL. In the activity, students will play the role of cometary scientist by observing and comparing the surfaces of two comet nuclei. They will propose possible causes for the differences between the two nuclei and list questions they have about them.

http://epoxi.umd.edu/pdfs/Comparing_Cometes_SA.pdf

Overcoming Misconceptions

Students may have the misconception that when a meteor shower occurs, meteors pour out of the sky like raindrops. Explain that a meteor shower is nothing like this. In a typical meteor shower, you are unlikely to see more than a few dozen meteors per hour. During the best meteor displays, the maximum rate of meteors might be about one per minute—not exactly a downpour!

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 25.4 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 25.4 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 25.4 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

In 2006, astronomers changed the definition of a planet and created a new category of dwarf planets. Do you think planets, dwarf planets, moons, asteroids, and meteoroids are clearly separate groups?

What defines each of these groups, and what do objects in these different groups have in common? Could an object change from being in one group to another? How?

We have learned about many different kinds of objects that are found within our solar system. What objects or systems of objects can you think of that are found outside our solar system?

CHAPTER **26** HS TE Stars, Galaxies, and the Universe

Chapter Outline

- 26.1 CHAPTER 26: STARS, GALAXIES, AND THE UNIVERSE
 - 26.2 LESSON 26.1: STARS
 - 26.3 LESSON 26.2: GALAXIES
 - 26.4 LESSON 26.3: THE UNIVERSE
-

26.1 Chapter 26: Stars, Galaxies, and the Universe

Chapter Overview

This chapter describes constellations and the classification of stars. It explains how stars produce energy and how stars evolve. Also included are multiple star systems, types of galaxies, black holes, the Big Bang Theory, and dark matter and dark energy.

Online Resources

See the following Web sites for appropriate laboratory activities:

The star lab at the URL below is divided into six investigations that can be done and evaluated separately. Each section has a combination of linked Internet sites to engage students and content questions they are to answer by visiting the linked sites. Most sections have a self-scored online quiz, and the last section has a Java applet for students to arrange stars of various temperatures in correct order on a Hertzsprung-Russell diagram of Luminosity vs. Temperature.

- <http://cse.ssl.berkeley.edu/SegwayEd/abtstellar.html>

In the interesting lab activity at the following URL, students estimate the number of civilizations in the Milky Way Galaxy by first estimating the number of craters on the moon and then by performing estimates of multiple-variable systems, culminating in the use of the Drake Equation.

- <http://btc.montana.edu/ceres/html/DrakeEquation/Drake.htm>

In the virtual spectroscopy lab at the URL below, students will use an online virtual spectroscope to examine the spectrum from a galaxy and determine whether it is moving toward or away from Earth and how quickly it is moving.

- <http://www.cfa.harvard.edu/seuforum/galSpeed/>

These Web sites may also be helpful:

You can find numerous links to useful star and galaxy Web sites at this URL: http://www.lpi.usra.edu/education/skytellers/galaxies/web_sites.shtml.

Go to this URL for recommended videos on galaxies, including the Milky Way Galaxy: http://www.lpi.usra.edu/education/skytellers/galaxies/audio_video.shtml.

At the URL below, you can find a long list of frequently asked questions and answers in cosmology. [http://www.aastro.ucla.edu/wright/cosmology_faq.html](http://www.astro.ucla.edu/wright/cosmology_faq.html)

NASA provides more information about chapter topics at these URLs:

- Stars: <http://science.nasa.gov/astrophysics/focus-areas/how-do-stars-form-and-evolve/>
- Galaxies: <http://science.nasa.gov/astrophysics/focus-areas/what-are-galaxies/>

- The Big Bang: <http://science.nasa.gov/astrophysics/focus-areas/what-powered-the-big-bang/>
- Black holes: <http://science.nasa.gov/astrophysics/focus-areas/black-holes/>
- Dark matter and dark energy: <http://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy/>

This booklet from NASA provides extensive background information and several activities on black holes for high school students.

- http://imagine.gsfc.nasa.gov/docs/teachers/blackholes/imagine/imagine_book.pdf

Pacing the Lessons

TABLE 26.1: short caption

Lesson	Class Period(s) (60 min)
26.1 Stars	2.0
26.2 Galaxies	1.5
26.3 The Universe	1.5

26.2 Lesson 26.1: Stars

Key Concepts

- Constellations
- Nuclear fusion in stars
- Classification of stars
- Lifetime of stars
- Measuring star distances
- Parallax

Lesson Objectives

- Define constellation.
- Describe the flow of energy in a star.
- Classify stars based on their properties.
- Outline the life cycle of a star.
- Use light-years as a unit of distance.

Lesson Vocabulary

- **asterism:** group of stars that appear from Earth to be close together in the sky
- **black hole:** super-dense core left after a supergiant star explodes as a supernova
- **main sequence star:** star that is actively fusing hydrogen atoms to form helium; considered to be a star in the main portion of its “life”
- **neutron star:** remnant of a massive star after it explodes as a supernova
- **nuclear fusion:** nuclear reaction that releases a huge amount of energy when two nuclei fuse to form a larger nucleus, such as two hydrogen nuclei fusing to form a helium nucleus
- **parallax:** method used by astronomers to calculate the distance to nearby stars, using the apparent shift of the star relative to more distant stars
- **red giant:** stage in a star’s “life” when the inner helium core contracts and the outer hydrogen layers expand
- **star:** glowing sphere of gases that produces light through nuclear fusion reactions in its core
- **supernova:** tremendous explosion that occurs when the core of a star is mostly iron
- **white dwarf:** small- to mid-sized star that has collapsed

Teaching Strategies

Introducing the Lesson

Show students images of constellations that are clearly visible in your part of the world. (Pictures of some well-known constellations can be found at the URLs below.) Point out that constellations are patterns of stars as they appear from Earth. Ask students if they can identify the constellations in one or more of the images. Identify the constellations if students cannot name them, and explain how they got their names. For example, the constellation in the image at the first URL below is Orion, which is one of the most recognizable constellations all over the world. Orion is named for a hunter in Greek mythology. Point out the stars in Orion's "belt," which holds his dagger. Explain that constellations are important for stargazers because they can help them locate particular stars in the night sky. Tell students they will learn more about constellations and stars in this lesson.

- <http://en.wikipedia.org/wiki/File:OrionCC.jpg>
- <http://en.wikipedia.org/wiki/File:UrsaMajorCC.jpg>
- <http://en.wikipedia.org/wiki/File:CassiopeiaCC.jpg>

Activity

The activity "Life Cycle of Stars" has students first analyze characteristics of the human life cycle and then apply them to various NASA pictures of stars to synthesize patterns of stellar life cycles. Specifically, students will sequence pictures of human beings by age, describe the observational characteristics used to determine a life cycle, observe NASA images of stars at various life cycle stages, synthesize a stellar life cycle based on observations, contrast their star life sequence with that of astronomers, and create a star life cycle concept map.

<http://btc.montana.edu/ceres/html/LifeCycle/stars1.html>

Building Science Skills

In the activity "A Case of the Wobbles: Finding Extra-Solar Planets" at the following URL, students will plot and analyze NASA data to determine the period of an invisible planet orbiting a wobbling star.

<http://btc.montana.edu/ceres/html/Wobble/Wobbles.htm>

Differentiated Instruction

Work with students to create a flow chart that shows the sequence of stages through which stars pass during their "lifetime." The chart will have branches to allow for different stages for small and large stars. Suggest that students keep their flow chart in their science notebook.

Enrichment

Assign the short and very entertaining article at the following URL. It is a good extension for the Building Science Skills activity above. The article describes the real-life discovery of a planet around the most famous star system in the sky, Alpha Centauri, which is the star system closest to our sun. The planet was detected by its gravitational effect on the stars in the system.

<http://blogs.discovermagazine.com/badastronomy/2012/10/16/alpha-centauri-has-a-planet/>

Science Inquiry

With the inquiry activity at the following URL, students will download NASA Hubble Space Telescope (HST) views of star-forming regions in nebulae and look for evidence of planetary systems forming beyond our own solar system. Specifically, students will hypothesize about mysterious objects in NASA HST images, systematically search NASA images of the Orion nebula for protoplanets, and study star charts to find night-sky locations of other planetary systems.

<http://btc.montana.edu/ceres/html/Disks/disks1.html>

Overcoming Misconceptions

Because most stars appear to observers on Earth as tiny points of twinkling light, some people erroneously believe that all stars are the same distance from Earth. Prove to students that this is not the case by giving them the distances from Earth of several different stars. You can use the stars below as examples. Tell students that all of the stars in the list are found in our own galaxy, the Milky Way Galaxy, so most stars are much farther from us than these.

- Proxima Centauri (star nearest to our sun): 4.2 light-years
- Polaris (also known as the North Star): 323 light-years
- Atlas (in the Pleiades constellation): 434–446 light-years
- Deneb (most distant star in the Milky Way galaxy that is visible with the unaided eye): 1400–3230 light-years

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 26.1 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 26.1 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 26.1 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Although stars may appear to be close together in constellations, they are usually not close together out in space. Can you think of any groups of astronomical objects that are relatively close together in space?

Most nebulas contain more mass than a single star. If a large nebula collapsed into several different stars, what would the result be like?

26.3 Lesson 26.2: Galaxies

Key Concepts

- Star systems and star clusters
- Types of galaxies
- Milky Way Galaxy

Lesson Objectives

- Distinguish between star systems and star clusters.
- Identify different types of galaxies.
- Describe our own galaxy, the Milky Way Galaxy.

Lesson Vocabulary

- **binary stars:** system of two stars that orbit a common center of mass
- **dwarf galaxy:** small galaxy containing a few million to a few billion stars
- **elliptical galaxy:** oval-shaped galaxy with older stars and little gas and dust
- **galaxy:** group of millions or billions of stars held together by gravity
- **globular cluster:** group of tens to hundreds of thousands of stars tightly held together by gravity
- **irregular galaxy:** galaxy that is neither spiral nor elliptical in shape
- **Milky Way Galaxy:** spiral galaxy in which Earth and our solar system are located
- **open cluster:** group of up to a few thousand stars loosely held together by gravity
- **spiral arm:** region of gas, dust, and young stars that wind outward from the central bulge of a spiral galaxy
- **spiral galaxy:** rotating galaxy with a central bulge and spiral arms
- **star cluster:** group of thousands of stars held together by gravity
- **star system:** small group of stars that are close together

Teaching Strategies

Introducing the Lesson

Define galaxy and tell students that our solar system is located in the Milky Way Galaxy. Share the following impressive facts and figures about galaxies with students, and then tell them they will learn more about galaxies in this lesson.

- The name of our galaxy as well as the term galaxy itself refers to the appearance of our galaxy as a milky or cloudy area in the sky when viewed from Earth without a telescope.

- There are as many as 200 billion stars in the Milky Way Galaxy and it has a diameter of 100,000 light-years.
- It takes the solar system about 200 million years to complete one revolution around our galaxy's center.
- The largest known galaxy is almost 80 times wider than the Milky Way, with a diameter of about 5.6 million light-years.
- The galaxy nearest the Milky Way is more than 70,000 light-years from Earth.
- The most distant galaxy is nearly 13.2 billion light-years from Earth.

Building Science Skills

Students can learn more about galaxies and how they are studied as well as develop knowledge and skills in statistics with the activity “Online Exploration: Galaxy Hunter” (see URL below). The activity uses real data from the Hubble Space Telescope. Students will investigate bias in sampling techniques and determine optimal sample size based on variability of different-sized samples. They will also use statistical data to make conjectures about the universe. Teaching tips and background information on statistics are included.

<http://amazing-space.stsci.edu/resources/explorations/ghunter/home.html>

Demonstration

The interactive video at the following URL shows how galaxies evolve through collisions with other galaxies. It outlines the eventual fate of our own galaxy, the Milky Way Galaxy, which is expected to collide with the Andromeda Galaxy. The video also introduces the expanding universe, which students will learn more about in the next lesson.

http://hubblesite.org/explore_astronomy/cosmic_collision/cosmic_collision.swf

Differentiated Instruction

Suggest that students may a three-way Venn diagram to compare and contrast spiral, elliptical, and irregular galaxies.

Enrichment

Encourage interested students to learn more about multiple star systems and their orbits. They can see animations of different types of multiple star orbits at the first URL below. The second URL describes different types of multiple star systems.

- <http://www.atlasoftheuniverse.com/orbits.html>
- http://orionatlas.wikia.com/wiki/Multiple_Star_Systems

Science Inquiry

In the inquiry activity “Galactic Inquiry” at the URL below, students will view NASA images of galaxies and develop a galaxy classification scheme. Then they will compare and contrast their classification scheme with that developed by Edwin Hubble. Specific learning objectives of the activity include understanding that galaxies take a variety of forms and developing and applying a galactic classification scheme.

<http://btc.montana.edu/ceres/html/Galaxy/gal1.html>

Overcoming Misconceptions

A recent study of students' misconceptions about astronomy found the misconceptions about galaxies listed below. Use these misconceptions as a true/false quiz with your students to identify which misconceptions they believe to

be true. Then explain why each identified misconception is false and provide evidence to support the explanation. You can learn more about the study at this URL: <http://blogs.physicstoday.org/thedayside/2012/07/analyzing-students-misconceptions-about-galaxies/>

- The Milky Way is the only galaxy.
- The solar system is not in the Milky Way (or any other) Galaxy.
- All galaxies are spiral.
- The Milky Way is the center of the universe.
- The sun is at the center of the Milky Way Galaxy.
- The sun is at the center of the universe.
- There are only a few galaxies.
- Galaxies are randomly distributed throughout the universe.
- We can see all the stars that are in the Milky Way Galaxy.
- All galaxies are the same in size and shape.
- The Milky Way is just stars—no gas and dust.
- New planets and stars are not still forming today.

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 26.2 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 26.2 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 26.2 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

Objects in the universe tend to be grouped together. What forces or factors do you think cause objects to form and stay in groups?

- [Object form and stay in groups because of gravity.]

Some people used to call galaxies “island universes.” Are they really universes?

- [No; the universe is expanding outward in all directions and contains all of space and time, whereas individual galaxies do not expand and are only a small part of the universe.]

Can you think of anything, either an object or a group of objects, that is bigger than a galaxy?

- [The entire universe is far bigger than a galaxy. In fact, it contains an estimated hundred billion galaxies.]

26.4 Lesson 26.3: The Universe

Key Concepts

- Hubble’s contribution to knowledge of the universe
- Expansion of the universe
- Big Bang Theory
- Dark matter and dark energy

Lesson Objectives

- Explain the evidence for an expanding universe.
- Describe the formation of the universe according to the Big Bang Theory.
- Define dark matter and dark energy.

Lesson Vocabulary

- **Big Bang Theory:** theory that all matter and energy were at one time compressed into a very small volume and exploded in a “big bang” that started everything expanding outward and formed the universe
- **cosmology:** study of the universe
- **dark energy:** as yet undiscovered form of energy that we cannot detect
- **dark matter:** matter in the universe that we cannot see because it does not emit light
- **Doppler effect:** change in the frequency of a wave that is apparent to an observer who is moving relative to the source of the wave
- **redshift:** shift of wavelengths of light toward the red end of the spectrum that occurs as a light source moves away from the observer
- **universe:** everything that exists; all matter, energy, space, and time

Teaching Strategies

Introducing the Lesson

Introduce students to the universe with the excellent 6-minute video “The Known Universe” from the American Museum of Natural History. The video will impress them with the incredible vastness of the universe. It will take them from Earth’s surface through our atmosphere and the inky black of space to the afterglow of the Big Bang. The film was created as part of an exhibition entitled “Visions of the Cosmos.”

<http://www.youtube.com/watch?v=17jymDn0W6U>

Building Science Skills

Have students do the activity “Online Exploration: No Escape: The Truth About Black Holes” at the following URL. The activity provides an opportunity for students to research the fascinating topic of black holes and to examine the concepts of escape velocity, gravity, mass, and the speed of light as they apply to black holes. Dramatic illustrations and spectacular Hubble Space Telescope images illustrate the activity and provide data that the students will use to hunt for black holes in the centers of galaxies.

<http://amazing-space.stsci.edu/resources/explorations/blackholes/lesson/>

Differentiated Instruction

This lesson covers some difficult content, such as an expanding universe, black holes, and dark matter. Suggest that students make a main ideas/details chart of the lesson to help them organize the material and reduce it to the most important points. Tell students that a general rule of thumb is to have at least one main idea per heading or sub-heading in the lesson and to include only the most important details that support each main idea.

Enrichment

Suggest to your more advanced students that they explore the theoretical foundations of the big bang, including Einstein’s theory of general relativity and the cosmological principle. They can start with these URLs:

- http://map.gsfc.nasa.gov/universe/bb_theory.html
- http://map.gsfc.nasa.gov/universe/bb_concepts.html

Science Inquiry

In the inquiry activity “The Expanding Universe” (see URL below), students will gain a deeper understanding of cosmology. They will develop authentic models and gather evidence supporting the Big Bang Theory. The activity uses observations, interactive media, and scientific models.

<http://btc.montana.edu/ceres/html/Universe/uni1.html>

Overcoming Misconceptions

The excellent article at the following URL discusses some common misconceptions about the expanding universe and Big Bang Theory. Reading the article may help you become aware of possible misconceptions in your students and ways to overcome them.

http://space.mit.edu/kcooksey/teaching/AY5/MisconceptionsabouttheBigBang_ScientificAmerican.pdf

Reinforce and Review

Lesson Worksheets

Copy and distribute the Lesson 26.3 worksheets in *CK-12 Earth Science for High School Workbook*. Ask students to complete the worksheets alone or in pairs to reinforce lesson content.

Lesson Review Questions

Have students answer the Review Questions at the end of Lesson 26.3 in *CK-12 Earth Science for High School*. The answer key can be found in the Resource tab above the Table of Contents.

Lesson Quiz

Check students' mastery of the lesson with Lesson 26.3 Quiz in *CK-12 Earth Science for High School Quizzes and Tests*.

Points to Consider

The expansion of the universe is sometimes modeled using a balloon with dots marked on it, as described earlier in the lesson. In what ways is this a good model, and in what ways does it not correctly represent the expanding universe? Can you think of a different way to model the expansion of the universe?

The Big Bang theory is currently the most widely accepted scientific theory for how the universe formed. What is another explanation of how the universe could have formed? Is your explanation one that a scientist would accept?