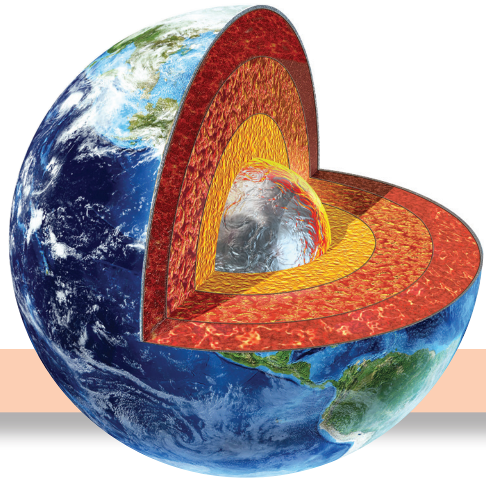
Core Knowledge® SCIENCE

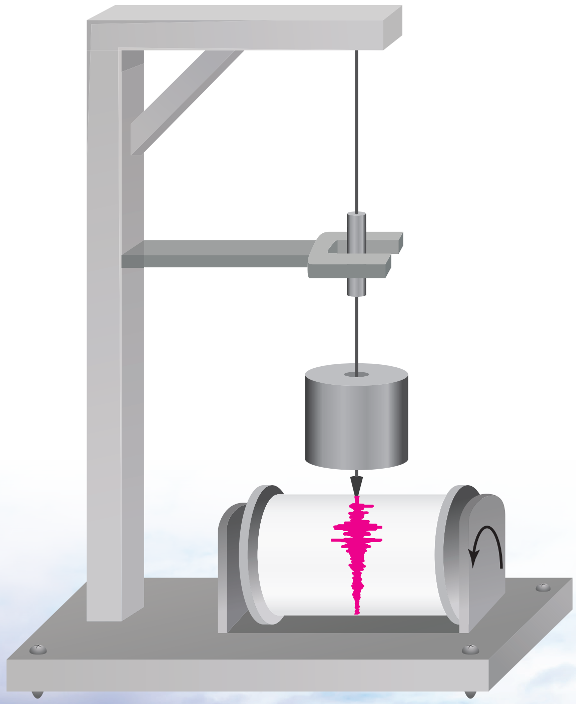
Processes That Shape Earth

Teacher Guide

Earth's hot interior



Volcanic activity



Measuring and recording seismic waves

Weathering and erosion

Processes That Shape Earth

Teacher Guide

www.coreknowledge.org

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Processes That Shape Earth

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Teacher Guide

Core Knowledge Science™ 4

UNIT 4

Introduction

About this Unit

The Big Idea

This unit focuses on Earth's composition and the processes that shape it over time.

Geologists investigate Earth's layers: the inner core, outer core, mantle, and crust. Earth's crust is not one solid thing; it is divided into huge parts, each of which moves independently over time. The ocean lies over much of the crust. Both land on the surface of Earth and the ocean's solid seafloor have features such as mountains, volcanoes, and flat areas.

By studying rocks, rock layers, and fossils, geologists have found evidence that the structure of Earth's surface has changed over time. Many processes, including weathering and erosion, change Earth over time. Mountains may be formed when large parts of Earth's crust push against each other.

Some natural geological events that change Earth's surface—such as earthquakes, tsunamis, volcanic eruptions, and mudslides—can be hazardous to people. Understanding the large-scale processes behind these events can help people engineer safeguards, such as earthquake-resistant buildings, that consider potential damage and danger. Communities also develop preparedness plans to help minimize the effects of natural hazards and to protect people in cases of emergency.

Note to Teachers and Curriculum Planners

This unit introduces Grade 4 students to real-world examples and fundamental concepts that will be explored in greater depth in later grades. Students will learn about how changes on Earth's surface affect people and will research the causes of geologic events that occur in their area, often due to large-scale system interactions on our planet. The following are preliminary considerations for planning and instruction relative to this unit:

- The study of geology is addressed here as a project-based learning (PBL) unit. Read more about project-based and problem-based learning on page 3.
- This unit introduces students to rock layers and patterns of rock formations as evidence of change; however, assessments do not include identification or memorization of specific steps in the rock cycle.
- Assessment of students' understanding that Earth changes over time is also limited to relative time and does not include specific definitions of geologic time periods/ages.
- Learning and research in this unit will prepare students for CKSci Grade 5 Unit 3, *Modeling Earth's Systems,* which explores interactions between Earth's different "spheres," such as the geosphere/atmosphere/hydrosphere.

Note to Core Knowledge Teachers

Thanks to ongoing research in the field, our understanding of how children learn continues to evolve. In the subject area of science, in particular, students benefit from not just reading about concepts and ideas, but also hands-on experiences. Following the release of the Next Generation Science Standards (NGSS), the Core Knowledge Foundation used this opportunity to update and enhance the science portion of the *2010 Core Knowledge Sequence*. The result of this effort is the revised *2019 Core Knowledge Science Sequence*.

While there have been some shifts in the grade levels at which certain topics are recommended, the fundamental principles of pedagogy inherent to the Core Knowledge approach, such as the importance of building a sequential, coherent, and cumulative knowledge base, have been retained.

Online Resources

To download the *2019 Core Knowledge Science Sequence*, use the links found in the Online Resources Guide.

www.coreknowledge.org/cksci-online-resources

This science unit, aligned to the *2019 Core Knowledge Science Sequence* and informed by NGSS, embodies Core Knowledge's vision of best practices in science instruction and knowledge-based schooling, such as the following:

- building students' knowledge of core ideas in life, physical, and Earth sciences, as well as engineering design
- developing scientific practices that give students firsthand experience in scientific inquiry, engineering, and technology
- connecting scientific learning to concepts across various disciplines, such as mathematics and literacy

To see how you can continue to use your current Core Knowledge materials with the 2019 CKSci™ curriculum, please see below an example of how this unit compares to the *2010 Core Knowledge Sequence*.

Examples of content retained from the *2010 Core Knowledge Sequence*	**Examples of Core Knowledge content in this CKSci unit**

Geology (Grade 4)
• Earth's layers: cores, mantle, crust
  o Movement of crustal plates
  o Earthquakes, volcanoes, geysers, etc.
• How mountains are formed, including volcanic, folded/fault-block/dome, and undersea mounts and trenches
• Formation and characteristics of metamorphic, igneous, and sedimentary rock
• Weathering and erosion by water, wind, and glaciers
	Features of Earth
	• Geologists study Earth's surface and its interior and the processes that have changed it over time.
	• Different kinds of maps are used to study patterns of features, including mountains, seamounts, volcanoes.
	Evidence that Earth's Surface Has Changed over Time
	• By studying rocks and rock layers, geologists can create models of what Earth was like in the past.
	How Geologic Events Affect People
	• Protecting people from geologic events, including earthquakes, tsunamis, volcanic eruptions, mudslides, etc.
	• Using data and tools to predict potential disasters

For a complete look at how CKSci relates to the *2010 Sequence*, please refer to the full Correlation Charts available for download using the Online Resources Guide for this unit: **www.coreknowledge.org/cksci-online-resources**	

Problem-Based Learning Projects

This unit is a **CKSci Problem-based Learning Unit** (PBL, also known as Project-based Learning).

In this pedagogical approach, lessons culminate in a capstone project that occurs at the end of the unit. Each lesson includes guidance for teachers to connect individual objectives to the capstone experience.

One key aspect of the CKSci Problem-based Learning Units is that students engage with their community—that is, the capstone project is presented to an audience beyond the classroom. The audience is often defined by the students themselves. The audience may include other classes at your school, parents/guardians, school principals, and/or scientists and engineers in your area. The goal is for the community to help determine how well students have applied their knowledge as they communicate possible solutions to real-world problems.

Advance preparation is critical to the success of a CKSci Problem-based Learning Unit. Please refer to the recommendations found throughout the lessons of this Teacher Guide. The goal of this unit is for students to present solutions based on what they learn across multiple lessons and to interact with their community during and after their culminating presentations.

What are the relevant NGSS Performance Expectations for this unit?*

This unit, *Processes That Shape Earth*, has been informed by the following Grade 4 Performance Expectations for the NGSS topic *Earth's Systems: Processes That Shape the Earth*. Students who demonstrate understanding can

4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Online Resources

For detailed information about the NGSS references, follow the links in the Online Resources Guide for this unit. Use the following link to download any of the CKSci Online Resources Guides:

www.coreknowledge.org/cksci-online-resources

Sources:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

What Students Should Already Know

The concept of progressions, articulated in the National Research Council's *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, is very much aligned to the Core Knowledge principle of building new knowledge on prior knowledge. According to the NRC, students build "progressively more sophisticated explanations of natural phenomena" over the course of many years of schooling. "Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning." In schools following NGSS recommendations, teachers can build on the "prior understandings" captured in the following summaries of NGSS Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

Grades K–2

- Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties (e.g., visual, aural, textural), by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes.

PS1.B: Chemical Reactions

Grades K–2

- Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing), and sometimes they are not (e.g., baking a cake, burning fuel).

PS2.A: Forces and Motion

Grades K–2

- Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.

PS2.B: Types of Interactions

Grades K–2
- When objects touch or collide, they push on one another and can change motion or shape.

PS2.C: Stability and Instability in Physical Systems

Grades K–2
- Whether an object stays still or moves often depends on the effects of multiple pushes and pulls on it (e.g., multiple players trying to pull an object in different directions). It is useful to investigate what pushes and pulls keep something in place (e.g., a ball on a slope, a ladder leaning on a wall) as well as what makes something change or move.

PS3.A: Definitions of Energy

Grade 4
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

PS3.B: Conservation of Energy and Energy Transfer

Grade 4
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

PS3.D: Energy in Chemical Processes and Everyday Life

Grade 4
- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.

ESS1.C: The History of Planet Earth

Grades K–2
- Some events on Earth occur in cycles, like day and night, and others have a beginning and an end, like a volcanic eruption. Some events, like an earthquake, happen very quickly; others, such as the formation of the Grand Canyon, occur very slowly, over a time period much longer than one can observe.

ESS2.D: Weather and Climate

Grade 3

- Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.
- Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

ESS2.E: Biogeology

Grades K–2

- Plants and animals (including humans) depend on the land, water, and air to live and grow. They in turn can change their environment (e.g., the shape of land, the flow of water).

ESS3.A: Natural Resources

Grades K–2

- Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from Earth to make cooking pans.

ESS3.C: Human Impacts on Earth Systems

Grades K–2

- Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.

ETS1.A: Defining and Delimiting Engineering Problems

Grade 3

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

Grade 3

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

ETS2.A: Interdependence of Science, Engineering, and Technology

Grades K–2

- People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas.

ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Grades K–2

- People depend on various technologies in their lives; human life would be very different without technology. Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. Thus, developing and using technology has impacts on the natural world.

LS1.B: Growth and Development

Grades K–2

- Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

Grade 3

- Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

LS1.C: Organization for Matter and Energy Flow in Organisms

Grades K–2

- All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

LS1.D: Information Processing

Grades K–2

- Animals have body parts that capture and convey different kinds of information needed for growth and survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator). Plants also respond to some external inputs (e.g., turn leaves toward the sun).

LS2.A: Ecosystems: Interactions, Energy, and Dynamics

Grades K–2

- Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat, and chew the food. Plants depend on air, water, minerals (in the soil), and light to grow. Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight.

What Students Need to Learn

For this unit, the *Core Knowledge Science Sequence* specifies the following content and skills. Specific learning objectives are provided in each lesson throughout the unit. NGSS References, including Performance Expectations, Disciplinary Core Ideas, and Crosscutting Concepts, are included at the start of each lesson as appropriate.

A. Problem-Based Learning Introduction — Lesson 1

- Plan and develop a model solution to reduce the effects of one kind of geologic event (such as an earthquake, tsunami, or volcanic eruption).

B. The Structure of Our Earth — Lessons 2–4

- Provide examples of what geologists study.
- Identify and describe four layers of Earth.
- Create and use a model to show Earth's layers.
- Interpret maps to discern patterns of major geologic features of Earth's surface.
- Create and use a model to show some of Earth's main geologic features.
- Describe major features of Earth's surface.
- Compare three different types of rocks: sedimentary, metamorphic, and igneous.

C. Earth's Moving Crust — Lessons 5–9

- Create and use a model to show how rock layers can provide evidence for change in Earth's surface over time.
- Explain what fossils are and what geologists can learn from them.
- Interpret fossil evidence to show that Earth's surface has changed over time.
- Describe a change over time in Earth's surface that led to the formation of mountains.

D. Other Changes on Earth's Surface — Lessons 10–13

- Explain different ways in which weathering can break down rocks.
- Construct a graphic representation to provide evidence of the effects of weathering by various phenomena.
- Explain what erosion is and how erosion changes Earth's surface.

E. Managing the Effects of Earth's Natural Processes in Our Area — Unit Capstone

- Identify types of geological hazards and natural disasters and some of their consequences.
- Describe an existing engineering solution to protect people from geological natural hazards.
- Plan and develop a model solution to reduce the effects of one kind of geologic event (such as an earthquake, tsunami, or volcanic eruption).

What Teachers Need to Know

Supportive information on the content standards and the science they address is provided throughout the lessons at points of relevance:

Know the Standards: These sections, found later in this Teacher Guide, explain what to teach and why, with reference to NGSS and Core Knowledge expectations.

Know the Science: These sections provide supporting, adult-level, background information or explanations related to specific examples or Disciplinary Core Ideas.

Using the Student Reader

Student Reader

The *Processes That Shape Earth* Student Reader has seven chapters and a student Glossary providing definitions to Core Vocabulary words. Engaging text, photographs, and diagrams encourage students to draw upon their own experiences and the world around them to understand scientific concepts. In addition to Core Vocabulary, the Student Readers include a feature called Word to Know, which provides background information to help students understand key terms, and may sometimes include additional informational boxes, such as Think About.

Explore, then read: In the CKSci program, lessons are sequenced to provide active engagement before reading. First, students explore phenomena through hands-on investigations or teacher demonstrations, accompanied by active questioning and analysis; then, students study the informational text provided in the Student Readers. The icon shown at left will signal Core Lesson segments that focus on Student Reader chapters.

CKSci Student Readers extend, clarify, and confirm what students have learned in their investigations. The text helps students develop a sense of the language of science, while images, diagrams, charts, and graphs deepen conceptual understanding. Use of the CKSci Student Readers supports the Science and Engineering Practice "Obtaining, Evaluating, and Communicating Information" as described in *A Framework for K–12 Science Education*.

Independent reading or group read-aloud: While the text in the Student Readers is written for independent reading, we encourage group read-alouds and engagement with the text. The Teacher Guide provides Guided Reading Supports to prompt discussion, clarify misconceptions, and promote understanding in relation to the Big Questions.

Using the Teacher Guide

Pacing

The *Processes That Shape Earth* unit is one of five units in the Grade 4 CKSci series. To meet NGSS Performance Expectations, we encourage teachers to complete all units during the school year. To be sure all NGSS Performance Expectations are met, each Core Lesson should be completed, and each requires thirty to forty-five minutes of instruction time. The time it takes to complete a lesson depends on class size and individual circumstances.

Within the Teacher Guide, the Core Lessons are divided into numbered segments, generally five or six, with approximate times listed per segment. The final segment is always a Check for Understanding, providing the teacher with an opportunity for formative assessment.

At the end of this Unit Introduction, you will find a Sample Pacing Guide on page 18 and a blank Pacing Guide on pages 19–20, which you may use to plan how you might pace the lessons, as well as when to use the various other resources in this unit. We strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson. As a general rule, we recommend that you spend no more than twenty-one days teaching the *Processes That Shape Earth* unit so that you have time to teach the other units in the Grade 4 CKSci series.

The Core Lessons

- Lesson time: Each Core Lesson constitutes one classroom session of up to forty-five minutes. Understanding that teachers may have less instructional time, we show a time range of thirty to forty-five minutes per lesson. Teachers may choose to conduct all Core Lesson segments, totaling forty-five minutes; may choose to conduct a subset of the lesson segments; or may choose to spend less time per segment.
- Lesson order: The lessons are coherently sequenced to build from one lesson to the next, linking student engagement across lessons and helping students build new learning on prior knowledge.

PART	LESSON	BIG QUESTION
A. Problem-Based Learning Introduction	**1.** Effects of Earth's Changing Surface	How do changes in Earth's surface affect people, and what can be done about them?
B. The Structure of Our Earth (4-ESS3-1)	**2.** Earth's Layers and Moving Crust	Why are some fossils of the same type found thousands of miles apart on different continents?
	3. Modeling Earth's Layers	How do scientists know that Earth is made up of layers?
	4. Evidence of Earth-Shaping Processes	What evidence shows that Earth's surface has changed over time?
C. Earth's Moving Crust (4-ESS3-1)	**5.** Earthquakes	Why are some communities more likely to experience an earthquake than others?
	6. Earthquake Problems and Solutions (three class sessions)	How can engineers reduce earthquake damage to buildings?
	7. Tsunamis	How can communities better protect themselves from tsunamis?
	8. Volcanoes	Can scientists predict when a volcano is going to erupt?
	9. Reading Maps of Volcanoes	How can you use maps to determine patterns of volcano formations?
D. Other Changes on Earth's Surface (4-ESS3-1)	**10.** Erosion	How do communities protect themselves from erosion?
	11. Erosion Problems and Solutions (three class sessions)	How does erosion affect Earth's surface, people, and communities?
	12. Landslides	How can communities prepare for landslide hazards?
	13. Landslide Problems and Solutions (two class sessions)	How can people protect themselves from the hazards of landslides?
E. Managing the Effects of Earth's Natural Processes in Our Area	Sharing Community Solutions (three class sessions)	What solutions can we develop to reduce the impact of natural Earth processes where we live?

Activity Pages

Activity Pages

AP 1.1
AP 1.2
AP 1.3
AP 1.4
AP 1.5
AP 2.1
AP 3.1
AP 3.2
AP 3.3
AP 4.1
AP 5.1
AP 5.2
AP 6.1
AP 6.2
AP 6.3
AP 6.4
AP 6.5
AP 6.6
AP 6.7
AP 6.8
AP 7.1
AP 8.1
AP 9.1
AP 9.2
AP 9.3
AP 9.4
AP 10.1
AP 11.1
AP 11.2
AP 11.3
AP 12.1
AP 13.1
AP 13.2
AP 13.3
AP 13.4
AP 13.5
AP 13.6
AP 13.7
AP UC.1
AP UC.2
AP UC.3
AP UC.4

Black line reproducible masters for Activity Pages, as well as an Answer Key, are included in Teacher Resources on pages 131–183. The icon shown to the left appears throughout the Teacher Guide wherever Activity Pages (AP) are referenced.

Students' achievement of the NGSS Performance Expectations is marked by their completion of tasks throughout the unit. A Unit Capstone project is provided as a summative close to the unit.

Lesson 1—Natural Hazards Concept Map (AP 1.1)

Lesson 1—The Consequences of Natural Hazards (AP 1.2)

Lesson 1—Natural Hazards Presentation Evaluation Guide (AP 1.3)

Lesson 1—Natural Hazards Team Contract (AP 1.4)

Lesson 1—Take-Home Letter (AP 1.5)

Lesson 2—Lesson 2 Check (AP 2.1)

Lesson 3—Planning a Model of Earth's Layers (AP 3.1)

Lesson 3—Developing a Model of Earth's Layers (AP 3.2)

Lesson 3—Lesson Reflection (AP 3.3)

Lesson 4—Lesson 4 Check (AP 4.1)

Lesson 5—Lesson 5 Check (AP 5.1)

Lesson 5—Natural Hazard Solutions (AP 5.2)

Lesson 6—Earthquake Solutions Evaluation Guide (AP 6.1)

Lesson 6—Describing the Problem (AP 6.2)

Lesson 6—Describing Criteria and Constraints (AP 6.3)

Lesson 6—Making and Evaluating Design Solutions, Part 1 (AP 6.4)

Lesson 6—Making an Earthquake Shaker (AP 6.5)

Lesson 6—Making and Evaluating Design Solutions, Part 2 (AP 6.6)

Lesson 6—Engineering Design Showcase (AP 6.7)

Lesson 6—Letter to Parents or Community Members (AP 6.8)

Lesson 7—Lesson 7 Check (AP 7.1)

Lesson 8—Lesson 8 Check (AP 8.1)

Lesson 9—Volcanoes Evaluation Guide (AP 9.1)

Lesson 9—State-by-State Volcano Data (AP 9.2)

Lesson 9—Volcanoes Infographic (AP 9.3)

Lesson 9—Volcanoes Map (AP 9.4)

Lesson 10—Lesson 10 Check (AP 10.1)

Lesson 11—Erosion Investigation Evaluation Guide (AP 11.1)

Lesson 11—Erosion Investigation Notebook (AP 11.2)

Lesson 11—Testing Erosion Solutions (AP 11.3)

Lesson 12—Lesson 12 Check (AP 12.1)

Lesson 13—Investigating a Landslide Problem (AP 13.1)

Lesson 13—Landslide Solutions Evaluation Guide (AP 13.2)

Lesson 13—Using Scientific Information (AP 13.3)

Lesson 13—Making a Landslide Model (AP 13.4)

Lesson 13—Describing Criteria and Constraints (AP 13.5)

Lesson 13—Brainstorming, Making, and Evaluating Design Solutions (AP 13.6)

Lesson 13—Writing Your Engineering Report (AP 13.7)

Unit Capstone—Earth Hazards Project Checklist (AP UC.1)

Unit Capstone—Earth Hazards Presentation Evaluation Guide (AP UC.2)

Unit Capstone—How to Publish and Present Your Earth Hazards Information Sheet (AP UC.3)

Unit Capstone—Earth Hazards Project Reflection (AP UC.4)

Online Resources for Science

Online Resources

For each CKSci unit, the Teacher Guide includes references to online resources (including external websites and downloadable documents) to enhance classroom instruction. Look for the icon on the left.

Use this link to download the CKSci Online Resources for this unit:

www.coreknowledge.org/cksci-online-resources

Teaching Strategies

Start with the familiar.

Lead with an experience. Begin each lesson with a demonstration, activity, or question about a phenomenon to engage students and focus their attention on the topic. Start with the familiar. Every science topic introduced to students relates in some way to their known world and everyday experiences. The purpose of every lesson is to build a bridge between what is familiar to students and broader knowledge about the way the world works.

Ask the Big Question.

At the beginning of each Teacher Guide lesson, you will find a Big Question and Core Lesson segment devoted to encouraging students to think about this question as they are introduced to new science content. Use this opportunity to engage students in conversation, to think about how their own real-world experiences relate to the topic, or to participate in a demonstration that relates to the Big Question.

Encourage scientific thinking.

Approach the lessons with students not as learning about science but as learning about the world with a scientific mind. Science learning models science practice.

Throughout the lessons, encourage students to ask questions about what they observe, do, and read. Record relevant questions in a prominent place in the classroom. Guide students back to these questions as opportunities to answer them emerge from readings, demonstrations, and activities.

Use continuous Core Vocabulary instruction.

As a continuous vocabulary-building strategy, have students develop a deck of vocabulary cards, adding a card for each Core Vocabulary term as it is introduced. Students can add illustrations and examples to the cards as their comprehension of terms expands. During instruction, emphasize Core Vocabulary terms and their meanings in context rather than relying on isolated drill for memorization of definitions. Students will be given the opportunity to preview Core Vocabulary words early in the lessons and to engage in Word Work activities toward the end of the lessons. Encourage students to come up with definitions in their own words and to use the words in their own sentences.

Core Vocabulary words for each lesson, as well as other key terms teachers are encouraged to use in discussing topics with students, are provided at the start of each lesson. You can find Core Vocabulary definitions in the Word Work lesson segments, as well as in the Glossary on pages 184–185.

Emphasize observation and experience.

Lessons employ various ways for students to learn, including watching, listening, reading, doing, discussing, and writing. To meet the NGSS Performance Expectations, which are multidimensional standards, students must not only gain factual knowledge associated with Disciplinary Core Ideas, but also *use* the content knowledge they acquire.

Use science practices.

Give students opportunities to discover new content knowledge through investigation and to use their new knowledge both in problem-solving exercises and as evidence to support reasoning. Students learn what science and engineering practices are by engaging in those same practices as they learn.

Core Lesson segments are designed to reinforce the idea of science as an active practice, while helping students meet NGSS Performance Expectations. Each lesson segment is introduced by a sentence emphasizing active engagement with an activity.

Make frequent connections.

Use a combination of demonstrations and reading materials, rich with examples, to help students recognize how the science concepts they are learning apply in their everyday lives. Prompt students to relate lesson content to their own experiences, to relate the new and unfamiliar to the familiar, and to connect ideas and examples across disciplines. Refer to the Crosscutting Concepts cited in the lessons, often included in the NGSS References listed at the start of each lesson.

Monitor student progress.

Use verbal questioning, student work, the Check for Understanding assessments at the end of each lesson, and the Unit Capstone at the end of the unit (see pages 122–128) to monitor progress during each lesson and to measure understanding at the conclusion of the unit. Many lessons provide tips to help you support students who need further explanations or clarifications.

Effective and Safe Classroom Activities

Conducting safe classroom demonstrations and activities is essential to successful elementary science education. The following resources provide Core Knowledge's recommendations for developing effective science classroom activities.

These resources, included at the back of the Teacher Guide on pages 186–190, consist of the following:

- Classroom Safety for Activities and Demonstrations
- Strategies for Acquiring Materials
- Advance Preparation for Activities and Demonstrations
- What to Do When Activities Don't Give Expected Results

Online Resources

These resources may also be accessed within the CKSci Online Resources Guide for this unit, available at

www.coreknowledge.org/cksci-online-resources

Materials and Equipment

The unit requires a variety of materials to support various ways of learning (including doing, discussing, listening, watching, reading, and writing). Prepare in advance by collecting the materials and equipment needed for all the demonstrations and hands-on investigations.

Part A: Problem-Based Learning Introduction

Lesson 1

- highlighters
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Part B: The Structure of Our Earth

Lesson 2

- modeling clay
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 3

- 12-inch rulers, ideally with both metric and standard rulings (1 per team)
- modeling clay or dough (4 different colors)
- rolling pins or soup cans (1 per team)
- straightened paper clips (1 per team)
- dental floss (1 30-cemtimeter length per team)
- markers, colored pencils, or crayons (colors to match clay or dough)
- index cards for student vocabulary deck (3 per student)

Lesson 4

- samples of igneous, metamorphic, and sedimentary rocks
- modeling clay
- putty knife

Lesson 4, continued

- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/video for whole-class viewing

Part C: Earth's Moving Crust

Lesson 5

- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 6

- pizza boxes (large or individual size)
- scissors
- marbles (10–20 marbles per box)
- ruler
- small rubber bands (4 per box)
- stapler
- mini-marshmallows
- plastic coffee stirrers (or dried spaghetti)
- internet access and the means to project images/video for whole-class viewing

Lesson 7

- 2-liter plastic soda bottle with cap
- small gravel (fish tank gravel)
- water
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 8

- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 9

- globe (optional)
- highlighters
- internet access and the means to project images/video for whole-class viewing

Part D: Other Changes on Earth's Surface

Lesson 10

- small milk cartons (2)
- plaster of paris
- balloons (2)
- water
- access to a freezer
- sand
- loamy garden soil
- small piece of grass-covered soil
- piece of cardboard
- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 11

- stream table
- catch bucket (if not in the kit)
- sand
- ruler
- water
- three sizes of blocks (if the stream table does not include a way to change its slope)

Lesson 11, continued

- water flow cup (if not in the kit), with a small hole near the bottom
- measuring cups, graduated cylinder, or scale (depending on what property students decide to measure)
- internet access and the means to project images/video for whole-class viewing

Lesson 12

- sand or sandy soil
- shoebox
- construction paper or thin cardboard
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Lesson 13

- empty half-gallon paper drink cartons (2 per team, 1 with cap in place)
- scissors (1 per team)
- potting soil or sand (slightly moist)
- plastic bins (1 per team, large enough to hold the carton on its side at an angle)

Part E: Managing the Effects of Earth's Natural Processes in Our Area

Unit Capstone

- online image library for the entire unit
- internet access and the means to project images/video for whole-class viewing
- name tags for students and event attendees

Sample Pacing Guide

The sample Pacing Guide suggests use of the unit's resources across a twenty-one-day period. However, there are many ways that you may choose to individualize the unit for your students, based on their interests and needs. You may elect to use the blank Pacing Guide on pages 19–20 to reflect alternate activity choices and alternate pacing for your class. If you plan to create a customized pacing guide for your class, we strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson.

Online Resources

For a yearlong pacing guide, please use the link found in the Online Resources Guide for this unit. This yearlong view of pacing also includes information about how this CKSci unit relates to the pacing of other programs, such as CKLA and CKHG in the *Core Knowledge Curriculum Series*™.

www.coreknowledge.org/cksci-online-resources

TG–Teacher Guide; SR–Student Reader; AP–Activity Page

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5
Effects of Earth's Changing Surface TG Lesson 1 AP 1.1–1.5, 13.2	*Earth's Layers and Moving Crust* TG Lesson 2 SR Chapter 1 AP 2.1	*Modeling Earth's Layers* TG Lesson 3 AP 3.1–3.3	*Evidence of Earth-Shaping Processes* TG Lesson 4 SR Chapter 2 AP 4.1	*Earthquakes* TG Lesson 5 SR Chapter 3 AP 5.1, 5.2

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
Earthquake Problems and Solutions DAY 1 TG Lesson 6 AP 6.1–6.5, 6.8	*Earthquake Problems and Solutions* DAY 2 TG Lesson 6 AP 6.6	*Earthquake Problems and Solutions* DAY 3 TG Lesson 6 AP 6.7	*Tsunamis* TG Lesson 7 SR Chapter 4 AP 7.1, 5.2	*Volcanoes* TG Lesson 8 SR Chapter 5 AP 8.1, 5.2

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
Reading Maps of Volcanoes TG Lesson 9 AP 9.1–9.4	*Erosion* TG Lesson 10 SR Chapter 6 AP 10.1	*Erosion Problems and Solutions* DAY 1 TG Lesson 11 AP 11.1, 11.2	*Erosion Problems and Solutions* DAY 2 TG Lesson 11 AP 11.2	*Erosion Problems and Solutions* DAY 3 TG Lesson 11 AP 11.1–11.3, 5.2

Week 4

Day 16	Day 17	Day 18	Day 19–21
Landslides TG Lesson 12 SR Chapter 7 AP 12.1	*Landslide Problems and Solutions* DAY 1 TG Lesson 13 AP 13.1–13.5	*Landslide Problems and Solutions* DAY 2 TG Lesson 13 AP 13.6, 13.7, 5.2	*Sharing Community Solutions* TG Unit Capstone AP UC.1–UC.4

Pacing Guide

Twenty-one days have been allocated to the *Processes That Shape Earth* unit to complete all Grade 4 science units in the *Core Knowledge Curriculum Series*™. If you cannot complete the unit in twenty-one consecutive days of science instruction, use the space that follows to plan lesson delivery on an alternate schedule.

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15

Week 4

Day 16	Day 17	Day 18	Day 19	Day 20

Week 5

Day 21	Day 22	Day 23	Day 24	Day 25

Week 6

Day 26	Day 27	Day 28	Day 29	Day 30

Week 7

Day 31	Day 32	Day 33	Day 34	Day 35

Week 8

Day 36	Day 37	Day 38	Day 39	Day 40

PART A

Problem-Based Learning Introduction

Overview

Lesson	Big Question	Advance Preparation
1. Effects of Earth's Changing Surface	How do changes in Earth's surface affect people, and what can be done about them?	Gather materials for a preview of the problem-based learning project. (See Materials and Equipment, page 16.)

Part A: What's the Story?

The role of science is to provide information, often to policy makers. Scientists and engineers are people who study a challenging problem or question, and what they learn is used to determine a course of action to solve the problem. Students learn more about this process by participating in a **problem-based learning project**, where they obtain and combine information to better understand the effects of natural hazards and how to make communities safer from them. Every lesson is designed to help students complete a unit capstone project in which they publish or present their findings to their community.

In Lesson 1, we start by setting the foundation for the remainder of the unit. Students begin by learning about the basics of natural hazards, including some of the processes that lead to them, such as major Earth changes over long periods of time or weather-related changes that happen quickly. Students form teams to investigate various Earth processes and natural hazards, with the goal of preparing their community for any natural hazard that might strike. This will prepare students to address the NGSS expectations associated with this unit, including designing a solution to a natural hazard as part of their problem-based learning project.

So, to repeat, **one role of science is to provide solutions to natural hazards, including weather-related ones**. Help your students design a solution to a natural hazard that might affect their community, and you will lay the groundwork for meeting the NGSS Performance Expectation 3-ESS3-3 addressed here and in the rest of this unit as well as beginning students on their problem-based learning project.

LESSON 1

Effects of Earth's Changing Surface

Big Question: How do changes in Earth's surface affect people, and what can be done about them?

Problem-Based Learning Project: Examine and identify natural hazards, and consider their effects on people and property, to prepare for the unit capstone project.

At a Glance

Learning Objectives

✓ Identify types of geologic hazards and natural disasters and some of their consequences.

✓ Define *geology*.

Lesson Activities

- problem-based learning introduction
- vocabulary instruction
- natural hazards mapping exercise

NGSS References

Disciplinary Core Idea ESS3.B: Natural Hazards

Disciplinary Core Ideas ETS1.B: Designing Solutions to Engineering Problems

Crosscutting Concepts: Cause and Effect; Influence of Engineering, Technology, and Science on Society and the Natural World

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Cause-and-Effect thinking is critical to understanding how and why geologic hazards affect humans. At the start of this lesson, the Big Question is worded to identify cause-and-effect relationships that explain change, specifically changes that occur on Earth's surface. Students draw on prior knowledge about the effects of different kinds of natural hazards. As the unit progresses, students will have the opportunity to test cause-and-effect relationships as they evaluate their own engineering solutions to reduce the impacts of geologic hazards.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

cause and effect   energy   **geology/geologic**   **natural hazard**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Pages

AP 1.1
AP 1.2
AP 1.3
AP 1.4
AP 1.5

Activity Pages

Natural Hazards Concept Map (AP 1.1)

The Consequences of Natural Hazards (AP 1.2)

Natural Hazards Presentation Evaluation Guide (AP 1.3)

Natural Hazards Team Contract (AP 1.4)

Take-Home Letter (AP 1.5)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- highlighters
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Problem-Based Learning Project: Advance Preparation

Decide how you will group students for this problem-based learning unit. Small groups of three or four students will allow assignment of roles and accountability of all team members.

Advance planning will be needed to carry out the unit capstone presentation event. Students may choose to prepare a presentation for their community. If so, students will need to identify invitees from your community, including other students, parents, and school administrators. You will also need to decide on a date and time that works for your class and school. Send out invitations as far in advance as possible. Be sure to allow students enough time to practice their presentations, especially using presentation materials. Presentations will be revisited in Lesson 13.

The Core Lesson 45 MIN

1. Focus student attention on the Big Question. 10 MIN

How do changes in Earth's surface affect people, and what can be done about them? Introduce students to this unit's **problem-based learning project**. Explain that this unit is different from all others. In this unit, students will learn about the causes and effects/consequences of natural hazards on people, property, and landscapes, as well as about design solutions to help keep communities safe. Every lesson in the unit develops student understanding of the issues surrounding different types of natural hazards and culminates in a problem-based project in which students present to community leaders their ideas for keeping their community safe. As students progress through the unit, they will research different natural hazards and then determine how to best prepare their community for any that might occur there. At the end of the unit, students will publish or present their findings.

Think about how natural processes affect people. For example, you may ask the following:

- How does rain/snow/etc. affect your daily life?
- What do people do to protect themselves when there is too much wind, rain, snow, ice, or heat?
- What are the effects of natural processes on our homes, roads, and food supply?

Explain to students that when parts of Earth move, energy is released and transferred. Support students as they recall that energy can be observed wherever and whenever a change occurs. The energy transferred by Earth's movements can cause collisions with other sections of Earth or even objects made by people. Show students a video of an earthquake, a volcanic eruption, a landslide, or a sandstorm happening in real time or using time-lapse video.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Ask the following:

» What changes can you identify in the video? (*Answers will vary; however, each should include a description of what has changed and how. If students begin to discuss why these changes occur, acknowledge their ideas, and write their thoughts in a prominent place on the board or chart paper, saving these ideas for later lessons.*)

» What evidence was there that energy was transferred? (*Answers will vary, depending on the video. For example, in the sandstorm video, each moving grain of sand carried energy, as indicated by each grain changing position.*)

» How could these changes affect objects or structures made by people? (*Examples: The moving sand could wear the paint off a car or house; earthquakes can cause even large buildings to collapse; etc.*)

Preview Core Vocabulary Terms

Write the terms **geology/geologic** and **natural hazard** on the board or chart paper. Encourage students to look or listen for either term as they discuss what they learn in the lesson. Explain that the terms *geology* and *geologic* are closely related and that geology is the study of Earth while *geologic* describes something related to Earth.

2. Elicit prior knowledge with visual modeling. 15 MIN

Activity Pages

AP 1.1
AP 1.2

Distribute Natural Hazards Concept Map (AP 1.1) and The Consequences of Natural Hazards (AP 1.2). Make sure students understand that natural hazards are events that happen in nature that cause problems and potential dangers for people. Have students read and follow the directions for Activity Page 1.1, adding labeled bubbles for all the kinds of natural hazards they can think of.

SUPPORT—Ask students to think about the kinds of effects that natural hazards have on people. If necessary, have students list these effects on a sheet of paper and refer back to it as they complete their maps.

When students have completed their maps, ask: Which of these natural hazards have something to do with the rocks and soil on Earth's surface? Explain that these are called geologic hazards. Guide students to understand that earthquakes, volcanic eruptions, soil and sand erosion, and landslides or mudslides are hazards related to rocks and soil. These, and not weather hazards, will be the focus of this unit. (See **Know the Science**.)

CHALLENGE—Encourage students who wish to go further to classify the rest of the hazards on their concept maps as hydrological (caused by water, such as floods), meteorological (storms), or climatological (drought and wildfires).

In addition, have students select at least one hazard on their concept map to extend and list potential dangers that occur to people as a result of that natural hazard event.

Know the Science

How are natural hazards classified? *It depends on the source of the hazard.* Natural hazards are extreme events on Earth that are caused by nature and cause harm to humans and human-made structures or systems. These hazards can be classified by the scientific fields that investigate them. Geologic hazards (earthquakes, volcanic eruptions, tsunamis, landslides, soil erosion) are related to Earth's rock and rocklike materials, landforms, and soils. Meteorological hazards (hurricanes, tornadoes, blizzards, ice storms, heat waves) are related to changes in air pressure and moisture content in Earth's atmosphere. Hydrological hazards (floods, mudslides) are related to liquid water on Earth's surface. Biological hazards (epidemics) are related to infectious diseases. Because all natural hazards cause problems for people, disaster preparations, responses, and recovery efforts are designed by governmental and nongovernmental agencies to reduce the harmful effects.

Discuss briefly with students the fact that natural hazards have consequences to people, property, and landscapes. Give examples for at least one natural hazard. For example, tornadoes can destroy structures as well as trees, fields, and other things, and they can result in a loss of human and animal life. One way to deal with tornadoes may be to build stronger structures and shelters to withstand them.

Next, place students in small groups and have them complete The Consequences of Natural Hazards (AP 1.2). Encourage students to engage in the discussion, and circulate among the groups, helping them in any way they need and offering input to stimulate conversation when it falters. Understand that at this point, most students will not be able to answer accurately the question of how best to deal with natural hazards. Note that this exercise is designed to get students thinking about solutions to the consequences of natural hazards.

3. Preview the unit project and evaluation guide. **5 MIN**

Activity Page

AP 1.3

Introduce the problem that students will focus on for the duration of this unit: What solutions can we develop to reduce the impact of natural Earth processes where we live? Tell students that throughout this unit, they will collect information that they can use to help answer this question, based on various types of natural hazards that they learn about. Students will work in groups for their final project, in which they will come up with a product and give a presentation that describes the solutions for reducing specific natural hazards in their areas.

Distribute Natural Hazards Presentation Evaluation Guide (AP 1.3). Explain that, throughout this unit, students will be developing the knowledge they will need to present their proposals to a community audience. With the class, read the “expert” level for each skill/row. Allow students to ask questions about the event you are planning. (See **Know the Standards**.)

Know the Standards

Influence of Science, Engineering, and Technology on Society and the Natural World is an NGSS Connection to Engineering, Technology, and Applications of Science. This problem-based learning science unit supports understanding that “Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.” Throughout this unit, students will design solutions that can reduce the impact of geologic hazards on humans and human systems. In the final lesson of this unit, students will recommend solutions to reduce the risks of hazards prevalent in their local community. There are two other related connection statements developed elsewhere in Grades 3–5. The first is, “People’s needs and wants change over time, as do their demands for new and improved technologies. Engineers improve existing technologies.” The second is, “When new technologies become available, they can bring about changes in the way people live and interact with one another.”

4. Establish student teams and set expectations. 5 MIN

Activity Page

AP 1.4

Divide the class into teams of three or four students of mixed ability who will work well together for the entire unit. Make sure that each team includes students with strong leadership, writing, speaking, and problem-solving skills.

Distribute one copy of Natural Hazards Team Contract (AP 1.4) to each team. Have students read the contract, discuss each bullet point, and then print and sign their names.

Collect the signed contracts, and show students that you are putting them in a safe place. This will allow you and students to later review them if a team does not seem to be working well.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms **geology/geologic** and **natural hazard**. Have students write each term in the upper left corner of an index card and underline it, one term per card.

Word Work

- **geology:** (n. the study of Earth's makeup and formation) Explain to students that in this lesson, they will begin learning about many of Earth's features. Explain that when something has to do with geology or is related to Earth in some way, it is called geologic. Have students write what they have learned geology is from this lesson (the study of Earth). Then have a volunteer share his or her definition, and discuss it as a class.
- **natural hazard:** (n. an extreme event in nature that can cause harm to living organisms and structures) Ask students if they have ever seen a natural hazard, such as a tornado or earthquake, covered on the news or in social media. Then have them write down the following definitions: for *natural*, something that occurs in nature; for *hazard*, an object or event that causes harm. Next, have students write down an example that was not covered in this discussion. (*examples: volcano, landslide, mudslide, wildfire, asteroid or meteor strike, severe storm, blizzard, lightning, and so on*)

6. Check for understanding. 5 MIN

Activity Pages

AP 1.1

AP 1.2

AP 1.3

AP 1.5

Answer Key

Formative Assessment Opportunity

Collect and evaluate the completed Natural Hazards Concept Map (AP 1.1) and The Consequences of Natural Hazards (AP 1.2). See the Activity Page Answer Key for correct answers and sample student responses. Look for evidence of the following:

- identification of natural hazards in general
- identification of geologic hazards specifically

Understand that student answers may be incorrect for the question about how to deal with natural hazards. This is okay, as most students will have very little understanding of natural hazards, their consequences, and their solutions at this point.

Find out if students understand the unit capstone project that will occur at the end of the unit. Ask the following:

» What information will be on the presentation your team produces? (*the causes and effects of the natural hazard for my community*)

» How should you behave when presenting to your audience? (*speak loudly and clearly, using formal language, and look at my audience*)

» How should you work with your team? (*work well, with all members getting to participate equally*)

Distribute one copy of Take-Home Letter (AP 1.5) to each student. Attach a copy of the Natural Hazards Presentation Evaluation Guide (AP 1.3) to each Take-Home Letter. Read the letter with the class, and answer any questions students may have. Have students take the letters home to share with their guardians/parents.

Problem-Based Learning Progress

Review progress students have made in learning about the causes and effects/consequences of natural hazards. They have done the following:

- showed what they know about natural hazards
- considered the consequences of at least one natural hazard
- previewed the unit capstone project

Explain that in Lessons 2–13, they will learn more about natural hazards so that they can develop an informed analysis of how best to protect their area/community.

PART B

The Structure of Our Earth

Overview

Lesson	Big Question	Advance Preparation
2. Earth's Layers and Moving Crust	Why are some fossils of the same type found thousands of miles apart on different continents?	Read Student Reader, Chapter 1.
3. Modeling Earth's Layers	How do scientists know that Earth is made up of layers?	Gather materials for hands-on investigation. (See Materials and Equipment, page 16.)
4. Evidence of Earth-Shaping Processes	What evidence shows that Earth's surface has changed over time?	Read Student Reader, Chapter 2.

Part B: What's the Story?

As part of their **problem-based learning project**, students learned in Part A (Lesson 1) about some of the Earth processes that cause changes on its surface, many of which can lead to natural hazards. Students also formed teams as they started working toward the unit capstone project.

In Part B (Lessons 2–4), students take a closer look at the various processes that shape Earth's surface, such as plate tectonics as evidenced by the fossil record and shown on detailed maps and the formation of sedimentary rock recording Earth's history in layers laid down over long periods of time.

In Lesson 2, we start by reading about Earth's shifting pieces, the plates that make up the planet's surface, known as its crust. Students come to an understanding that Earth's plates are always moving, though so slowly that they cannot be perceived by the human eye. This movement between plates also leads to earthquakes and volcanic eruptions where plates are crashing together or separating. Students learn how scientists know that the planet is made up of plates that are moving.

In Lesson 3, students come to a better understanding of how Earth's crust works by modeling the planet's layers as well as how plates move. This activity is designed to help them understand some of the forces that lead to the natural hazards that affect parts of the planet, from volcanic eruptions to earthquakes.

In Lesson 4, students learn more about the processes that shape Earth and the evidence for them. This includes how the three main types of rock form and the relative positions of Earth's landmasses in the distant past.

So, to repeat, **Earth has systems that change its surface, and these systems' processes can take many millions of years to act**. Help your students understand that Earth's systems and its many processes contribute to natural hazards, and you will lay the groundwork for meeting the NGSS Performance Expectation MS-ESS2 Earth's Systems, addressed here and in the rest of this unit, as well as continuing students on their problem-based learning project.

LESSON 2

Earth's Layers and Moving Crust

Big Question: Why are some fossils of the same type found thousands of miles apart on different continents?

Problem-Based Learning Project: Consider explanations about how we know that Earth's surface is made up of moving plates in anticipation of the unit capstone project.

At a Glance

Learning Objectives

✓ Interpret maps to discern patterns of major geologic features of Earth's surface.

✓ Describe major features of Earth's surface.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Disciplinary Core Idea ESS1.C: The History of Planet Earth

Crosscutting Concepts: Patterns; Scale, Proportion, and Quantity

Science and Engineering Practices: Asking Questions; Constructing Explanations and Designing Solutions

Patterns will be explored in this lesson as students read about and discuss common ways that geologists know and investigate how Earth's plates move and interact. This lesson introduces how Earth's crust moves, which serves as a precursor to the future lessons in this unit. In later units, students will learn about Earth-shaping natural hazards, including earthquakes, volcanic eruptions, tsunamis, erosion, and landslides.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

fossil **geologist** molten **plate**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 1

Student Reader, Chapter 1
"Earth's Shifting Pieces"

Activity Page

AP 2.1

Activity Page
Lesson 2 Check (AP 2.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- modeling clay
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/video for whole-class viewing

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 5 MIN

Why are some fossils of the same type found thousands of miles apart on different continents? Explain to students that this lesson is part of a **problem-based learning project**. As a result, this unit is different from all others. In it, students will learn about Earth's natural hazards and how communities prepare for or protect themselves from them. Every lesson in the unit develops student understanding of the issues surrounding different types of Earth hazards and culminates in a problem-based project. As students progress through the unit, they will research different Earth hazards and then determine which are most likely to affect their community and how to best prepare for them. At the end of the unit, students will publish or present their findings.

Remind students to keep the overall goal of this unit in mind as they read Chapter 1: to develop solutions that reduce the impact of hazardous natural Earth processes where they live. The movements of Earth's plates are involved in many of those hazardous processes. Explain that knowing how plates have moved and continue to move is one of the main topics studied by geologists and can help people identify ways to stay safe and reduce the negative effects associated with geologic changes.

Make Frequent Connections

Tell students that in today's class they will focus on Earth processes that can lend themselves to causing natural hazards.

Assess students' prior knowledge using the following questions:

» What are some changes on Earth's surface that result from movements of Earth's crust or movement of material through the crust? (*earthquakes, tsunamis, volcanic eruptions, landslides*)

» How is a mountain range evidence of Earth's crust moving over time? (*Some mountain ranges are formed when the crust crumples.*)

Discuss how Earth scientists rely on evidence to piece together explanations of past events, including those that have shaped Earth's surface and been hazardous at times. Detecting and interpreting patterns is particularly important when evidence and events are hard to perceive in real time. Explain that these patterns can help scientists understand how fossils that should be close together are found thousands of miles apart. (See **Know the Standards** for support.)

2. Encourage student questions. 5 MIN

Lead a discussion about asking questions. Prompt students to pair up with a neighbor and talk about why asking questions is an important skill in science. Encourage them to think about what kinds of things can be learned from answering questions related to Earth processes, such as: What evidence shows that Earth's surface has changed over time? What are earthquakes, tsunamis, landslides, and volcanoes? Tell students that there is an art to asking questions. Good scientific questions are focused and specific. Explain that scientists ask questions to learn and understand more information. Urge students to be asking themselves questions as they work through this lesson.

Know the Standards

Studying Earth's past requires analysis of patterns in the physical evidence. The NGSS standards emphasize the importance of finding patterns in the physical evidence of Earth's changing surface, especially patterns in layers of rock. A layer can itself be part of a pattern, and a layer can contain other pieces of evidence, such as fossils, that may fit into a different pattern.

SUPPORT—Give students sample questions that they can be thinking about in relation to the unit project as they read the Student Reader, such as "How does this Earth process affect the safety of people?" and "What are some ways scientists can reduce the impact of this hazard?"

3. Read and discuss: "Earth's Shifting Pieces." 20 MIN

Student Reader

Ch. 1

Read together, or have students read independently, "Earth's Shifting Pieces," Chapter 1 in the Student Reader. Students will learn more about plate tectonics in middle school. The key takeaway from this chapter is that Earth's outer surface is broken up into plates that move and interact in ways that have profound effects on Earth's surface.

Preview Core Vocabulary Terms

Before students read, write these terms on the board. Discuss the terms when you come upon them in the reading selection:

fossil **geologist** **plate**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 1

After students have read the page, discuss with students what fossils are (the remains of a prehistoric organism preserved in rock form). Have students name some examples of fossils they might have seen in a museum, read about in a book, or seen on television. Examples may include dinosaur skeletons or plant impressions. Ask the following:

» What is a geologist? (*a scientist who studies what Earth is made of and how it changes over time*)

Page 2

Cultivate context to allow students to better understand fossil findings. Most species of animals live relatively closely together, often on the same continent or in a small area. Therefore, when two fossils of the same species that lived hundreds of millions of years ago are found thousands of miles apart on different continents, the conclusion is that the land they were on was closer together at that time.

SUPPORT—Discuss/clarify what *fossil record* means with students. In scientific terms, the fossil record is all the specimens, research, and other evidence worldwide that is shared and understood by all geologists.

Online Resources

If time permits, display an image of Alfred Wegener. See the Online Resources Guide for a link to this resource:

www.coreknowledge.org/cksci-online-resources

Help students interpret the illustration showing the fossil evidence that Wegener /VAY-guh-nur/ assembled to support his theory of continental drift. Ask the following:

» Why did it matter that the fossilized organisms were animals that were not strong swimmers? (*It suggests these organisms could not have traveled between continents that are now far apart. Either the continents were close together, or something else carried the organisms around the planet.*)

» Why are the fossils found on Antarctica of particular significance? (*Antarctica has a frigid climate that does not support plants or many animals. The fact that it had plants and animals like the other continents in the diagram suggests all of the continents were together in a more tropical region of Earth.*)

SUPPORT—If time permits, it may be helpful to demonstrate the significance of the fossil evidence to the early theories about continental drift. Set up a layer of modeling clay, and invite students to leave trace fossils of their thumbprints all over the layer. Then separate the layer of clay into three pieces, and move them several feet apart. Have students describe what they observe. They should be able to tell that the three pieces of clay may be separated now but that they once belonged to the same large piece.

Page 3

After reading the page, emphasize to students that Earth's plates move very slowly—fewer than ten centimeters per year—but that they are so vast in physical scale that their movements are almost impossible to perceive with the naked eye.

Ask students to think about processes that take a long time. Because students are so young and school is such a major part of their lives, they may see getting to graduation after Grade 12 as a process that takes a long time. Or students may think of growing old. Explain that the timescale on which Earth operates takes place not in decades but in thousands to millions of years. Check for understanding, and address any misconceptions. Ask: If a process takes place over a small timescale, does it happen more quickly or does it take longer than a process that takes place over a large timescale? (*It happens more quickly.*)

SUPPORT—If time permits, show students a video of Australia's incorrect GPS coordinates to emphasize how GPS is used to track the movement of plates around the world.

SUPPORT—See the Online Resources Guide for analogies to help students comprehend the immensity of the geologic timsecale.

Online Resources

Use this link to download the CKSci Online Resources Guide where specific links to these resources may be found

www.coreknowledge.org/cksci-online-resources

CHALLENGE—Emphasize that GPS technology offers a way to track and measure the movements of plates. Ask: How could we model the use of GPS technology to track plate movements using objects in the classroom? (*We could monitor the locations of desks and take measurements in between them over time to track how they shift. We could also use photography to capture relative positions over time.*)

Page 4 After reading the page, draw student attention to the diagram, and ask someone to describe Earth's interior. (*The mantle is made of mostly solid rock, but the tremendous heat of it allows material to flow slowly over time.*) Emphasize that it is this movement within the mantle that carries the crustal plates above it. The mantle makes up about eighty-four percent of Earth's volume. (See **Know the Science 1 and 2**).

4. Review and reflect. 5 MIN

Reflect on the map-based images that students saw, along with what they read about, in the Student Reader. Ask students to discuss any of the patterns that they noticed. Use the following question prompts:

» Do the shapes of the continents around the world suggest any patterns? (*Yes, it looks like they could fit together like puzzle pieces.*)

» Are there any patterns when it comes to fossils? (*Yes, some fossils are found in certain parts of the world, even if they don't naturally belong there.*)

Close the lesson with the following question that ties the lesson content back to the unit capstone project: In what way do you think Earth's land-shaping processes can cause problems that need to be addressed and solved?

Elicit from students that the ways in which the plates move can cause things such as volcanoes and mountains to form and earthquakes to happen, which can affect society and human life.

Know the Science

1. How do we know what Earth's interior is like? Students may wonder how we know what Earth's interior is made of, since, for all intents and purposes, the interior of Earth is too deep and hot to explore. Scientists can analyze the interior by comparing how seismic waves travel through Earth and reach different points on the surface at different times. Because waves travel at different speeds, scientists have inferred the composition and temperatures of the different layers, including the more-molten outer core and the solid inner core. This is content that students will learn in later grades.

2. Why is Earth's core so hot? Much of the heat in Earth's interior is latent heat—it's left over from the formation of Earth billions of years ago. It takes a very long time for heat to move from the interior to the surface through conduction. The crust is like a blanket that keeps in much of that heat. The tremendous pressure deeper in the interior also results in high temperatures. Friction is produced as iron-rich material, which is very dense, sinks toward the center of Earth. This also produces heat. But some heat is released at plate boundaries in the form of lava, steam, and hot gases.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms displayed at the beginning of the lesson. Have students write each term in the upper left corner of an index card and underline it, one term per card.

fossil **geologist** **plate**

Word Work

- **fossil:** (n. the remains of an organism preserved in rock form) Ask students if they have ever seen a fossil, either at home, at school, in a museum, on the internet, or on television. Have students describe on their cards how the fossil(s) made them feel. Then have students write down what fossils they believe they saw. If some students have not seen a fossil, show them a picture of the skeleton of a Tyrannosaurus rex, and have them write down what animal they think it is.
- **geologist:** (n. a scientist who studies what Earth is made of and how it changes over time) Remind students of what they learned about the words *geology* and *geologic* in the previous lesson. Tell students that a geologist is a person. Then have students write what they think is the meaning of the word *geologist* and what they have learned. Next, have them share their ideas and discuss them as a whole class.
- **plate:** (n. in geology, a large fragment of Earth's crust and upper mantle) Explain that the word *plate* has more than one meaning. For example, a plate may be an object that people eat off of. Or it may be a kind of bone that comes off the back of some living organisms (such as a *Stegosaurus*, which lived on Earth long ago). Ask students to write down why they think parts of Earth's crust might be called plates. Then discuss students' answers as a class.

6. Check for understanding. 5 MIN

Activity Page

AP 2.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 2 Check (AP 2.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in learning how we know that Earth's crust is made up of moving plates.

Explain that in Lesson 3, students will learn more about how to model the movement of Earth's plates. In preparation for their unit capstone project, students will also learn how plate movement leads to geologic events (earthquakes and, secondarily, landslides) that affect people.

LESSON 3

Modeling Earth's Layers

Big Question: How do scientists know that Earth is made up of layers?

Problem-Based Learning Project: Learn how to model Earth's layers and their interactions in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Create and use a model to show Earth's layers.

Lesson Activities

- discussion
- modeling
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Crosscutting Concept: Scale, Proportion, and Quantity

Science and Engineering Practices: Analyzing and Interpreting Data; Developing and Using Models

Developing and Using Models is a key aspect of this lesson. Students begin by identifying different kinds of models. Next, students use number sense to plan a model that is smaller than the real object: our massive planet. Then, students build 3-D models of Earth's layers and cut them in half to reveal a cross section of Earth's interior. Finally, students consider the limitations of their models based on what scientists can explain without directly observing the phenomenon in question.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

core	**mantle**	scale
crust	plate	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Pages

AP 3.1
AP 3.2
AP 3.3

Activity Pages
Planning a Model of Earth's Layers (AP 3.1)

Developing a Model of Earth's Layers (AP 3.2)

Lesson Reflection (AP 3.3)

Materials and Equipment

Collect or prepare the following items:

- 12-inch rulers, ideally with both metric and standard rulings (1 per team)
- modeling clay or dough (4 different colors)
- rolling pins or soup cans (1 per team)
- straightened paper clips (1 per team)
- dental floss (1 30-centimeter length per team)
- markers, colored pencils, or crayons (colors to match clay or dough)
- index cards for student vocabulary deck (3 per student)

Advance Preparation

Straighten a paper clip and cut a length of dental floss for each team. Group students into teams of two to four, depending on the quantities of materials you have on hand. Consider assigning cooperative roles within each team, such as materials collector, measurer, cutter, and so on.

The Core Lesson 45 MIN

1. Focus student attention on the Big Question. 5 MIN

How do scientists know that Earth is made up of layers? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students continue to learn how Earth's plates move and interact. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Prompt students to think about things that cannot be seen with the human eye, and ask them to give examples. (*air, living things too small to be seen, different types of energy waves*) Explain that models help scientists understand better how things they cannot see work. Scientists also have different ways of knowing whether their models are accurate, as students will learn later in this lesson with models of Earth's layers.

Have students share their prior knowledge of models by brainstorming kinds of models. List their ideas on the board. (*Examples: models of spaceships, toy cars, model train sets, a planetarium, a huge model heart in a science museum, etc.*)

Explain to students that sometimes models are smaller than the real thing they represent and that other times they are larger than the real thing. Ask the following:

» If we are going to make models of Earth, should the models be smaller or larger than the real thing? (*smaller*)

» Why should they be smaller? (*because Earth is too big to see all at once, so the only way to look at all its parts is to make it smaller*)

Preview Core Vocabulary Terms

Write the terms **crust**, **mantle**, and **core** on the board or chart paper. Encourage students to look or listen for these terms as they go through the lesson. Have students look for ways these words are related in terms of what they mean. (*They are parts of Earth that work together.*)

2. Preview modeling. 10 MIN

Activity Page

AP 3.1

Distribute Planning a Model of Earth's Layers (AP 3.1). Point out that students will be making a model of Earth that is much smaller than the real thing. Have students compare the real numbers for all four layers. Ask the following:

» Which two layers are the closest in thickness? (*inner core and outer core*)

» Which layer is the thickest? (*mantle*)

» Which layer is the thinnest? (*crust*)

Have students discuss how the thickness of the model's inner core was determined. Once students understand the conversion of kilometers to centimeters, have them work in their small teams to complete the rest of the chart. (See **Know the Standards**.)

SUPPORT—Have students think about how models are often bigger (models of things too small for the human eye to see) or smaller (models of Earth, stars, or the solar system) than their real counterparts. One way to help students understand this is with the use of fractions. Students can work with scale models using their understanding of fractions or decimals taught in Grade 4. Guide students to reason that if 1,000 kilometers on Earth is represented by 1 centimeter on the model, then 2,400 (1,000 + 1,000 + 400) kilometers on Earth would be represented as $2\frac{4}{10}$ $(1 + 1 + \frac{4}{10})$ centimeters on the model.

3. Support student modeling. 15 MIN

Activity Page

AP 3.2

Distribute Developing a Model of Earth's Layers (AP 3.2). If you have not arranged students in teams yet, now is the time to do so. Have each team follow the steps to make a model. Circulate among the teams to answer questions and troubleshoot as needed.

CHALLENGE—Share with interested students information about how and when the layers were discovered. (See **Know the Science**.) Invite students to create time lines that begin around 1850 and end today. Ask them to present their

Know the Standards

Scale, Proportion, and Quantity: Students in Grades K–2 begin to understand this Crosscutting Concept by comparing and describing objects by size (e.g., bigger/smaller) and learning that standard units (e.g., inches or centimeters) are used to measure length. In Grades 3–5, students recognize that natural objects can be immensely large to very small and learn to use units to measure weight, time, temperature, and volume. The concept of scale models is mastered in middle school, including the idea that models are needed to study objects that are too large or too small.

Know the Science

How did scientists discover details about Earth's layers? ***Hard work over a long time!*** We live on Earth's crust, and so geologists are able to directly observe its rocks and, using the tools of mining, drill several kilometers beneath the surface to collect specimens. But below those few kilometers, the pressure is too great and the temperatures too hot to use probes to observe Earth's interior. Since the invention of the seismograph in 1880, geologists have studied the behavior of recorded seismic waves that travel through Earth. These waves move at different speeds and in different directions depending on the properties of the materials they encounter. The boundary between the crust and mantle was discovered in 1909 by Croatian scientist Andrija Mohorovičić using data from seismographs. In 1913, Beno Gutenberg, a German/American seismologist, identified the transition from the mantle to the core. In 1906, R. D. Oldham discovered Earth's core. In 1929, a Danish seismologist named Inge Lehmann inferred that Earth's core has two parts, a solid inner core and a more liquid outer core.

time lines to the rest of the class and explain why the discoveries occurred when they did (*not long after the invention of the seismograph*) and why they were all clustered in a relatively short span of years. (*Once scientists figured out how to interpret the seismic waves, they were eager to learn all that they could.*)

4. Support student reflection. 5 MIN

Activity Page

AP 3.3

Distribute Lesson Reflection (AP 3.3). Tell students that they will be reflecting on what they did during class. Read the directions with the class, and have each student complete the sheet.

SUPPORT—For item 1, make sure students understand that a cross section is what they revealed when they cut their models in half with dental floss.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms displayed at the beginning of the lesson. Have students write each term in the upper left corner of an index card and underline it, one term per card.

crust **mantle** **core**

Word Work

- **crust:** (n. the outer part of Earth's surface) Ask students what they know about the word *crust*. Have them give examples. Refer to a loaf of bread. Explain that the outer part, which is rougher than the rest, is known as the crust. On their cards, have students write how Earth's surface is like the crust on bread. (*Both are the hard outer parts of something.*)
- **mantle:** (n. the part of Earth's interior that is between the crust and the core) Explain that the word *mantle* can mean a couple of things. Often, it is a covering, such as an outer garment that someone wears. Give students the definition of *mantle*, and have them write it on their cards. Then have volunteers explain how it is similar to an outer garment. (*It covers Earth's core, or innermost part.*)
- **core:** (n. the innermost part of Earth) Have students describe things that have a core (such as an apple). Explain what Earth's core is, and have students use the word *core* in a sentence. (*Example: Earth's core is below its crust.*) Note that the skin on an apple is also a good analogy for the location and relative thickness (or thinness) of Earth's crust.

6. Check for understanding. 5 MIN

Activity Pages

AP 3.1

AP 3.3

Answer Key

Formative Assessment Opportunity

As students work, or at the conclusion of this lesson, collect and evaluate students' work on Planning a Model of Earth's Layers (AP 3.1). See the Activity Page Answer Key for the correct answers.

Also collect and evaluate students' work on Lesson Reflection (AP 3.3). See the Activity Page Answer Key for the correct answers. Look for evidence of the following in student understanding:

- Models can show relationships, including relative sizes and scale, between parts of an object or phenomenon.
- A model is limited based on how we choose to represent the thing/phenomenon being modeled and based on the evidence we have to help support our models.

If time allows, have the class consider what other materials or media they could have used to make their models.

Problem-Based Learning Progress

Review progress students have made in learning how we know that Earth's crust is made up of moving plates.

Explain that in Lesson 4, Students will learn more about how natural processes such as weathering, mountain formation, and earthquakes affect and change Earth's surface. Students will also continue to relate geologic events to their effects on people.

LESSON 4

Evidence of Earth-Shaping Processes

Big Question: What evidence shows that Earth's surface has changed over time?

Problem-Based Learning Project: Learn how Earth's surface changes over time because of natural events in anticipation of the unit capstone project.

At a Glance

Learning Objectives

✓ Compare three different types of rocks: sedimentary, metamorphic, and igneous.

✓ Create and use a model to show how rock layers can provide evidence for change in Earth's surface over time.

✓ Explain what fossils are, and interpret fossil evidence to show that Earth's surface has changed over time.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS1.C: The History of Planet Earth

Disciplinary Core Idea ESS2.A: Earth Materials and Systems

Crosscutting Concepts: Cause and Effect; Patterns

Science and Engineering Practices: Planning and Carrying Out Investigations; Constructing Explanations and Designing Solutions

Patterns are important to this lesson because students study patterns to construct an explanation about how parts of Earth's surface formed and have changed over long periods of time. They also study the places where fossils have been found to learn more about Earth's features and the movement of its plates.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

boundary	**metamorphic rock**	**sedimentary rock**
igneous rock	sediment	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 2

Student Reader, Chapter 2
"More Evidence of Earth-Shaping Processes"

Activity Page

AP 4.1

Activity Page
Lesson 4 Check (AP 4.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- samples of igneous, metamorphic, and sedimentary rocks
- modeling clay
- putty knife
- index cards for student vocabulary deck (3 per student)
- internet access and the means to project images/video for whole-class viewing

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

What evidence shows that Earth's surface has changed over time? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students continue to learn how Earth's surface has changed. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Assess students' prior knowledge of Earth-shaping processes and the evidence that scientists use to help explain how these processes work. Ask the following:

» What is an example of a process that helps shape Earth's surface? (*erosion, earthquake effects, plate movements*)

» What is an example of a piece of evidence that an Earth-shaping process has occurred? (*A new landform is present; a landform is a different size or shape.*)

Briefly preview the evidence that scientists examine to trace changes on Earth's surface. (See **Know the Standards 1** for support.)

2. Read and discuss: "More Evidence of Earth-Shaping Processes." 20 MIN

Student Reader

Ch. 2

Read together, or have students read independently, "More Evidence of Earth-Shaping Processes," Chapter 2 in the Student Reader. The three general types of rocks are described and defined. Comparisons of rocks and rock layers are described, and maps and other techniques to observe and measure change over time are discussed.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Discuss the terms when you come upon them in the Student Reader. (See **Know the Standards 2**.)

igneous rock **metamorphic rock** **sedimentary rock**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Know the Standards

1. Earth's materials and systems provide evidence of change. The NGSS standards emphasize the cause-and-effect relationships between processes of Earth systems and the materials involved. For example, water cycles among systems and the movement of water through these systems have effects that can be identified in materials such as sediment and soil even if water is absent from the system when it is observed or analyzed. On Mars, for example, there are few signs of liquid water, but there is evidence on Mars's surface that liquid water was once abundant. Scientists know this thanks to studies of surface processes on Earth. Another way that Earth's materials and systems provide evidence of change is in their patterns. Different types of rock form in different ways. By examining where fossils and certain rock layers are found, scientists have found patterns they can then apply to other rock formations to better understand their history.

2. The rock cycle is not part of most curricula at this grade level, but some students may find it helpful to either discuss the rock cycle or see a diagram of it on the board as you go through this lesson. One way to approach this is to write each rock type's name on the board as you come to it in the chapter and then draw arrows and labels to connect them to each other.

Page 5

After reading the page, have volunteers sketch the scene on the board and use chalk to shade in the sedimentary rock that once surrounded the buttes. This will help students see that the buttes are the slender remains of what used to fill the valley, not landforms that were pushed up from the crust or produced by eruptions. Discuss the scales of space and time that must have been involved in the massive amount of weathering and erosion that occurred to make the valley and leave the buttes standing out like this.

SUPPORT—Assure that students understand the term *landform*, a natural feature of Earth's surface.

Pages 6–7

After reading the spread, check student understanding of the different kinds of rocks. Ask the following:

- Which type of rock do you think was the first to be made on Earth? Why? (*Igneous. Both metamorphic and sedimentary rock form from other rocks. Igneous is made directly from cooled material from Earth's interior, so it must have been the first type of rock.*)
- Which rock type is made from other rocks that are put under tremendous pressure and heat? (*metamorphic*)
- Granite from a mountain is worn away by natural forces. It accumulates downhill as sand and gravel. Over time, substances carried by water and the weight of the material cement the particles together. What kind of rock has been made? (*sedimentary*)

Online Resources

SUPPORT—If you have any samples of different rock types, pass them around, and identify them as igneous, sedimentary, or metamorphic. If time permits, display an image of granite as a specific example of igneous rock. For more activities on rock type and formation, see the Online Resources Guide for specific links:

www.coreknowledge.org/cksci-online-resources

Page 8

After reading the page, ask: The presence of marine fossils and sedimentary rocks made of marine fossils is evidence of what? (*that the location used to be underwater and was home to marine organisms*)

CHALLENGE—If time permits, have students research the interesting fact that Florida is made almost entirely out of limestone, a sedimentary rock that is made of the remains of corals, clams, and other marine organisms. This tells us that at one time Florida was an undersea reef. Marine organisms' skeletons, particularly those of corals and bivalves such as clams, accumulated over time and were compacted and cemented into limestone.

Pages 9–10

Draw student attention to the image of the buttes on page 9. Ask: Which layer is the oldest in each butte? (*the bottom layer*) What happened to the area between the two buttes? (*It was worn down by natural processes.*)

SUPPORT—If needed and if time permits, modeling clay can be used to show how mountain ranges that are now thousands of miles apart have a common origin. Slabs of clay can represent tectonic plates. A putty knife can be used to cut converged plates into several new plates. Move the slabs of clay away from each other to show how Earth's plates have, in some cases, drifted apart.

Clay can also be used to lay down model layers of sedimentary rock. Use three different colors to differentiate the layers. Use a putty knife to cut the rock into distinct pieces representing different locations, as in the figure on the page. You can remove the middle layer from one of the locations to model how erosion could have removed that layer before the top layer formed at that particular location. You can also add a new layer in the third location to model an intrusion of igneous rock.

Page 11 Before students read the page, draw their attention to the term *mountain building*. If students find this confusing, have them separate each word. Ask: What is a mountain? (*a very large hill*) What does the word *building* mean? (*to make something*) Ask students what they think this might mean. Then have students read the page.

SUPPORT—Use slabs of modeling clay to show how mountain building happens. On a flat, smooth surface, press two pieces of clay into fairly flat but moderately thick pieces. Explain that each represents one of Earth's plates. Then, push the two pieces against each other. One may move under the other, pushing the other up. Or they may push up against each other. In both examples, land is pushed upward. Explain that this is how mountains are "built," or are formed.

Page 12 After reading the page, ask a volunteer to summarize the three pieces of evidence of how and when dinosaurs (other than birds) became extinct.

SUPPORT—It may be helpful to draw a model of Earth to show how the meteorite's impact a) affected Earth and b) left evidence behind. A basic outline of Earth should suffice. Draw a small circle near the center to indicate the crater produced by the meteorite's impact. Draw an arrow to the circle, and label it with "crater" and "signs of melted rock." You may want to draw lines or provide labels to show how shockwaves, fire, and other disastrous effects of the impact radiated out from the impact site. Next, shade in the whole Earth circle to indicate that when the meteorite exploded, a cloud of iridium dust fell upon Earth's surface. This dust was preserved in sedimentary rock. Next, draw a cross section of Earth's crust that looks like the following:

Dinosaur fossils

Iridium layer

No dinosaur fossils

---

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms **igneous rock**, **metamorphic rock**, and **sedimentary rock**. Have students write each term in the upper left corner of an index card and underline it, one term per card.

Word Work

- **igneous rock:** (n. rock made of magma or lava that has cooled and hardened) Have students write the definition of *igneous rock* on their card. Then have them describe where they might find igneous rock. (*example: near or around a volcano*)
- **metamorphic rock:** (n. rock that forms when igneous or sedimentary rock is placed under tremendous heat or pressure) Have students write the definition of *metamorphic rock* on their card. Then have them describe how metamorphic rock forms. (*from heat and pressure deep inside Earth*)
- **sedimentary rock:** (n. rock made of sediment compacted together) Have students write the definition of *sedimentary rock* on their card. Then have them describe what can sometimes be found inside sedimentary rock. (*fossils of once-living organisms*)

4. Support discussion. 10 MIN

Establish a Scientific Mindset

Discuss with students examples of technology within the framework of problems and solutions. Draw attention to what they learned in Chapter 2 of the Student Reader regarding maps, imagery, and other tools used to study rocks and Earth changes. Tell students that whether or not the words *problem* and *solution* are spelled out in a description, every human-made device that is used in science to study geology began with the identification of a problem that the designer wanted to try to solve. Designers use their knowledge of science to support their solutions.

Give students practice identifying technology that helped scientists or engineers gather evidence to construct explanations. Know that at this grade level, most students will not know the answers to the following questions, so guide them to the correct answers. Ask these prompting questions to stimulate student thinking:

» What is one way scientists might have been able to locate the crater? (*sonar, satellite imaging*)

» How have scientists been able to come up with a date for when the asteroid struck Earth? (*They use techniques that determine how many of certain types of particles are in the material. This can be used to determine age* [radiometric *dating*].)

» What might be some simple technologies that scientists use to help them when constructing an explanation for how and when the dinosaurs went extinct? (*Writing utensils, computers, and recording devices are just a few examples.*)

Tie the concept of a solution back to a disaster preparedness plan and discuss why learning about changes to Earth's surface can help people come up with ways to prepare for hazardous events.

This may also be a good place to explain that maps are one kind of tool that can be used to measure and track changes in Earth's surface over time. For example, maps of islands and coastlines from hundreds of years ago can be compared to today's maps to detect changes. One drawback of maps is they need to be drawn accurately.

Satellite imagery is another kind of tool that helps scientists measure and track Earth's changes. Satellite imagery is pieced together from many individual photographs taken by satellites orbiting Earth. Photographs are more likely to be accurate than hand-drawn maps, and with satellites they can be taken many times per year. This lets us see changes that occur on Earth over time by looking at the photographs in order. Another way to take pictures of Earth's surface is to put cameras on airplanes or drones and fly them overhead. This is known as aerial imagery. Scientists often take aerial and satellite photographs and draw layers of information onto them. This helps show changes over time, such as erosion along the shore of a river or the shifting shape of an island.

Some students may be familiar with drone technology and digital cameras. Explain that these technologies are much more helpful if location can be measured with precision and accuracy. (See **Know the Science**.)

» Why is it important for satellite images or images taken by drones or other aircraft to be recorded along with the locations of the satellites or aircraft? (*Without knowing where the image was taken, it's just an image. It only has meaning if it can be aligned with the correct, actual location on Earth.*)

Know the Science

How are satellite images and other geographic-based data used by people? The underlying technology is called GIS, for Geographic Information System. The key feature of any GIS data is location. Once location is precisely recorded and tagged to a given piece of data, that data can be geolocated as a layer or spot on a GIS-based map or image. This allows scientists, planners, engineers, farmers, fishermen, and many other professionals to visualize data in an intuitive way. They can see data regionally. Layers can be removed or made invisible if they aren't relevant to a given discussion or investigation. See the Online Resources Guide for a specific link to more information about GIS:

www.coreknowledge.org/cksci-online-resources

» Why do you think modern science and surveying favor the use of satellites and drones over hand-drawn maps? (*Real images such as photographs are more accurate than drawings. Satellites and drones can record thousands of images without having anyone up in the air or moving around Earth's surface in the time it would take to measure and record things using hand tools.*)

5. Check for understanding. 5 MIN

Activity Page

AP 4.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 4 Check (AP 4.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in learning how Earth's surface has changed over long periods of time. Students have learned the following:

- how Earth's plates move and how weathering wears down Earth's surface
- how new rocks and mountains form
- how volcanic activity contributes to the recycling of Earth's crust
- how major events such as asteroid strikes have altered Earth's surface

Explain that in Lesson 5, students will learn more about how earthquakes contribute to changes in and hazards on Earth's surface and how these occurrences affect people.

PART C

Earth’s Moving Crust

Overview

Lesson	Big Question	Advance Preparation
5. Earthquakes	Why are some communities more likely to experience an earthquake than others?	Read Student Reader, Chapter 3.
6. Earthquake Problems and Solutions (3 days)	How can engineers reduce earthquake damage to buildings?	Gather materials for problem-based learning project. (See Materials and Equipment, page 16.)
7. Tsunamis	How can communities better protect themselves from tsunamis?	Read Student Reader, Chapter 4.
8. Volcanoes	Can scientists predict when a volcano is going to erupt?	Read Student Reader, Chapter 5.
9. Reading Maps of Volcanoes	How can you use maps to determine patterns of volcano formations?	Gather materials for problem-based learning project. (See Materials and Equipment, page 17.)

Part C: What’s the Story?

In Part B (Lessons 2–4), students learned about the slow processes that shape Earth’s surface, including the movement of the plates and the building up of layers of rock, and how the three main types of rock form. Students also read about the evidence that scientists have used to discover these things, helping establish a foundation that will aid students as they work toward their unit capstone project.

In Part C (Lessons 5–9) and as part of their **problem-based learning project**, students continue to ask questions about natural hazards as well as the Earth processes that drive them, and students learn how to determine whether such events are a threat to the communities in which they live.

In Lesson 5, we start by having students read and learn about earthquakes, which usually occur near Earth’s plate boundaries, or the area where different plates are interacting (either colliding or pulling apart). Students examine specific areas where earthquakes have struck and examine the type of effects the seismic waves from earthquakes have on land and human-made structures. Then, based on the evidence, students ask themselves if earthquakes can happen in their community.

In Lesson 6, students learn more about the problems that earthquakes can cause, but they also learn about ways that engineers have developed to predict earthquakes in advance, to warn communities about earthquakes, and to best protect communities from earthquakes. Students pull from this ideas about how they could protect their own communities from earthquakes if necessary.

In Lesson 7, students read about tsunamis, their causes (usually earthquakes at sea or the displacement of land—caused by earthquakes or landslides—into bodies of water, which in turn causes the displacement of water), and their effects. They also ask themselves whether their own communities are at risk of earthquakes and, if so, how to best predict them, warn people about them, and protect the community from them.

In Lesson 8, students read and learn more about volcanoes, how they form, and where they form. They also learn that most volcanic activity occurs along plate boundaries, particularly where the Pacific plate meets other plates. This is known as the Ring of Fire because of the sheer number of volcanoes located there. Students learn about the tools that scientists use to detect and warn communities about volcanic eruptions, as well as what to do should one occur.

In Lesson 9, which concludes Part C, students continue to learn about volcanoes and how to predict volcanic eruptions by looking at and reading maps. Maps can help us see patterns in where volcanoes occur. Students ask themselves, “Could this happen in my area?” and what to do if it could, in anticipation of the unit capstone project.

So, to repeat, **the movement of Earth’s crust contributes to a number of different natural hazards, including earthquakes, tsunamis, and volcanic eruptions**. Help your students understand Earth’s systems and processes and how they relate to natural hazards, and you will lay the groundwork for meeting the NGSS Performance Expectation MS-ESS2 as well as help students on their problem-based learning project.

LESSON 5

Earthquakes

Big Question: Why are some communities more likely to experience an earthquake than others?

Problem-Based Learning Project: Learn why some communities are more prone to experience earthquakes than other communities in anticipation of the unit capstone project.

At a Glance

Learning Objectives

✓ Identify earthquakes as a geological hazard, and examine some of their consequences.

✓ Describe an engineering solution that helps protect the people of Japan from earthquakes.

✓ Interpret maps to discern patterns of major geologic features of Earth's surface.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Disciplinary Core Idea ESS3.B: Natural Hazards

Crosscutting Concepts: Cause and Effect; Patterns

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions is important to this lesson, as students will be introduced to solutions that can be used to minimize the damages caused by earthquakes in their reading selection.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

earthquake geologic **magnitude** seismic

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 3

Activity Pages

AP 5.1

AP 5.2

Student Reader, Chapter 3
"Earthquakes"

Activity Pages
Lesson 5 Check (AP 5.1)

Natural Hazard Solutions (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 10 MIN

Why are some communities more likely to experience an earthquake than others? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn why some areas are more prone to earthquakes than others in support of the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

In the previous lessons, students learned about Earth-shaping processes. Earthquakes are one such process that can drastically change the way Earth looks in a given area. Explain that today students will read about earthquakes and why they occur and consider where these natural events are most likely to occur. Check student background knowledge on earthquakes. Ask: What is an earthquake? (*an event that makes the ground shake or move*)

Describe earthquakes as one of several hazardous events that occur at or near Earth's surface. Explain that they occur in patterns, which students will learn more about as they go through their Student Readers. (See **Know the Standards** for support.)

Preview Core Vocabulary Terms

Prepare students to approach the reading by writing **earthquake** and **magnitude** on the board or chart paper. Have students work with a neighbor and discuss the following:

- » What are some of the effects of earthquakes that you have heard of in the news, seen in a movie, or experienced yourself? (*The ground shakes a lot, buildings are damaged, gas lines rupture, fires break out, injuries and deaths occur.*)
- » What do you think causes earthquakes? (*movement of Earth's plates, volcanic eruptions*)
- » Where do you think earthquakes most often occur? (*near volcanoes, where plates meet*)

2. Read and discuss: "Earthquakes." 20 MIN

Student Reader

Ch. 3

Read together, or have students read independently, "Earthquakes," Chapter 3 in the Student Reader, which defines earthquakes, helps students understand where they occur and why, describes their causes and effects, and explains how scientists measure them and engineers attempt to make human civilization less vulnerable to earthquake hazards.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 13

After reading, have students list the effects of an earthquake (*ground movement, damage to trees and buildings, etc.*), and ask them if they can come up with more (*injury to people, movement of waterways*). Understand that, if earthquakes are not common in their area, students may have a harder time listing effects and will need to be guided.

Know the Standards

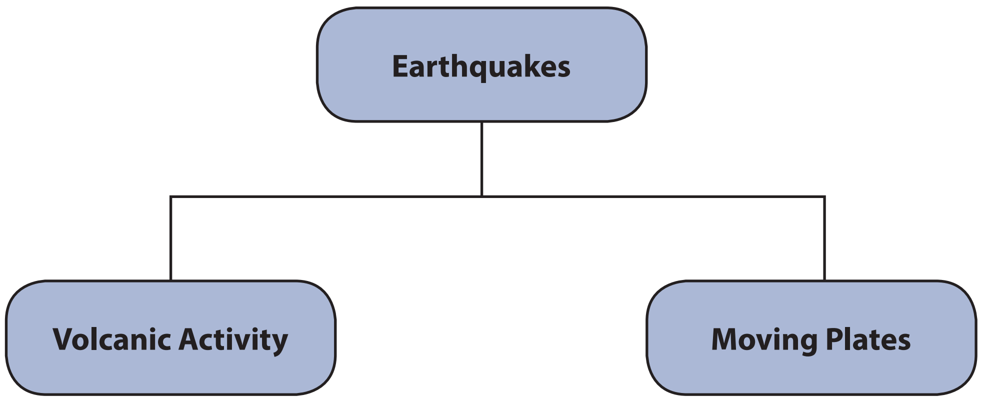
Earthquakes occur in patterns. The NGSS standards emphasize that patterns of natural phenomena can be used as evidence to explain events such as earthquakes. Most earthquakes occur near boundaries between crustal plates. Maps of Earth's surface and crust can help scientists find patterns and make connections between features and events, including earthquakes.

WORD WORK—The term *earthquake* describes and encompasses a series of discrete events that occur on Earth. The "quake" is the shaking caused by vibrations that are transmitted through Earth's crust and the materials that lie above it.

CHALLENGE—Challenge students to think about why most earthquakes occur where plates meet.

Pages 14–15

Draw a blank hierarchy chart on the board or chart paper with one top box labeled "Earthquakes" and two boxes underneath it labeled "Moving Plates" and "Volcanic Activity."



Call on two volunteers to approach the board. Assign each student to one of the two lower boxes. Have the students write down how each cause leads to an earthquake. Students can use short statements to get the main ideas across.

SUPPORT—If students require a demonstration to understand how earthquakes are formed from the movement of plates, suggest the following:

- Tell students to place one hand on top of the other. Have students press their hands against each other while also trying to slide the top hand over the other. This will most likely result in stress and vibrations. Eventually, the force of the plates against or over/under each other will overcome the force that prevents them from moving, and they will lurch into motion.
- To model where plates are sliding past each other, students can press their palms together while simultaneously trying to slide them in opposite directions. Again, the forces that are moving the plates in opposite directions will eventually overcome the friction between them.

Online Resources

There are ample online resources to further visualize the pattern of earthquakes at or near plate boundaries. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Page 16

After reading the page, use analogies to discuss landslides and why certain types of soil and sediment are more vulnerable during earthquakes. Ask the following:

» Why is it easier to maintain your footing and balance when a surface is solid? (*Hard surfaces are easier to grip.*)

» Why would soil that is wet with water be more vulnerable to an earthquake's vibrations than a thick slab of rock? (*The particles aren't packed as tightly. The water is mixed with the particles of soil, and everything is looser and able to vibrate and move more easily.*)

Page 17 Remind students that they learned about the amplitude of waves in Unit 2, *Investigating Waves*. The magnitude of an earthquake is related to the amplitude of seismic waves recorded on a seismograph during the event. To reinforce the information and give students the opportunity to practice Using Mathematics and Computational Thinking (NGSS SEP5), it may help to draw two upright bars on the board or chart paper. The bars should be the same height and separated into ten squares of equal size. Label the first bar "Magnitude 1." Label the second bar "Magnitude 2." For the first bar, shade in only the bottom square. For the second bar, shade in all ten squares. Explain that these represent the difference in magnitude. Magnitude 2 is ten times the area of magnitude 1 in the graph. (See **Know the Science**.)

A magnitude-3 earthquake would be ten times the size of a magnitude-2 earthquake and one hundred times the size of a magnitude-1 earthquake. Ask the following:

» How much more energy would be released by a magnitude-9 earthquake than a magnitude-7 earthquake? (*about one thousand times more energy*)

CHALLENGE—If time permits, have students research and compare the magnitudes of different earthquakes that took place in different parts of the world. For instance, the magnitude-9.0 earthquake that struck Japan in 2011 was a little more than ten times larger in terms of seismic wave size than the magnitude-7.9 earthquake that struck China three years earlier. And that 2011 earthquake in Japan released more than thirty-two times as much energy as the 2008 quake in China.

Page 18 After reading this page, call on students to summarize the ways that people can live safely in areas that get earthquakes. (*avoiding building on vulnerable soil, using proper materials for construction, using braces*)

Take this time to remind students of the product they will be making for their unit capstone project. Point out that the page provides information that students

Know the Science

What is an earthquake magnitude scale? Students (and people in general) tend to think in scales that are linear. Students may assume that an earthquake of magnitude 7 is "one more" unit of intensity or strength than a magnitude-6 earthquake. The magnitude scales that are used to measure and describe earthquakes are logarithmic. The first logarithmic scale was the Richter scale, but it did not go high enough to capture extremely strong earthquakes, nor did it account for the amount of energy released. It has since been replaced by more accurate scales. One full step up a logarithmic scale means a tenfold increase in the amplitude of seismic waves and an increase of about thirty-two times in terms of energy released. The scale used most often now is the moment magnitude scale.

may find useful for the project at the end of the unit. There are abundant online resources for learning more about earthquake-resistant structures, building materials, engineering practices, and more. There are also resources for determining seismic hazards by location.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

3. Refocus student attention on the Big Question. 5 MIN

Why are some communities more likely to experience an earthquake than others? Quickly go around the room in a "lightning round," and have each student answer one of the following questions:

- What is an earthquake? (*an event that makes the ground shake or move*)
- What does *seismic* mean? (*the type of waves related to earthquakes or vibrations in Earth's crust*)
- What can cause earthquakes? (*the movement of Earth's plates against each other*)
- Where do most large earthquakes occur? (*near volcanoes or by where plates meet*)
- How do landslides happen? (*Landslides can be caused when the soil becomes full of water or when earthquakes shake the ground loose.*)
- What is the tool called that measures earthquakes? (*seismograph*)
- Geologists who study earthquakes measure their strength on a scale of what? (*magnitude*)
- What can people do to live safely in areas that have earthquakes? (*have alarm systems to warn of earthquakes, build in areas where earthquake damage is less likely, design buildings to withstand earthquake damage*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms **earthquake** and **magnitude** displayed at the beginning of the lesson. Have students write each term in the upper left corner of an index card and underline it, one term per card.

Word Work

- **earthquake:** (n. shaking of the ground caused by a seismic wave) Have students draw on their card an example of an earthquake. Ask them to show in the drawing what an earthquake can do to the ground and buildings in the area. (*Drawings should show an understanding of the effects of earthquakes. For example, they may show ground that has cracked open or a building that has fallen down or been damaged in some way.*)
- **magnitude:** (n. the size or extent of an earthquake) Have students write a sentence using the words *magnitude* and *earthquake*. (*A stronger earthquake has greater magnitude.*)

5. Check for understanding. 5 MIN

Activity Pages

AP 5.1
AP 5.2
Answer Key

Formative Assessment Opportunity

Have students complete Lesson 5 Check (AP 5.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Next, have students complete the first row of Natural Hazard Solutions (AP 5.2). Explain that students should think about whether this is or could be a hazard in their community and why. Do not collect the Activity Page. Instead, tell students to keep it in a safe place because they will be returning to it throughout the unit. In addition, you may also wish to check with a city engineer, a local environmental education center, or a high school Earth science teacher to ask which of the natural hazards listed are most prevalent in your area. Have students pay special attention to this as they go through the remainder of the unit. Remind students that in the final lesson, they will have to craft a presentation for their community explaining how to protect against local natural hazards.

Problem-Based Learning Progress

Review progress students have made in learning why some areas are more prone to earthquakes than others. Students have learned the following:

- how the interaction of Earth's plates can lead to earthquakes
- about some of the areas where Earth's plates are interacting the most

Discuss with students whether or not earthquake hazards pose a threat in your location. Explain that in Lesson 6, students will learn more about how communities help protect themselves from earthquakes.

LESSON 6

Earthquake Problems and Solutions

Big Question: How can engineers reduce earthquake damage to buildings?

Problem-Based Learning Project: Learn how engineers work to reduce earthquake damage to human-made structures in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Plan and develop a model solution to reduce the effects of one kind of geologic event (such as an earthquake).

Lesson Activities (3 days)

- reading
- discussion
- hands-on activity
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Disciplinary Core Idea ESS3.B: Natural Hazards

Disciplinary Core Idea ETS1.B: Designing Solutions to Engineering Problems

Crosscutting Concepts: Cause and Effect; Influence of Engineering, Technology, and Science on Society and the Natural World

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Designing Solutions to Engineering Problems: This three-day lesson focuses on how scientific investigations are used to test solutions to engineering problems. On Day 1, students will build small shake tables to simulate the side-to-side motion of certain kinds of earthquakes. On Day 2, students will generate and evaluate solutions to reduce the impact of an earthquake on a model building. On Day 3, students will use their designs to test several proposed solutions.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

criteria and constraints | design solution | earthquake

Instructional Resources

Activity Pages

AP 6.1
AP 6.2
AP 6.3
AP 6.4
AP 6.5
AP 6.6
AP 6.7
AP 6.8

Activity Pages

Earthquake Solutions Evaluation Guide (AP 6.1)

Describing the Problem (AP 6.2)

Describing Criteria and Constraints (AP 6.3)

Making and Evaluating Design Solutions, Part 1 (AP 6.4)

Making an Earthquake Shaker (AP 6.5)

Making and Evaluating Design Solutions, Part 2 (AP 6.6)

Engineering Design Showcase (AP 6.7)

Letter to Parents or Community Members (AP 6.8)

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images for whole-class viewing

Shake table:

- pizza boxes (large or individual size)
- scissors
- marbles (10–20 marbles per box)
- ruler
- small rubber bands (4 per box)
- stapler

Model building(s):

- mini-marshmallows
- plastic coffee stirrers (or dried spaghetti)

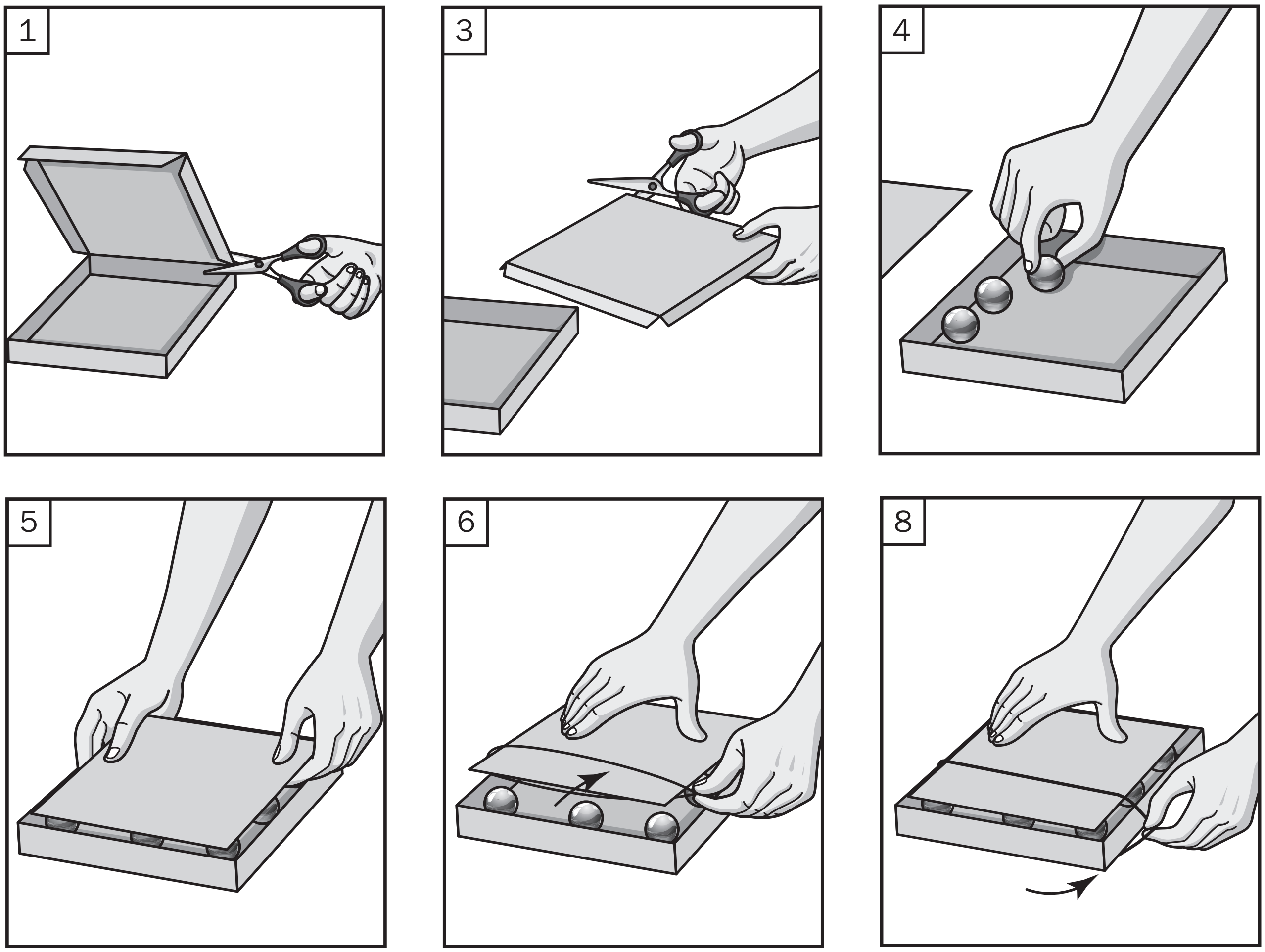
Advance Preparation

If you have already assigned students to teams for this unit, have them work in those teams for this lesson. If you have not yet assigned teams, groupings of three or four students will allow assignment of roles and allow accountability of all team members.

It is important that when testing their design solutions, students should conduct a fair test. For more about fair testing, see the Online Resources for a link to a suggested website: **www.coreknowledge.org/cksci-online-resources**

Students will be building the shake table with cardboard boxes and marbles to investigate the following problem: How can engineers reduce earthquake damage to buildings? The criterion is that the shake table prevents side-to-side motion of the building. You or your students will also build one model building for each shake table.

Decide how many shake tables you will need for the class (from one per team to one for the entire class). Make and test one shaker in advance for students to use as a model for making theirs. To do so, cut the top off the pizza box, and then trim the edges off each side of the top so that it is 2 cm smaller than the box itself. Place marbles in the bottom of the box, and put the top over the marbles. Staple a rubber band to each corner of the top and then to the corner of the bottom of the box (or wrap with a large band). The rubber bands should be taut, but not overly so.



Be aware that some of the Activity Pages will be used more than once. For example, Earthquake Solutions Evaluation Guide (AP 6.1) is used on both Days 1 and 3 of this lesson.

On Day 1, send Letter to Parents or Community Members (AP 6.8) home with students. You may also want to invite members of the community such as a city planner or seismologist to engage students with their shaker designs.

The Core Lesson   Three days, 45 min each

1. Day 1: Focus student attention on the Big Question. 10 min

Activity Page

AP 6.1

How can engineers reduce earthquake damage to buildings? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn some of the design solutions engineers have come up with to lessen the impact of earthquakes on human-made structures in support of the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Online Resources

Show students images of buildings that have been damaged by earthquakes. See the Online Resources for a link to suggested images:

www.coreknowledge.org/cksci-online-resources

Have them recall and discuss what they learned in Lesson 5 about the effects of earthquakes. Ask the following:

» How do earthquakes affect Earth's surface? (*The soil can shift or slide. Solid rocks move up and down or side to side and can fracture. Landslides can form. Large water waves can occur from the shaking of rocks or landslides falling into the ocean. This displaces water, which can cause large water waves that can destroy structures when they reach land elsewhere.*)

» How do earthquakes affect people? (*Roadways and buildings can be damaged and even collapse. People can be injured or killed by falling building materials, landslides, or tsunamis.*)

» What do people do to reduce the impacts of Earth's natural processes? (*They design buildings that resist the motion of earthquakes so that the buildings do not fall down.*)

Set the stage for this three-day engineering task by distributing Earthquake Solutions Evaluation Guide (AP 6.1). With the class, read the "expert" level for each skill/row. Explain that, at the end of this lesson, this rubric will be used to evaluate students' work. (See **Know the Standards**.)

Know the Standards

Developing Possible Solutions: Over the course of Grades 3–5, NGSS ETS1.B exposes students to the aspect of the engineering design process related to Developing Possible Solutions. Students need to gain experience in the process themselves, including researching options, testing ideas, communicating with peers, and identifying elements of designs that need improvement.

2. Define the problem. 5 MIN

Activity Page

AP 6.2

Distribute Describing the Problem (AP 6.2). Arrange students in teams of small groups, for example with three or four students per group. Ask each team to read the directions, discuss possible answers, and complete their individual concept maps. Each student's responses to Activity Page 6.2 should be based on what they learned in Lesson 5, their prior knowledge, and the example images you showed them in Step 1 today.

> **SUPPORT**—If students struggle to add facts to their concept maps, allow them to review Chapter 3 in the Student Reader for ideas.

Explain to students that buildings respond in different ways to earthquakes. One reason this is true is that not all earthquakes are the same. Some seismic waves, the cause of an earthquake, move faster or slower than others. Another reason is that buildings of different heights respond differently to seismic waves. (See **Know the Science 1**.)

3. Specify criteria and constraints of solutions. 10 MIN

Activity Pages

AP 6.3
AP 6.4

Distribute Describing Criteria and Constraints (AP 6.3). Discuss this page as a class. The problem to solve should be written as a question. Use the Big Question (How can engineers reduce earthquake damage to buildings?) for this lesson as a starting point.

Review the definitions of *criteria* and *constraints* with students. Make sure students understand that both are requirements for a successful solution. Remind students that possible solutions to a problem are limited by the materials and resources that are available. These are constraints. How successful a solution can be is determined by the desired features of that solution. These are the criteria. Scientists and engineers often come up with different solutions, which they then test and compare to determine which one best meets the criteria.

Know the Science

1. Which are safer in an earthquake, taller or shorter buildings? ***It depends on the types of seismic waves.*** Shorter buildings sustain more damage than taller buildings when the earthquake involves high-frequency seismic waves. Taller buildings sustain more damage than shorter buildings when the earthquake involves lower-frequency waves. Buildings have what engineers call a natural frequency. The natural frequency is the period of time it takes for the building to sway back and forth. Shorter buildings have quicker natural frequencies, and taller building have slower ones. If the frequency of the earthquake waves is the same as that of the building's natural frequency, then the building may sustain a large amount of damage, regardless of its height.

(See the Online Resources for a link to a suggested video: **www.coreknowledge.org/cksci-online-resources**)

SUPPORT—Have students reread page 18 of the Student Reader. Then ask students to describe the criteria and constraints that the construction industry in Japan had to deal with when designing solutions to earthquakes in the nation.

Have volunteers tell what they think makes a building resistant to earthquakes. Allow students to refer back to anything they have learned in the previous lesson or "Earthquakes," Chapter 3 in the Student Reader. Discuss each criterion and constraint listed on the Activity Page, making sure students understand that they will be making model buildings to test by shaking.

Place students in groups, and have them discuss the best way to build their model buildings. Then, have students put their model buildings together. Explain to students that their models will have to sit on the shaker, so the base of the model should be smaller than the top surface of the shaker.

Circulate among the teams, and make sure students understand that they may use the scissors to cut the stirrers. Ask guiding question such as, "Are there shapes other than squares that you can make with the stirrers?"

Afterward, pass out Making and Evaluating Design Solutions, Part 1 (AP 6.4). Have students complete it individually.

4. Support the investigation. 15 MIN

Activity Page

AP 6.5

The earthquake simulators that engineers use are called shake tables. (See **Know the Science 2**.) In this lesson, they are called shakers. Explain that shakers are models because they help engineers understand how human-made structures might react in the event of a real earthquake. The simulators help model real-world phenomena and can help test design solutions. Some are very large, as can be seen in the recommended video. Explain to students that they will be working with a shake table, or shaker, much smaller in size. See the Online Resources for a link to a suggested video:

Online Resources

www.coreknowledge.org/cksci-online-resources

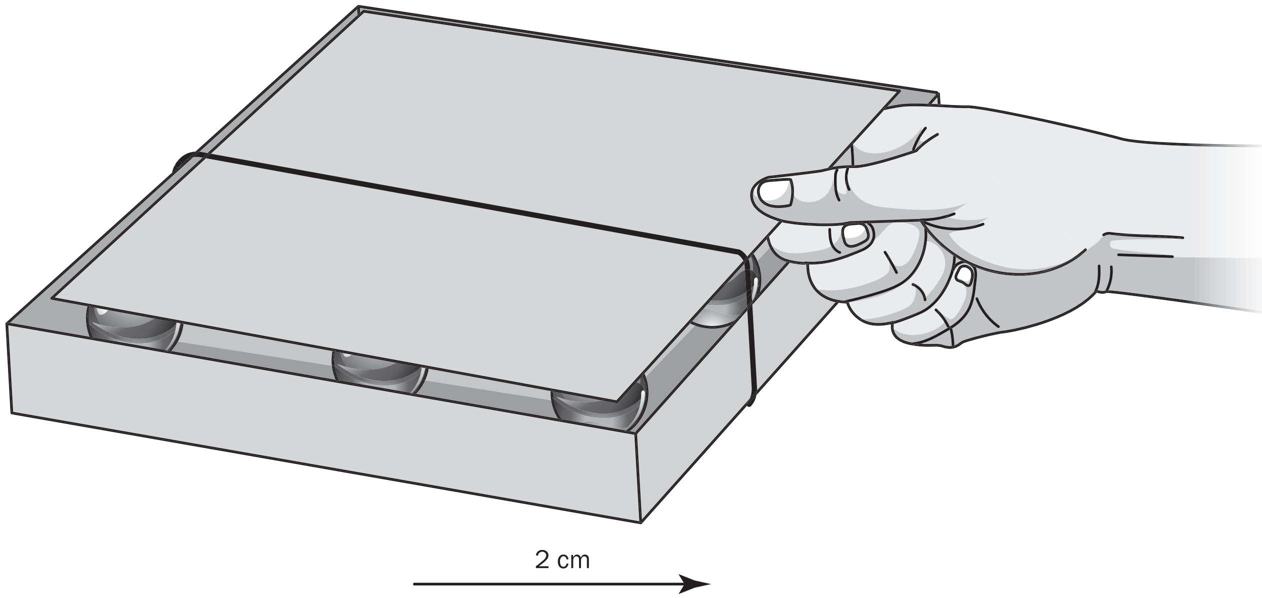
Distribute Making an Earthquake Shaker (AP 6.5). Have one student from each team take the role of the person who collects the materials. Depending on the quality of scissors available, students may have trouble cutting the boxes. You may need

Know the Science

2. What are earthquake shake tables? Shake tables, also called shaking tables, are devices scientists build in order to conduct investigations of the effects of earthquakes on human-built structures. They are platforms that use hydraulic devices controlled by computer software to vibrate in specific ways in order to observe objects that are subjected to seismic waves. Model bridges, houses, and/or office buildings are placed on the top of the tray and observed under varied earthquake conditions. The earliest known shake tray was developed in Japan in the 1890s. In 2009, Japanese scientists built a huge shake tray that can accommodate a full-size seven-story apartment building. After testing a building design, scientists and engineers can modify the design and test it again.

to use a large pair of shears or a straightedge and cutting blade to make the cuts for students.

Have students test the shaker several times. Point out that pulling the top two centimeters to the side each time will ensure that the shaker moves in the same way each time students use it. For more control over the test conditions, each team can choose one member to operate the shaker later in the lesson.



5. Check for understanding. 5 MIN

Formative Assessment Opportunity

Have teams share their results, comparing the similarities and discussing the differences. If there were major differences, have volunteers attempt to explain why.

1. Day 2: Refocus student attention on the Big Question. 5 MIN

Activity Page

AP 6.6

How can engineers reduce earthquake damage to buildings? Tell students that today they will continue exploring how engineers consider design solutions to reduce earthquake damage to buildings.

Distribute one copy of Making and Evaluating Design Solutions, Part 2 (AP 6.6) to each student.

2. Support the investigation. 35 MIN

Have students retrieve their model buildings. Make sure that all students in each team have a chance to test their models on the same shaker. Then have students answer the questions on the Activity Page.

CHALLENGE—If there is time, some students may wish to modify their design solutions and test them again on the shaker.

3. Check for understanding. 5 MIN

Formative Assessment Opportunity

Have these students draw and label a diagram explaining what modifications they made if they had to make modifications. Then, have them write a caption explaining the result of testing it on the shaker.

1. Day 3: Refocus student attention on the Big Question. 5 MIN

How can engineers reduce earthquake damage to buildings? Remind students of the Big Question that they are trying to answer, and review with them the steps they have taken so far in the investigation.

2. Support student evaluation. 30 MIN

Activity Pages

AP 6.7
AP 6.1

Distribute one copy of Engineering Design Showcase (AP 6.7) to each student. Tell students that they will be introducing their designs to others. Have students read and write the answers to the questions.

Have each team come up with a team name. Then have the students cut out their name tags, fill in their names, and attach them to their clothing.

Direct students to take out Earthquake Solutions Evaluation Guide (AP 6.1) again. Read and discuss the Presenting and Teamwork rows, and explain that you will be looking for the behaviors described during the showcase presentations.

For the showcase, invite some parents, teachers, administrators, or younger students to visit the class. This is also an opportunity for a city planner or seismologist to speak with students, answering questions about how likely earthquakes are in the area and what the community has done to deal with them. Have each team stand near their model buildings and shakers so that they can answer visitors' questions. If you prefer not to invite visitors to class, an alternative activity is to have each team take a three-minute turn presenting to their own class. Be sure to allow time for questions and answers after each presentation.

3. Check for understanding. 10 MIN

Activity Pages

AP 6.1
AP 6.2
AP 6.3
AP 6.4
AP 6.6
AP 6.7
Answer Key

Formative Assessment Opportunity

Have each student place their completed Activity Pages 6.2, 6.3, 6.4, 6.6, and 6.7 in a folder and attach their Engineering Design Showcase identification badge to the cover. Collect the folders.

Use Earthquake Solutions Evaluation Guide (AP 6.1) to evaluate each student's work over the three days to meet Performance Expectation 4-ESS3-2. Note that multiple solutions to the design problem were generated within each team. Some students may also have refined their own designs and retested them.

Assess students' work developing a concept map on Describing the Problem (AP 6.2). Look for understanding of cause-and-effect relationships.

Review Describing Criteria and Constraints (AP 6.3) to make sure that students checked off all the criteria and constraints for the solution.

Use the Answer Key for Making and Evaluating Design Solutions, Part 1 (AP 6.4) and Making and Evaluating Design Solutions, Part 2 (AP 6.6) to assist you in assessing how well students understood the core idea that testing a design solution involves a scientific investigation.

Use students' responses to the open-ended questions on Engineering Design Showcase (AP 6.7) to evaluate student attitudes and interests in the engineering design process.

Circulate around the room during each team activity (making the shakers, designing the model building, testing the models on the shaker, and presenting at the showcase) to assess individual effort and teamwork.

Problem-Based Learning Progress

Review progress students have made in learning some of the solutions engineers have developed to combat damage to structures from earthquakes. They have done the following:

- learned about some of the devices that engineers have developed to detect earthquakes
- learned about some of the devices that engineers have developed to measure earthquakes
- learned about some of the designs that engineers have developed to make buildings stronger in the event of an earthquake

Explain that in Lesson 7, students will learn more about destructive water waves.

LESSON 7

Tsunamis

Big Question: How can communities better protect themselves from tsunamis?

Problem-Based Learning Project: Learn about the damage that tsunamis can cause and how communities deal with them in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Describe tsunamis and how people can avoid them or minimize their damage.

Lesson Activities

- student observation
- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Disciplinary Core Idea ESS3.B: Natural Hazards

Crosscutting Concept: Cause and Effect

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Cause and Effect is important to this lesson, as students will be learning about what causes tsunamis, as well as the types of devastating effects that tsunamis have on nature and society.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

displace **tsunami**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary term designated in blue on the previous page.

Instructional Resources

Student Reader

Ch. 4

Activity Pages

AP 7.1

AP 5.2

Student Reader, Chapter 4
"Tsunamis"

Activity Pages
Lesson 7 Check (AP 7.1)

Natural Hazard Solutions (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- 2-liter plastic soda bottle with cap
- small gravel (fish tank gravel)
- water
- index cards for student vocabulary deck (1 per student)
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Prepare in advance for this activity by doing the following:

1. Remove any labels from the soda bottle.
2. Fill the soda bottle with the small gravel (until there is about a two-inch layer of gravel on the bottom of the bottle).
3. Pour water into the soda bottle.
4. Secure the cap onto the soda bottle.

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 10 MIN

How can communities better protect themselves from tsunamis? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn what causes tsunamis, the effects they can have on communities, and how those communities deal with them. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Remind students that so far they have learned about earthquakes, where they tend to occur, and the types of devastating effects that earthquakes can have on the Earth and people, animals, and plants. Assess students' prior knowledge of earthquakes to build a connection to tsunamis. Ask the following:

» Do earthquakes occur under the ocean? (*yes*)

» Are there faults in the ocean? (*yes*)

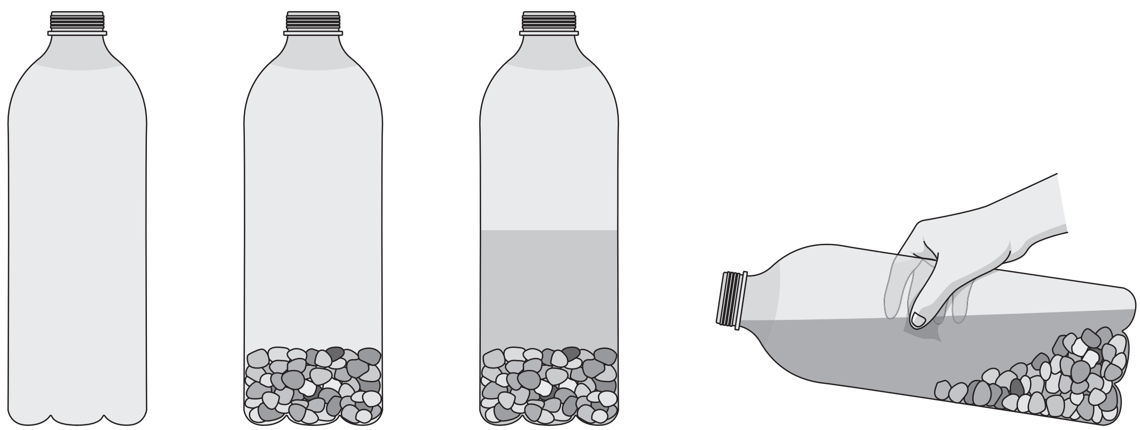
» What can earthquakes in the ocean cause? (*large waves/tsunamis*)

» What do you think a tsunami is? (*a large wave*)

Remind students of water waves. Explain that water waves occur when energy travels through water.

Describe tsunamis as one of several hazardous events that occur at or near Earth's surface and that these events occur in patterns, similar to earthquakes. (See **Know the Standards 1** for support.) Explain that it is not uncommon for tsunamis to follow earthquakes that occur in or near the ocean or other bodies of water.

Demonstrate a tsunami for the class. Show students the plastic bottle that is filled with gravel and water. Explain that you filled the bottle with gravel and water. Now, lay the bottle on its side. The pebbles will slide to the side and create a hill. Tell students to watch what happens next as you place a hand underneath the mouth of the bottle and move your hand up. This will create a wave in the water that crashes onto the small gravel. (See **Know the Science 1** for support.)



Know the Standards

1. Tsunamis occur in a similar pattern to earthquakes. The NGSS standards emphasize that patterns of natural phenomena can be used as evidence to support an explanation for events. The pattern of where and when tsunamis occur follows such a pattern. Most, but not all, tsunamis occur as a result of plate interactions at plate boundaries. Earthquakes and tsunamis often coincide. When an earthquake strikes, water is likely to have been displaced and may cause a tsunami wave.

Know the Science

1. Why are we making waves in bottles? *To simulate a tsunami.* Students can get a basic visual of a tsunami, or large wave crashing onto the shore, through this demonstration to prepare them for what they are about to read in the Student Reader Chapter 4.

Ask the following:

- » What do you think the water represents? (*the ocean*)
- » What do you think the gravel represents? (*the land, shore, beach*)
- » Do you think tsunamis are different from regular waves? (*yes*) How so? (*They are bigger.*)
- » Do you think tsunamis can be dangerous? (*yes*) Why? (*because they can wash up to shore and ruin things in their way and cause flooding*)

2. Read and discuss: "Tsunamis." 20 MIN

Student Reader

Ch. 4

Read together, or have students read independently, "Tsunamis," Chapter 4 in the Student Reader, which describes tsunamis, their history, and how people can try to detect and survive them.

Preview Core Vocabulary Term

Before students read, write **tsunami** on the board or chart paper. Encourage students to pay special attention to this term as they read.

Have students write just the term in the upper left corner of a new Core Vocabulary card. Students will revisit the card later in the lesson to add notes about what the word means.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 19

After reading the page, check for student understanding of the term *displacement*.

SUPPORT—Compare the word *displacement* with the word *misplacement,* which students are likely to know. Ask: What happens when you misplace something? (*You forget where you put something; you put it in the wrong place.*) Tell students that *displacement* means that something is moved from where it should be.

CHALLENGE—If time permits, have students research and share about tsunamis that have occurred in history. For example, the volcanic island Krakatau exploded in Indonesia in 1883. The collapsing chunks of the volcano caused tsunamis that killed more than thirty thousand people. The 2004 tsunami that began in Indonesia affected coastlines around the Indian Ocean. It killed more than 220,000 people. That tsunami occurred during an earthquake. The tsunami in Indonesia in 2018 was caused by a volcano erupting and a large part of it breaking off into the ocean.

Page 20

After reading the page, address any misconceptions about tsunamis. While movies make tsunami waves look like the curling waves that surfers try to ride, in reality a tsunami is more like a wall of water that just keeps rushing ashore.

SUPPORT—Before a tsunami strikes a shore, the water may recede as though the tide is going out. This has caused some beachgoers to be lured farther out as their curiosity compels them to explore the intertidal zone, look at animals, or try to see how far out the water recedes. Then the water comes flooding back in but much higher than it was before, sweeping people off their feet. A number of vacationers died this way in Thailand during the 2004 tsunami.

Page 21

The page describes Japan's history of experiencing and learning from tsunamis. Clarify for students that the tsunami stones that were erected on hillsides were markers of how high the ocean had reached during a tsunami. Tell students that today, scientists and planners use inundation maps to plot where tsunami waves, storm surges, and sea-level rise will reach based on GIS data and sophisticated modeling. Students may be able to incorporate some of these techniques into their unit capstone project.

Online Resources

SUPPORT—You can use online resources to show examples of how GIS data can be used to predict how a tsunami will affect a coastal area. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Have students think back to the beginning of this lesson and to what they learned about earthquakes in the previous lesson. Ask: Why might tsunami warnings be issued when there is an earthquake at sea? (*Earthquakes at sea cause displacement, or a huge movement, of water. When the ground beneath a body of water shifts, it causes the water above it to move. This can cause a tsunami to form.*)

Page 22

After reading the page, ask: What are some direct effects of tsunamis? (*drowning organisms*) What are some indirect effects of tsunamis? (*damage to power plant reactors*)

SUPPORT—If needed, explain to students the difference between direct and indirect effects (of tsunamis or other natural hazards). Explain that direct effects refer to the physical or structural impacts that are caused by the disaster, such as destruction of homes caused by flooding of the waves. Indirect effects usually occur later as a result of the disaster, such as the disruption of goods or medical supplies being able to be imported to the area or economic decline.

If needed, discuss the example of the indirect effect given in the Student Reader. Explain that like an earthquake, a tsunami can have direct effects that are hazardous and that it can also trigger other hazards. The disaster at the Fukushima Daiichi Nuclear Power Plant after the 2011 tsunami is an example of how a natural disaster can lead to other disasters. Another effect of the 2011 tsunami was the large amount of debris that was pulled out to sea when the water receded from Japan's shores. For months, debris drifted on the Pacific Ocean. Some of it drifted all the way across to the Pacific coast of the United States, and some became trapped in the North Pacific Gyre, which is home to the Great Pacific Garbage Patch.

Ask:

- » How did the large-scale movement of crustal plates near Japan trigger a series of disastrous events? (*It caused an earthquake that did some damage by itself, but it also triggered a tsunami that flooded the coast, destroyed property, killed people, and disabled a nuclear power plant to the point that its reactors melted down.*)
- » What are some ways to prevent one event or disaster from turning into many others? (*There should be backup systems in place for things such as nuclear power plants or even backups for the backups. When it takes just one thing to go wrong and create a new disaster, that's a problem.*)

Pages 23–24 After reading the two pages, draw student attention to the graph. Explain that a normal graph of sea level looks like the one shown from Hawaii, with gradual ups and downs as the tide rises and falls. Explain to students that the sea level swings by about one meter with the tides and that these swings take hours to occur. When a tsunami wave passes beneath a buoy that measures sea level, the change is abrupt. (See **Know the Standards 2**.)

Online Resources

SUPPORT—If time permits, use online resources to explore the network of DART tsunameters and how they measure sea level and communicate to the mainland about tsunamis. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

CHALLENGE—Ask: What is the difference between a one-meter change in sea level due to the tides and a one-meter change in sea level due to a tsunami? (*The tide change is gradual. It takes about six hours to go from high to low or low to high. A tsunami changes the sea level very quickly, and the change does not last long.*) Ask: Why have scientists placed the buoys in the areas where they can currently be found? (*These areas are along plate boundaries, where the movement of crust is more likely to cause earthquakes under the seas, which can lead to tsunamis.*)

Know the Standards

2. Reducing or alleviating effects of hazards: The NGSS standards applicable to this chapter emphasize that natural hazards such as tsunamis can rarely be prevented but that humans do have some tools and techniques that can be applied to reduce such hazards' effects. While the seawalls that were in place in some Japanese harbors did not necessarily save any of those coastal towns from the 2011 tsunami, they may have lessened the damage or at least reduced the amount of debris that was swept out to sea. Meanwhile, the warnings on the seemingly primitive tsunami stones had, in some cases, been heeded, and those villages did not suffer as much damage as they might have had the warnings been ignored. Hazard mitigation techniques do not necessarily need to be "modern" or involve sophisticated technology or expensive engineering.

3. Teach Core Vocabulary. 5 MIN

Word Work

Direct student attention to the Core Vocabulary term **tsunami** displayed at the beginning of the lesson, and draw their attention to the card they prepared before the reading.

- **tsunami:** (n. a wave or series of waves caused by displaced water) Point out that *tsunami* is a Japanese word. Ask volunteers to use the term in a sentence. Then write it on the board. (*The 2011 tsunami was produced when a large area of seafloor was lifted up. This displaced a huge amount of ocean water above it.*) Have students copy this on their card and underline the word *tsunami*.

Students should store their deck of Core Vocabulary cards in alphabetical order.

4. Demonstrate examples and guide discussion. 5 MIN

Choose one or more of the following examples to stimulate further discussion. (See **Know the Science 2** for support with the analysis.)

Online Resources

- To put the tsunamis described in this chapter in a helpful context, open or project a world map or virtual globe so you can tag the locations of the tsunamis and find a pattern. Ask students what they can observe: Where do most tsunamis occur? (*Pacific Ocean*) What else occurs in frequent patterns in the Pacific Ocean? (*earthquakes*)
- It's possible to demonstrate how displacement produces a tsunami, but the scale at which such a demonstration is feasible can make the results underwhelming. It may be more productive to view online simulations or videos of large-scale wave tank demonstrations. There are also resources for analyzing tsunami travel times, wave height forecasts, and more. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to these resources may be found:

  www.coreknowledge.org/cksci-online-resources

Know the Science

2. Where do most tsunamis occur? You will find that most tsunamis occur around the Pacific Ocean, in what is known as the Ring of Fire. The plate boundaries that surround that ocean produce many volcanoes and are the sites of many earthquakes.

5. Check for understanding. 5 MIN

Activity Pages

AP 7.1

AP 5.2

Answer Key

Formative Assessment Opportunity

Have students complete Lesson 7 Check (AP 7.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Next, have students complete the second row of Natural Hazard Solutions (AP 5.2). Explain that students should think about whether this is or could be a hazard in their community and why. Do not collect the Activity Page. Instead, tell students to keep it in a safe place because they will be returning to it throughout the unit.

Problem-Based Learning Progress

Review progress students have made in learning about large water waves known as tsunamis. Students have learned about the following:

- causes of tsunamis
- damaging effects of tsunamis
- some of the designs that engineers have developed to detect and warn about tsunamis
- some of the solutions that engineers have developed to mitigate the effects of tsunamis

Explain that in Lesson 8, students will learn more about volcanoes.

LESSON 8

Volcanoes

Big Question: Can scientists predict when a volcano is going to erupt?

Problem-Based Learning Project: Learn about the damage that volcanic eruptions can cause and how scientists can predict when they will occur in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Describe volcanoes, the hazards they pose, and how humans can avoid those hazards.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Disciplinary Core Idea ESS3.B: Natural Hazards

Crosscutting Concept: Cause and Effect

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Cause and Effect is important to this lesson as students learn about volcanic eruptions and the things that cause these events to occur. Students will also learn about the effects that volcanic eruptions have on nature and society in the areas around them.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

converging	**hot spot**	**magma**	**volcano**
diverging	**lava**	seamount	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 5

Student Reader, Chapter 5
"Volcanoes"

Activity Pages

AP 8.1
AP 5.2

Activity Pages
Lesson 8 Check (AP 8.1)

Natural Hazard Solutions (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 5 MIN

Can scientists predict when a volcano is going to erupt? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn about the destructive nature of volcanoes and how scientists predict them. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Assess students' prior knowledge of volcanoes. Ask the following:

» What is a volcano? (*a formation that erupts; a formation that spews lava*)

» What do you think causes a volcano to erupt? (*earthquakes, plates moving, buildup and pressure of magma*)

» Where do you tend to find most volcanoes? (*in the ocean as islands, near the edges of continents*)

Describe volcanic eruptions as one of several hazardous events that occur at or near Earth's surface and occur in patterns. (See **Know the Standards** for support.)

2. Read and discuss: "Volcanoes." 25 MIN

Student Reader

Ch. 5

Read together, or have students read independently, "Volcanoes," Chapter 5 in the Student Reader, which describes volcanoes, some eruptions from history, why eruptions vary, and how people can try to avoid them or survive them.

Preview Core Vocabulary Terms

Before students read, write the following terms on the board or chart paper. Encourage students to look or listen for any of these terms as they read and discuss what they learn in the lesson.

hot spot **lava** **magma** **volcano**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 25

After reading the page, ask students what it means that a "volcano is born," referring to the sentence that discusses the "birth" of a volcano. (*Students should be able to explain that it means volcanoes form and are not long-established parts of Earth's surface features.*) Ask: Do you think it takes a long time or a short time for volcanoes to form? (*long time*) Remind students of the magnitude of geologic time. (See **Know the Science 1**.) Point out that in the example in the Student Reader, the volcano forms under the water, and the island is evidence of a volcanic eruption.

Know the Standards

Volcanoes are another feature of Earth's surface that occurs in patterns. The NGSS standards emphasize that patterns of natural phenomena can be used as evidence to explain hazardous events and features such as volcanoes. Most active volcanoes are found near plate boundaries where plates are converging and subduction is occurring. Subduction is the sliding of one plate downward beneath the edge of another plate. Some volcanoes, such as those that have formed the Hawaiian Islands, are produced by hot spots, where the shape and direction of the volcanoes produced is itself a pattern.

SUPPORT—Remind students that they learned about the formation of igneous rock in "More Evidence of Earth-Shaping Processes," Chapter 2 in the Student Reader. If students struggle to remember how different types of rock form, allow them to return to those pages and reread them.

Online Resources

It is possible to use 3-D virtual Earth browsers to tour active volcanoes and "fly" into the craters of shield volcanoes whose calderas collapsed in the past. There are also abundant online resources about volcano hazards, recent eruptions, and monitoring programs. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to these resources may be found:

www.coreknowledge.org/cksci-online-resources

Page 26 After reading the page, call on a volunteer to summarize the hazards that volcanoes can pose. (*climate change, damage and destruction, tsunami waves*)

Page 27 After reading the page, ask: What is the primary factor that makes some volcanoes more or less hazardous than others? (*the amount of silica in the magma*)

SUPPORT—If necessary, explain that less silica means thin, runny magma that will most likely be thin, runny lava on the surface. It also means gases are dissolved less easily, so there are fewer explosions. Fewer explosions means less risk from "bombs"—masses of lava that fly into the air and then cool and harden before reaching the ground. It also means less risk from rapidly moving, terribly hot, suffocating clouds of gases and ash and less risk from blast waves such as those that occurred during the eruption of Mount St. Helens. (See **Know the Science 2**.)

Know the Science

1. How long do volcanoes take to form? Volcanoes are not solely the conical landforms of volcanic mountains. But those recognizable features provide good examples for context in considering geologic time. Here's a quantitative example about how long it takes to form an oceanic volcanic island. A new underwater volcano was discovered to the southeast about thirty-two kilometers (twenty miles) off the shoreline of the Big Island of Hawaii. Known as the Loihi Seamount, it already rises more than 3,000 meters (9,000 feet) above the floor of the Pacific and is currently within about 1,000 meters (3,000 feet) of the ocean surface. Sometime in the next 100,000 years, it could rise above the waves to produce the newest addition to the Hawaiian islands.

2. Are quiet volcanic eruptions safer? In general, a quiet eruption is less likely to be dangerous, but it depends on how the lava flows from the volcano and where it ends up. A large-scale flow of runny, thin lava can destroy forests, homes, roads, and other things in its way even though it may not be explosive. When the lava flows into the sea, as often occurs on Hawaii's Big Island, the reaction between the molten lava and cool seawater can be explosive. In 2018, a sightseeing boat was bombed by pieces of cooled lava from a nearby lava flow, and many people were injured.

CHALLENGE—If time permits, have students work with a neighbor to make a T-chart that compares and contrasts explosive and "quiet" eruptions.

Page 28

After reading the page, explain that when plates meet, one plate slides under the other one. The heat and pressure from this can cause old rock to melt into magma. That magma can then return to the surface as lava, where it can harden into new rock. In this way, rock is constantly being recycled on Earth's surface. (See **Know the Science 3**.)

SUPPORT—If needed, show a map of the Ring of Fire, and explain that, like earthquakes and tsunamis, volcanoes are usually associated with plate boundaries. It is the Ring of Fire because of the fiery volcanic eruptions that form a ring around the Pacific.

Online Resources

There are many reputable, safe online resources about volcanoes. (Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to these resources may be found: **www.coreknowledge.org/cksci-online-resources**)

Page 29

Ask: What is the difference between a seamount and a volcanic island? (*An island is above sea level or grows tall enough to be above sea level; a seamount is not tall enough and remains underwater.*)

SUPPORT—If necessary, clarify for students that hot spots are fixed locations of volcanic activity that isn't resulting from plate interactions but rather a plume of magma. The plume is essentially motionless relative to Earth, but the overlying plate moves over it, thereby setting up a conveyor-like system for volcanic eruptions to make a linear series of volcanoes on the surface of the overlying plate. The volcanoes can be seamounts or islands.

CHALLENGE—Challenge students to work with a neighbor to discuss why the older islands in the Hawaiian Island chain are smaller but more heavily forested than the newer, larger Big Island? (*They have been around much longer, so there's been more time for weathering and erosion to reduce the rock in size so it can be part of the soil and more time for plant communities and ecosystems to develop. The Big Island has had less time for soil to develop, and some of its habitats are destroyed by eruptions.*)

Know the Science

3. What happens at convergent zones? At convergent zones, oceanic-oceanic subduction is likely to result in an arc of volcanic islands near the edge of the overlying plate. At a convergent zone where the subduction is between oceanic and continental crust, the overlying continental plate may have a range of volcanoes. This is the case in the Cascades. The Juan de Fuca plate is diving under the North American plate. As the diving plate is melted down, water and other material explode upward, and magma is able to pierce the thick continental crust. Where continental crust meets continental crust, little subduction occurs, and the mountains that occur are built by uplift as the two plates collide (Himalayas).

Pages 30–32 After reading the pages, ask: If a volcano's slopes are more tilted today than they were yesterday, what does this suggest about what's happening inside the volcano? (*Its magma chamber is filling up, and an eruption may be imminent.*)

SUPPORT—As a class, compare and contrast the three tools that can be used to monitor volcanoes and predict eruptions: tiltmeters, spectrometers, and seismometers. Write about each of the tools on the board. You can use a carpenter's level or the equivalent app on a mobile device to show how the tilt of a surface can be measured. Spectrometry is basically quantifying different gases in a sample of air. Students should know what a seismometer is from the lesson on earthquakes.

Online Resources

Show students video of how spectrometers work. (Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found: **www.coreknowledge.org/cksci-online-resources**)

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms diaplayed at the beginning of the lesson. Have students write each term in the upper left corner of an index card and underline it, one term per card.

hot spot **lava** **magma** **volcano**

Word Work

- **hot spot:** (n. in geology, a plume of magma that causes eruptions through Earth's crust without plates interacting) Have students break the word into its two parts, hot and spot. Ask students to define the word hot (something that is heated) and the word spot (an area). Then have students describe what a hot spot is in geology. *(a plume of magma that causes eruptions through the crust without plates interacting)*
- **lava:** (n. molten material from Earth's mantle after it has reached Earth's surface) Have students replicate the erupting volcano they drew on their *volcano* card here, but have them draw or label the part that is lava.
- **magma:** (n. molten material from Earth's mantle below Earth's surface) Have students draw Earth. Allow students to consult their Student Readers for this unit if they need support. Have students use a red or orange ink pen or marker, and ask them to label the area that magma comes from. Also, ask students to write on the card the word for what magma becomes once it reaches Earth's surface. (*lava*)
- **volcano:** (n. an opening in Earth's crust through which lava erupts onto the surface) Have students draw an erupting volcano on their card. Then discuss with students what they have drawn.

Students should store their deck of Core Vocabulary cards in alphabetical order.

4. Demonstrate examples and guide discussion. 5 MIN

Online Resources

Choose one of the following or a similar example to stimulate further discussion. (If time permits, use both.)

Option 1: Show a video explaining how hot spots work.

Option 2: Show a video of a volcano. Ask the following:

» In what ways do volcanoes help maintain Earth's life cycle? (*They create a cyclical process that helps form new structures to support life in new places.*)

See the Online Resources for links to suggested videos:

www.coreknowledge.org/cksci-online-resources

5. Check for understanding. 5 MIN

Activity Pages

AP 8.1
AP 5.2
Answer Key

Formative Assessment Opportunity

Have students complete Lesson 8 Check (AP 8.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Next, have students complete the third row of Natural Hazard Solutions (AP 5.2). Explain that students should think about whether this is or could be a hazard in their community and why. Do not collect the Activity Page. Instead, tell students to keep it in a safe place because they will be returning to it throughout the unit.

Problem-Based Learning Progress

Review progress students have made in learning about volcanoes. Students have learned about the following:

- Earth processes that cause volcanoes
- damaging effects of volcanoes
- some of the designs that scientists have developed to predict and warn about volcanoes

Discuss with students whether or not volcano hazards pose a threat in your location. Explain that in Lesson 9, students will learn more about where volcanoes can be found.

LESSON 9

Reading Maps of Volcanoes

Big Question: How can you use maps to determine patterns of volcano formations?

Problem-Based Learning Project: Learn about how maps can be used to determine where volcanoes will occur in anticipation of the unit capstone project.

AT A GLANCE

Learning Objective

✓ Analyze and interpret maps to identify patterns in the locations of volcanoes on Earth.

Lesson Activities

- map reading
- discussion
- hands-on activity
- vocabulary instruction

NGSS References

Performance Expectation 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.

Disciplinary Core Idea ESS2.B: Plate Tectonics and Large-Scale System Interactions

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

Patterns can be used as evidence to support explanations. In this lesson, students will use a map and their data tables to find a pattern related to the locations of U.S. volcanoes. On their infographics, students will state a simple explanation for that pattern.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

analyze **data** **map** **volcano**

Instructional Resources

Activity Pages

AP 9.1
AP 9.2
AP 9.3
AP 9.4

Activity Pages

Volcanoes Evaluation Guide (AP 9.1)

State-by-State Volcano Data (AP 9.2)

Volcanoes Infographic (AP 9.3)

Volcanoes Map (AP 9.4)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- globe (optional)
- highlighters
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

You may choose to separate students into "travel guide" teams. Then have each student complete the hands-on activity as part of his or her group.

Go online to preview the USGS map, and practice using the zoom tool to enlarge the map enough to make the state borders visible. Then drag the map to view particular states. Decide if you will project the map for the class to share, provide a tablet or laptop to each group, or use Volcanoes Map (AP 9.4).

This lesson is dependent upon students' use of the USGS website, with a supplemental Activity Page to accomplish the same Learning Objective if a library, media center, or in-class tech is not available to them.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

How can you use maps to determine patterns of volcano formations? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn about how maps can be used to determine patterns in where volcanoes occur. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Suggest a scenario to students that will frame this lesson's activities. Say: *You are writing a travel guide to the United States for foreign visitors. One part of your guide will be about natural hazards to look out for. Today you will work on preparing the travel guide page for volcanic hazards.*

Elicit prior knowledge. Ask the following:

» What is a volcano? (*an opening in Earth's crust through which lava erupts onto the surface*)

» What are the hazards of volcanic eruptions that travelers should know about? (*People can be injured or killed by explosions, hot flowing lava, falling debris, or tsunamis.*)

» How are volcanoes monitored? (*with devices that can sense the ground tilting, analyze gases coming from the ground, or detect earthquakes*)

Point out to students that the data they collect in this lesson will be important for completing the capstone project at the end of this unit.

Preview Core Vocabulary Term

Before the activity, write the Core Vocabulary word **volcano** on the board or chart paper. Have students look and listen for it as they proceed.

2. Preview the investigation. 10 MIN

Activity Page

AP 9.1

Distribute one copy of Volcanoes Evaluation Guide (AP 9.1) to each student. Tell students that this is a rubric that will be used to evaluate their work in this lesson. Have students focus on the Expert level descriptors, and explain that these are the behaviors you will be looking for as the travel guide teams carry out the activities that will come next. Answer any questions students may have.

SUPPORT—If needed, explain what an infographic is. Tell students that infographics are visual representations of data or information. For this lesson, their infographic will be in the form of a travel guide page.

Establish a Scientific Mindset

Assume the role of a USGS geologist specializing in volcanoes, and invite the "travel guides" to an information session at your headquarters. Take students online to the U.S. Geological Survey's (USGS) webpage.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Review the key with students:

- Unmonitored (white triangles) volcanoes are those that USGS does not closely observe.
- Normal (green triangles) volcanoes are the least worrisome volcanoes.
- Advisory (yellow triangles), Watch (orange triangles), and Warning (red triangles) levels are volcanoes at increased alert levels due to data suggesting they are more active.

Point out to students that the map is always changing and that when they use it, it may not show all the levels of alert. (See **Know the Science 1**.)

If students are going to share tablets or laptops to use the map, now is a good time to organize them into their teams. Allow students to take practice turns interacting with the map, including using the zoom tool and dragging the map to see all the states. If students do not have access to tablets, laptops, or other technology that allows them to access the internet, then pass out Volcanoes Map (AP 9.4).

> **SUPPORT**—If students seem to be struggling with understanding what part of Earth they are looking at on the USGS map, use a globe to help them. First, zoom the USGS map as far out as it will go. Then have students find the same part of Earth on the globe. Point out the entirety of the Pacific Ocean, as knowing its location will be relevant later in the lesson. Then drag the USGS map to show that it actually shows the entire globe, only flat. Choose a few places on the globe, and ask students to find the same places on the map. You may also want to make available to students a U.S. map of the states that they are familiar with as a reference.

3. Support the investigation. 20 MIN

Activity Page

AP 9.2

Distribute one copy of each sheet of State-by-State Volcano Data (AP 9.2) to each team, and have all the students on a team write their names on it.

Discuss the directions on this page as a class. Choose your home state, as well as such states as California, Oregon, and Washington (if none of these is your home state) and at least one from every major region of the United States. Explain that every cell in each row for these states should have a value in it, even if it is 0. Using the projected map, demonstrate how to zoom out until students see the entire lower forty-eight states and then find the state of New Mexico. Make sure that

Know the Science

1. How do people monitor U.S. volcanoes to determine their hazard level? *In a few different ways.* *Monitored* means that scientists have placed tools and equipment where they can detect changes in the volcano. Some of these changes could be hints that a volcano might erupt. The USGS website explains that to fully understand a volcano's behavior, monitoring is required on a continuous or near-real-time basis. Changes in the shape or tilt of the ground are detected with tiltmeters and surveying tools. Earthquakes, which are often a predictor of volcanic activity, are monitored with seismographs on the ground. The air above a volcano is also monitored for the release of gases associated with eruptions using instruments placed on the ground and carried by planes that fly over the volcano. Cameras mounted near a volcano can collect images that may reveal activity in the volcano. Sensors on satellites in space can also detect motion of the ground, lava flows, and dust plumes. While much of these data can be accessed in USGS observatory offices, some types of data can only be gathered by scientists visiting the site. Scientists then analyze the data, comparing them to historical data from the same volcano and to other volcanoes to make predictions about the hazard level.

students understand that the word *data* is plural and means pieces of information. (See **Know the Standards**.) Ask the following:

» How many unmonitored volcanoes does New Mexico have? (*three*)

» Does New Mexico have any volcano symbols in other colors? (*no*) Explain that if it had, students would record the number of each color on the table.

» What is the total number of volcanoes in New Mexico? (*three*) Direct students to enter this sum in the total column.

Have students change roles (map reader, recorder, checker) periodically while collecting the data for the states you have chosen. Circulate among the teams, making sure that students take turns in the various roles and that their interpretation of the map is accurate.

Activity Page

AP 9.3

Distribute to each student Volcanoes Infographic (AP 9.3). Direct students to use their state-by-state volcano data to complete the infographic statements. Encourage team members to discuss before finalizing the Activity Page. Allow time for students to make the infographic more visually appealing by adding color.

After students have added the details, remind them to write the best question to title the infographic.

Online Resources

CHALLENGE—If students wish to create more elaborate infographics, show them a few examples online, and allow them to use one of the web-based tools available to create them. (See the Online Resources Guides for links to examples: **www.coreknowledge.org/cksci-online-resources**) Keep the focus on data related to volcanoes, and encourage students to include maps and numerical data about the locations of volcanoes, frequency of eruptions, recent eruptions, and the hazards to people and property. Share students' infographics as PDF files, or print them and display on bulletin boards.

Know the Standards

Analyzing and Interpreting Data: In this lesson, the focus of this Science and Engineering Practice is on science, rather than engineering design. Over the course of Grades 3–5, NGSS develops aspects of analyzing and interpreting data. The one for this lesson states that students will "Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation." In the context of this activity, students are interpreting data on a map and translating it to a table. Later in this lesson, students will analyze the data in the table to reason about the pattern in the locations of most volcanoes.

Circulate among the teams, asking guiding questions as needed, to focus students on three-dimensional thinking. (See **Know the Science 2**.) Ask the following:

» What patterns do you see in the locations of volcanoes in the United States? (*Most volcanoes are in states touching the Pacific Ocean.*)

» How did you use data from the map to explain this? (*We checked every state on the map and wrote down the number of volcanoes in each category. Then we added up the number to find a total for each state.*)

4. Revisit Core Vocabulary. 5 MIN

Revisit Core Vocabulary Card

- Have students sort through their Core Vocabulary decks and find the card with the word related to Chapter 5 of the Student Reader and this lesson's demonstrations. Students should select the card for this term:

  volcano

- Have volunteers explain how the term relates to the lesson. Prompt students to add notes to the card, extending their previous definition with more examples.

5. Check for understanding. 5 MIN

Activity Pages

AP 9.1
AP 9.2
AP 9.3
Answer Key

Formative Assessment Opportunity

Have each student place their completed Activity Pages 9.1, 9.2, and 9.3 in a folder and write their team member names on the cover. Collect the folders. Note that the Answer Key for State-by-State Volcano Data (AP 9.2) may change depending on how USGS updates its website based on monitoring of individual volcanoes within the United States.

Use Volcanoes Evaluation Guide (AP 9.1) to evaluate each student's work to meet Performance Expectation 4-ESS2-2, with the assistance of the Answer Keys for Activity Pages 9.2 and 9.3.

Know the Science

2. Why don't states bordering the Atlantic Ocean have volcanoes? *Because the features of Earth's plates that cause them are not present.* Volcanic eruptions occur where plates diverge (move apart), where plates converge (such that one plate moves below another plate), and at hot spots in the middle of plates. There is a divergent boundary in the Atlantic Ocean, but it is not where the North American continent meets the water of the Atlantic. Instead, the boundary of the North American plate with the Eurasian plate to the east is a long north-south boundary called the Mid-Atlantic Ridge. Volcanic eruptions are frequent along this ridge on the ocean floor but also on land in Iceland, which sits on the Mid-Atlantic Ridge.

Problem-Based Learning Progress

Review progress students have made in learning about how maps can help determine patterns in where volcanoes are found. Students have learned about the following:

- how maps help predict where volcanoes will occur
- some of the devices that scientists have developed to predict and warn about volcanoes

Explain that in Lesson 10, students will learn more about the causes of erosion and the effects of erosion.

PART D

Other Changes on Earth's Surface

Overview

Lesson	Big Question	Advance Preparation
10. Erosion	How do communities protect themselves from erosion?	Read Student Reader, Chapter 6.
11. Erosion Problems and Solutions (3 days)	How does erosion affect Earth's surface, people, and communities?	Gather materials for problem-based learning project. (See Materials and Equipment, page 17.)
12. Landslides	How can communities prepare for landslide hazards?	Read Student Reader, Chapter 7.
13. Landslide Problems and Solutions (2 days)	How can people protect themselves from the hazards of landslides?	Gather materials for problem-based learning project. (See Materials and Equipment, page 17.)

Part D: What's the Story?

Students learned in Parts B and C (Lessons 2–9) that Earth's systems have processes that act over long and short periods, changing the planet's surface. When these processes happen quickly, natural hazards result. While students learned about the dangerous effects of natural hazards, they also learned about devices that can help detect and predict them, as well as ways that communities can be made safer from them.

In Part D (Lessons 10–13), students continue to study Earth's natural hazards, how to detect and predict them, and how to stay safe from them. Students also continue to ask, "Can my community be affected by these, and if so, how can we make the community safer?" in anticipation of completing their **problem-based learning project**.

In Lesson 10, students read about slow-moving processes such as weathering, which breaks small pieces of rock and debris from larger pieces of rock and debris, and erosion, which carries them elsewhere. Students learn that these are rarely dangerous to humans or communities.

In Lesson 11, students learn for themselves how erosion works by modeling it in the classroom. Students are also tasked with thinking about how they can prevent long-term erosion events if those events negatively impact communities.

In Lesson 12, students read about quick-moving erosion events such as landslides and mudslides, how these affect communities, and what can be done about them. Students also ask themselves, "Could this happen in my community, and if so, what can we do to lessen their effects or protect against them?"

In Lesson 13, students model quick-moving erosion events and design a solution to prevent them from happening. This is to help students craft their unit capstone project, which is to present to their community ways to protect against real-life natural hazards.

So, to repeat, **some Earth processes happen quickly, and these tend to have larger short-term effects that are dangerous to people, other living organisms, and structures**. Help your students understand Earth's systems and processes and how they relate to natural hazards, and you will lay the groundwork for meeting the NGSS Performance Expectation MS-ESS2 as well as help students on their problem-based learning project.

LESSON 10

Erosion

Big Question: How do communities protect themselves from erosion?

Problem-Based Learning Project: Learn about the effects of slow erosion events and how communities protect themselves from the effects in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Describe erosion, the hazards it poses, and how people cope with those hazards.

Lesson Activities

- reading
- discussion
- demonstrations
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS1.C: The History of Planet Earth

Disciplinary Core Idea ESS2.A: Earth Materials and Systems

Disciplinary Core Idea ESS3.B: Natural Hazards

Crosscutting Concept: Cause and Effect

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions is important to this lesson, as students learn about ways communities are dealing with problems related to erosion, including planting specific vegetation and building retaining walls to prevent erosion from occurring.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

agent	**erosion**	**sinkhole**	**weathering**
creep	**sediment**	survey	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 6

Activity Page

AP 10.1

Student Reader, Chapter 6
"Erosion"

Activity Page
Lesson 10 Check (AP 10.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- small milk cartons (2)
- plaster of paris
- balloons (2)
- water
- access to a freezer
- sand
- loamy garden soil
- small piece of grass-covered soil
- piece of cardboard
- index cards for student vocabulary deck (4 per student)
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Prepare in advance for the weathering demonstration by cutting the tops off the milk cartons prior to class time. The activity requires preparation the day before the results can be shown or a second day to show results if the class assists with preparation. See the activity for a diagram of how to complete the molds.

For the erosion activity, finding soil may be difficult in some areas. Some retail stores carry different types of soil. If you cannot locate these, you may choose instead to show students the video provided in the link in that section.

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question. 5 MIN

How do communities protect themselves from erosion? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn about slow erosion events, their effects, and how communities combat the effects. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Assess students' prior knowledge of or experience with erosion. Have students work with a neighbor to discuss the following questions:

» Where or when have you seen erosion in your own life? (*sand moved at beach, soil washed away during rain*)

» What kinds of things do you think cause erosion? (*wind, water, things that dig/burrow, earthquakes*)

As students discuss in pairs, explain that erosion can be as simple and small as a single grain of sand being moved by a light breeze or as complex and vast as a sandstorm blowing many tons of sand across a desert. The processes that cause erosion are diverse. (See **Know the Standards** for support.)

2. Read and discuss: "Erosion." 20 MIN

Student Reader

Ch. 6

Read together, or have students read independently, "Erosion," Chapter 6 in the Student Reader, which describes erosion, weathering, related hazards, and how people can avoid or cope with them.

Preview Core Vocabulary Terms

Before students read, write these terms on the board. Discuss the terms when you come upon them.

erosion **sediment** **sinkhole** **weathering**

Know the Standards

Weathering and erosion are carried out by diverse processes. The NGSS standards emphasize the role of erosion in shaping Earth's surface and systems and the roles of agents of erosion: liquid water, ice, wind, and animals. Water and gravity are responsible for much of the weathering of rock, which produces the sediment that erosion moves.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Pages 33–34

After reading the pages, ask: What could happen if erosion is allowed to happen over a long period of time? (*Answers will vary, but students may say that coastlines could look different, mountains might wear down, some areas may be overtaken by sand, and so on.*)

Online Resources

SUPPORT—If needed, show students real-world visuals and data of coastal erosion. 3-D virtual Earth browsers can also be used to visualize large-scale erosion over time if you search for and load layered satellite imagery. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

CHALLENGE—Ask: If you lived in a seaside home that was built on land slowly eroding into the ocean, how could you try to predict when it might be time to leave the home? (*Measure the rate of loss* [*meters/year*] *and then measure how much more land would need to erode before the home is in danger. Apply the rate to the distance to get the time.*)

Page 35

After reading the page, quickly go around the room in a "lightning round," and have students answer one of the following questions about agents of erosion:

» How can the sun cause erosion? (*Sunlight leads to wind, which can blow dirt around.*)

» How can gravity cause erosion? (*Earth materials will be pulled down by gravity.*)

» How can the movement of Earth's crust cause erosion? (*The movement will cause rocks to move around like in landslides.*)

» How can animals cause erosion? (*They can move dirt and rocks around when they make their homes.*)

» How can water cause erosion? (*It will move dirt downhill.*)

If necessary, compare the erosive powers of water and wind. Ask: Which is responsible for more erosion—water or wind? (*Answers will vary, but students should understand that water can result in erosion in multiple ways. In addition to picking up sediment from surfaces, water can saturate sediment and cause hillsides to collapse. Wind cannot do that.*)

SUPPORT—Ask students to consider their local environment and determine which likely causes more erosion to their schoolyard, wind or water.

CHALLENGE—If time permits, have students work with a neighbor to discuss other examples of animals causing erosion. (*herd of wildebeests stampeding across dry savanna soil, gophers digging holes to make homes, beavers building dens in wetland mud*)

Page 36

After reading the page, draw a chart with arrows that arranges the terms *weathering* and *erosion* and shows that weathering leads to erosion (by providing sediment).

CHALLENGE—Discuss with students what they have learned about fossils in the past, that they are the remains of once-living organisms that have been preserved in rock over time. Remind students of how fossils form. Explain that often, the remains of an organism fall into or are covered by water and then sediment. Over time, the sediment becomes rock, trapping the organism's remains. The remains are then replaced by minerals, which also harden into rock in the exact same form as the original organism's remains. Have students research the role of weathering and erosion and how they relate to fossils. Over time, weathering and erosion wear the rock around the fossil away, revealing the fossil. Ask: If sedimentary rock is where archeologists can find fossils, why can't we find fossils of every type of organism that has ever existed? (*Most organisms are not fossilized at all. Their remains decompose before fossilization can occur. But even if this weren't true, sedimentary rock can be weathered and eroded, or it can become metamorphic rock. This means many if not most fossils end up being destroyed.*)

Page 37

Online Resources

After reading the page, show students a video of sinkholes in action. (See the Online Resources for a link to a suggested video: **www.coreknowledge.org/cksci-online-resources**) Have students describe what they see. Ask the following:

» What is happening to the ground? (*It is falling apart; it is sinking.*)

» Is this an example of erosion or weathering? (*erosion*)

» What was causing this sinkhole? (*water*)

Pages 38–40

Discuss what makes erosion hazardous. In most cases, the key factor is the angle of a slope. Ask: Why does a steeper slope pose more of an erosion hazard than a gentle slope? (*It is easier for gravity to pull down sediment that is on a steeper slope. The sediment is closer to falling and will accelerate faster once it begins to fall from a steeper slope.*)

Discuss how people can decide where to place signage that warns people of erosion hazards. Ask: If you were surveying a hilly landscape where erosion occurs, how would you decide where to place signs warning people about erosion? (*The signs should be placed where people are or will be in the landscape. Evidence of erosion events should be gathered and analyzed. Signs should be placed where the sediments might erode as well as where they might be deposited, as that's where the processes will be most dangerous.*)

Have students name one way that hillsides can be protected from erosion. (*Answers will vary but may include planting vegetation, building walls, or diverting water drainage.*)

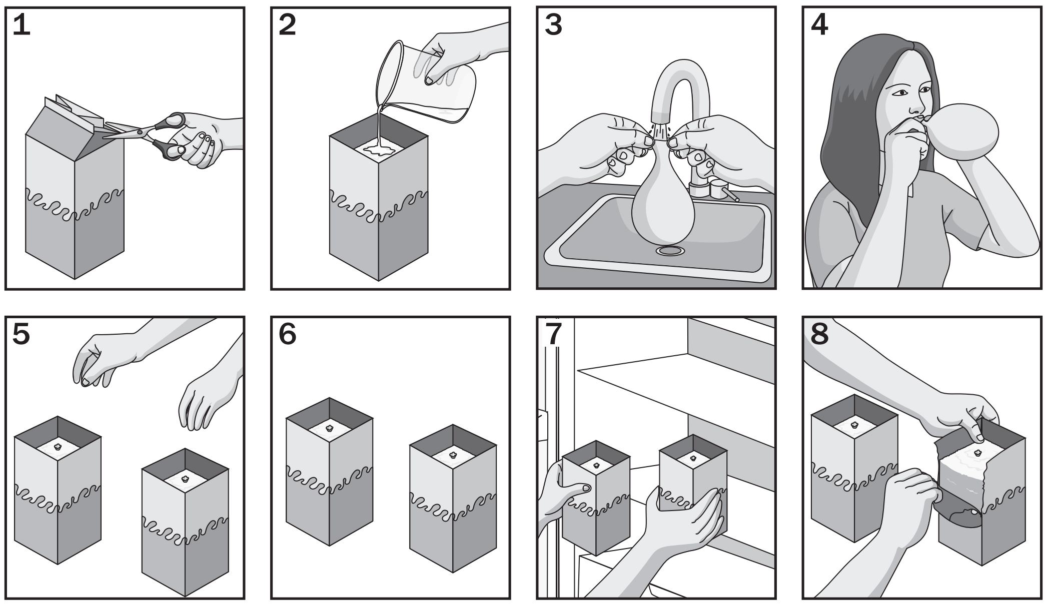
3. Demonstrate examples and guide discussion. 10 MIN

Choose one of the following or a similar example to stimulate further discussion. (If time permits, use both.)

Option 1, Weathering: Follow the steps below:

1. Set up two small milk cartons with their tops opened or removed.
2. Prepare plaster, enough to fill each carton about two-thirds full. Label one carton "ice" and the other carton "air."

3. Fill a small balloon with water.
4. Fill the other balloon with a similar volume of air. Both should be full enough to fit into the milk cartons.
5. Tie both balloons closed, and lower them into their respective labeled cartons shortly after the plaster has been poured into them. The balloons should be submerged with only their knotted ends peeking out from the plaster.
6. Let the plaster dry.
7. Once they are dry, place both cartons in a freezer for at least eight hours or overnight.
8. Remove them from the freezer, carefully peel or cut off the carton material, and allow students to compare the plaster around the balloons.



Ask students the following questions to help with their analysis of the demonstration.

» Which model rock was weathered? (*the one with the water balloon*)

» Why was that rock weathered? (*Water expands when it freezes, and the expansion forced apart the "rock" around it.*)

Online Resources

Option 2, Erosion: Use different types of soil, including grass-covered soil, to compare how erosion affects them. Set a piece of cardboard down on a table. Shape hillsides of the different soil types at identical angles, and pour identical amounts of water down them to see how they are affected. You can also experiment with building water-saturated slopes and watching what happens to them as they dry out. Sand or sandy soil, for example, might pile up and keep its shape more easily when wet and then collapse when dry. Grass-covered soil will likely lose less of its underlying soil because the grass and roots keep the soil in place. (See the Online Resources for a link to a suggested video: **www.coreknowledge.org/cksci-online-resources**)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms. Have students write each term in the upper left corner of an index card and underline it, one term per card.

erosion **sediment** **sinkhole** **weathering**

Word Work

- **erosion:** (n. movement of sediment from one location to another) On their cards, have students give one example of erosion at work. (*example: water moving particles of rock broken from a mountain and leaving them elsewhere*) Then discuss the examples students came up with.
- **sediment:** (n. small pieces of rock or other hard material that has broken down over time) Have students write the definition of the word *sediment* on their cards. (*small pieces of rock or other hard material that has broken down over time*) Allow students to look at Chapter 6 in the Student Reader if necessary. Then ask students to use the word in a sentence. (*Example: Wind and water can carry sediment away.*)
- **sinkhole:** (n. a hole in Earth's surface that develops when the ground collapses into space beneath it) On their cards, ask students to describe what a sinkhole is in simple terms. (*example: a hole that appears in the ground*) Then ask students to explain why this is a natural hazard. (*Sinkholes can damage property or be dangerous to living organisms.*)
- **weathering:** (n. the process of breaking rock into smaller pieces) Engage in a brief discussion about weathering. Ask students to write on their cards some of the agents that can cause weathering. (*water, wind, animals*)

5. Check for understanding. 5 MIN

Activity Page

AP 10.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 10 Check (AP 10.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in learning about slow erosion events. Students have learned the following:

- what erosion is and some of the causes
- about specific erosion events and how communities have dealt with them

Discuss with students whether or not erosion hazards pose a threat in your location. Explain that in Lesson 11, students will learn even more about erosion events and how communities deal with them.

LESSON 11

Erosion Problems and Solutions

Big Question: How does erosion affect Earth's surface, people, and communities?

Problem-Based Learning Project: Learn about the effects of erosion events and how communities protect themselves from the effects in anticipation of the unit capstone project.

At a Glance

Learning Objectives

- ✓ Make observations and/or measurements to investigate erosion by water.
- ✓ Identify variables in an investigation.
- ✓ Explain cause-and-effect relationships using claim-evidence-reasoning thinking.

Lesson Activities (3 days)

- viewing examples and discussion
- previewing criteria
- investigation
- proposal of solution

NGSS References

Performance Expectation 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

Disciplinary Core Idea ESS2.A: Earth Materials and Systems

Disciplinary Core Idea ESS2.E: Biogeology

Crosscutting Concept: Cause and Effect

Science and Engineering Practice: Planning and Carrying Out Investigations

Planning and Carrying Out Investigations, according to the NGSS Evidence Statement, focuses on carrying out a given investigation plan. In this three-day lesson, students follow a procedure to use a stream table to collect data about erosion caused by flowing water.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

downstream	sediment
erosion	upstream

Instructional Resources

Activity Pages

AP 11.1
AP 11.2
AP 11.3
AP 5.2

Activity Pages

Erosion Investigation Evaluation Guide (AP 11.1)

Erosion Investigation Notebook (AP 11.2)

Testing Erosion Solutions (AP 11.3)

Natural Hazard Solutions (AP 5.2)

Materials and Equipment

Collect or prepare the following items:

- stream table
- catch bucket (if not in the kit)
- sand
- ruler
- water
- three sizes of blocks (if the stream table does not include a way to change its slope)
- water flow cup (if not in the kit), with a small hole near the bottom
- measuring cups, graduated cylinder, or scale (depending on what property students decide to measure)
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

If you have already assigned students to teams for this unit, have them work in those teams for this lesson. If you have not yet assigned teams, groupings of three or four students will allow assignment of roles and allow accountability of all team members.

There are several options for obtaining a stream table for the class to share. You might also ask a high school Earth science teacher if you may borrow one for a few days. If you wish to purchase a stream table, several scientific supply companies sell kits online that are appropriate for the K–12 classroom. If you prefer to build your own, an internet search will give you instructions for many options, from elaborate (using plywood and two-by-fours) to simple (disposable aluminum roasting pans). Set up the stream table in a corner of your classroom, near a water source, if possible. Be sure to test the apparatus and procedure prior to working with students.

The Core Lesson   Three days, 45 min each

1. Day 1: Focus student attention on the Big Question. 10 MIN

How does erosion affect Earth's surface, people, and communities? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn about erosion events, their effects, and how communities combat the events. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Have students recall that they are part of a natural hazards team established in Lesson 1 and that they have already investigated several Earth hazards. Elicit prior knowledge by asking the following:

» What are some of the natural hazards your team has already explored? (*earthquakes, tsunamis, and volcanic eruptions*)

» What did you learn in the previous lesson about weathering? (*Weathering is the breaking of rock into smaller pieces. Weathering is caused by various agents.*)

» What is erosion? (*the transport of weathered sediments away from a location*)

» What are some examples of how erosion affects people and communities? (*Highways can be buried so that people cannot travel on them. Houses can be destroyed when they fall into sinkholes. Topsoil can be carried away from farms, making it impossible to grow crops. Buildings along beaches can collapse.*)

Point out to students that this lesson will focus on investigating certain aspects of erosion. Explain that students will take turns using a tool called a stream table. Remind students that they worked in teams earlier in the unit and that they will get back in their teams for this investigation.

2. Present examples and guide discussion. 25 MIN

Show the class a video that describes how sudden or extreme erosion affects people and their community. (See the Online Resources for a link to a suggested video.) Discuss the event shown in the video with students. Ask the following:

» What was the cause of the erosion? (*moving water; a windstorm followed by very heavy rainfall and flooding*)

» What part of the landscape was eroded? (*the banks of a stream/creek*)

» How was this a risk to people? (*The stream bank lost soil, and a sewer line was exposed. If more soil were lost, the pipe could break. Then, sewer waste would pollute the stream. If the stream overflowed, the sewage could come near people's homes and a children's playground.*)

» How could the erosion affect wildlife? (*A break in the sewer pipe could harm salmon and other fish living in the stream.*)

» How did the community solve the problem? (*Money was found to repair the stream bank by placing pieces of dead trees, rocks, and plantings along the stream bank.*)

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

3. Preview evaluation criteria. 5 MIN

Activity Page

AP 11.1

Distribute one copy of Erosion Investigation Evaluation Guide (AP 11.1) to each student. Tell students that this rubric is to be used so they can evaluate their work. Direct students to focus on the Expert level descriptors, and explain that these are the student behaviors you will be looking for as each team carries out the investigation using a stream table. Answer any questions students may have about the expectations described in the rubric.

4. Check for understanding. 5 MIN

Activity Page

AP 11.2

Formative Assessment Opportunity

Distribute Erosion Investigation Notebook (AP 11.2) to each student, and have them staple the sheets together. Have students group themselves into their natural hazard teams. Familiarize students with the parts of the "notebook" by explaining that scientists keep careful and detailed records of their investigations. Ask the following:

» In what part of the notebook will you record the data you collect? (*in the Observation/Measurements section in the middle*)

» In what part of the notebook will you practice claim-evidence-reasoning thinking? (*in the Explanation section at the end*)

» In what part of the notebook will you make decisions about how you will conduct the investigation? (*in the Planning section at the beginning*)

1. Day 2: Refocus student attention on the Big Question. 5 MIN

Activity Page

AP 11.2

How does erosion affect Earth's surface, people, and communities? Have students retrieve their Erosion Investigation Notebook (AP 11.2) that they started working on in the previous class session.

Demonstrate the use of the stream table, following the lettered steps on the Activity Page. When you get to the step that says to measure the sand, tell students you are skipping it because they will have to make decisions about what property to measure.

Allow students to ask questions about how the stream table setup works and what it models. (See **Know the Science**.)

2. Support the investigation. 35 MIN

Have students assemble into their teams again, taking their notebook Activity Pages with them. Direct students to discuss in their teams the answers to the questions under Planning. After students have had some time to discuss, hold a whole-class discussion to refine and write their answers on the Activity Page.

To answer question 2, students will have to decide whether to measure the eroded sand's volume, using measuring cups, or its mass, using a scale. Demonstrate how to use a graduated cylinder or measuring cups to find the volume of the sand that was deposited in the bucket at the end of the stream table. Also demonstrate how to use the scale to measure the mass/weight of the sand.

> **SUPPORT**—If students find the concept of variables difficult, spend some time discussing what they are. Variables are the factors that affect an experiment. The factor that students will change is the steepness of the stream table. Factors that should not change in an experiment are called controlled variables. Emphasize that the only way to know that the steepness affects the erosion is to keep all the other factors the same each time the stream table is used. (See **Know the Standards**.)

Know the Science

What factors affect erosion of Earth materials by streams? ***Several factors!*** Moving water exerts forces on rocks, sediments, and other objects, which can move them downstream. This is what is meant by *erosion*. The steeper the gradient (slope) of the streambed, the faster the water will flow. In general, faster-moving water causes more erosion than slower-moving water. Another factor is the amount (volume) of water. Large rivers have more water in them than small creeks and can cause more erosion. A third factor is the type of material that the stream flows over. Certain types of Earth materials are carried away by moving water at greater rates than other materials. For example, fine particles of mud are carried away at higher rates than pebbles and large rocks.

Know the Standards

Planning and Carrying Out Investigations: Like all Science and Engineering Practices, Planning and Carrying Out Investigations is developed across all grade bands with increasing complexity. In Grades K–2, students plan and conduct simple investigations with guidance, including making decisions about observations and measurements. In Grades 3–5, students continue to use those skills but also learn to use fair tests, in which variables are controlled. In Grades 6–8, students learn to identify independent and dependent variables and revise experimental designs. In Grades 9–12, students learn to construct hypotheses that specify what happens to dependent variables when independent variables are manipulated.

Assign roles within each team such as pourer, collector, sand measurer, and recorder.

Allow each team enough time using the stream table to carry out their investigation.

3. Check for understanding. 5 MIN

Formative Assessment Opportunity

Make sure students record their measurements in the Observations/Measurements table on Erosion Investigation Notebook (AP 11.2) using appropriate units such as grams or milliliters.

As each team completes its turn with the stream table, have students discuss and write answers to the Explanation questions on Erosion Investigation Notebook (AP 11.2).

1. Day 3: Refocus student attention on the Big Question. 5 MIN

Activity Page

AP 11.2

How does erosion affect Earth's surface, people, and communities? Remind students of what they completed during the previous class session, and let them know that today they will continue carrying out their investigations.

Prompt students to take out their Activity Page 11.2.

2. Support the investigation. 35 MIN

You will likely need additional time on a third day to allow all teams to use the stream table to carry out their investigation and to complete Erosion Investigation Notebook (AP 11.2).

Activity Page

AP 11.3

Distribute a copy of Testing Erosion Solutions (AP 11.3) to each student. Have students recall the video they saw at the beginning of the lesson, and remind them that the conservationists suggested several solutions for reducing erosion along a stream bank.

SUPPORT—If necessary, show the video again, stopping and starting to find those solutions (placing rocks, cut-up dead trees, and live plants along the stream banks). Then have students think about how they would solve the problem and follow the directions on the Activity Page.

CHALLENGE—If students wish to carry out the investigation to test the solution they came up with, discuss what additional materials they could place in or on the sand in the stream table. For example, they could bring to class small potted grasses, such as those sold in pet shops for cats to chew on. The plants, including their roots, can be removed from their pots and planted in the sand on the stream table. Give students fresh copies of Activity Page 11.2 so that they can carry out the investigation, record their measurements, and develop their explanations.

4. Check for understanding. 5 MIN

Activity Pages

AP 11.1
AP 11.2
AP 11.3
AP 5.2
Answer Key

Formative Assessment Opportunity

Collect Activity Pages 11.1, 11.2, and 11.3.

The completed tasks in this lesson fulfill NGSS Performance Expectation 4-ESS2-1.

Use Erosion Investigation Evaluation Guide (AP 11.1) to evaluate each student's performance of the Science and Engineering Practice, Disciplinary Core Ideas, and Crosscutting Concept associated with 4-ESS2-1, along with the Answer Key for Activity Page 11.2.

Next, have students complete the fourth row of Natural Hazard Solutions (AP 5.2). Explain that students should think about whether this is or could be a hazard in their community and why. Do not collect the Activity Page. Instead, tell students to keep it in a safe place because they will be returning to it throughout the unit.

Problem-Based Learning Progress

Review progress students have made in learning about slow erosion events. Students have learned the following:

- more about what erosion is and some of the causes
- about specific erosion events and how communities have dealt with them

Explain that in Lesson 12, students will learn about quick erosion events such as landslides and mudslides and how communities deal with them.

LESSON 12

Landslides

Big Question: How can communities prepare for landslide hazards?

Problem-Based Learning Project: Learn about the effects of quick-moving erosion events and how communities protect themselves from the effects in anticipation of the unit capstone project.

At a Glance

Learning Objectives

✓ Describe landslides and the hazards they pose for people.

✓ Consider ways that people can minimize the dangers of landslides.

Lesson Activities

- reading
- discussion
- demonstrations
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS2.A: Earth Materials and Systems

Disciplinary Core Idea ESS2.C: The Roles of Water in Earth's Surface Processes

Crosscutting Concepts: Cause and Effect; Scale, Proportion, and Quantity

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions is important to this lesson as students learn about how communities protect themselves from landslides. Students also will read about the ways in which landslides can be predicted or prevented in Chapter 7 in the Student Reader.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 184–185 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

debris **landslide** **mass movement**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader

Ch. 7

Student Reader, Chapter 7
"Landslides"

Activity Page

AP 12.1

Activity Page
Lesson 12 Check (AP 12.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- sand or sandy soil
- shoebox
- construction paper or thin cardboard
- index cards for student vocabulary deck (2 per student)
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Advance planning will be needed to carry out the unit capstone project at the end of the unit. This is a good time to identify invitees from your community, including other students, parents, and school administrators, if you have not done so already. Decide on a date and time for the presentation that works for your class and school. Send out invitations as far in advance as possible. Be sure to allow students enough time to practice their presentations, especially if they are using presentation materials.

The Core Lesson 45 min

1. Focus student attention on the Big Question. 5 min

How can communities prepare for landslide hazards? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn more about erosion events, in particular types of landslides, their effects, and how communities combat landslides. This knowledge supports the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Online Resources

Focus students on landslides as a particular erosion event that involves a large scale of space and a short scale of time. Note that most erosion events occur very slowly, unlike landslides, which are quick erosion events. Assess student background knowledge on quick erosion events using a video and questions. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Ask the following:

» What do you think a quick erosion event is? (*when a piece of land breaks apart from other land very quickly*)

» What might be an example of a quick erosion event? (*possible answers: landslide, mudslide*)

» What do you think makes a landslide different from the slow downhill erosion of sediment on a mountainside? (*It happens faster, and a lot of material moves all at once.*)

SUPPORT—If needed, remind students of what they learned in the previous lesson about erosion.

» Why would a landslide be dangerous both at the top and at the bottom of the slope where the landslide is occurring? (*At the top, the material you're on can slip out from under you and cause you to fall with it. At the bottom, you can be buried or knocked over by the falling material.*)

2. Read and discuss: "Landslides." 20 min

Student Reader

Ch. 7

Read together, or have students read independently, "Landslides," Chapter 7 in the Student Reader, which delves deeper into landslides, particular threats they pose, and how humans cope with landslides.

Preview Core Vocabulary Terms

Before students read, write these terms on the board. Have students identify the words as they read. Stop and discuss the meaning of each term in context.

landslide **mass movement**

Explain that there are different meanings for the word *mass*. It can mean what a thing is made of, a group, or a large body of matter. When it is used in this lesson, it refers to a large body of matter, such as a hill, slope, mountain, and so on.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 41 Draw student attention to the image on the page. The image shows snowy peaks above the bay. Point this out to the students. Ask the following:

» How do you think melting snow and ice may have contributed to this rockslide? (*It weathered and eroded the area, making the steep slope that was then vulnerable to further weathering and erosion.*)

Online Resources

SUPPORT—There are abundant online resources of real-world visuals and data about landslides, including how landslides can be monitored and predicted. 3-D virtual Earth browsers can also be used to visualize landslides that have occurred. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to these resources may be found:

www.coreknowledge.org/cksci-online-resources

Pages 42–43 After reading the spread, have students pinpoint on the photo on page 42 where the landslide occurred. Ask students to identify from the text what caused the landslide to happen and trace the direction in which the land moved. (*to the lower right corner of the photo*) Next, point out the photo on page 43, and ask what it shows. (*the kind of damage done by the landslide*)

Pages 44–45 Clarify for students that water is a key factor in landslides. Too much water can saturate a slope to the point of collapse. Too little water can make a slope crumbly and weak. Frost wedging caused by the freeze-thaw cycle can also trigger landslides. (See **Know the Standards** for support.)

SUPPORT—If necessary, help break down the various ways in which each agent can cause a landslide. Gravity is the force that causes debris to move downhill. Essentially, the force of gravity overcomes the frictional or adhesive forces that had kept things in a fixed position on a slope. Some event or input of energy can cause the given piece of rock or sediment to reach the physical tipping point that causes it to move downhill. The physical jolt of an earthquake is one cause.

Know the Standards

Rainfall shapes the land. The NGSS standards emphasize the role of water in weathering and erosion, both of which are processes that contribute to and trigger landslides. Water adds weight to saturated sediment, physically and chemically weathers rock, and has other erosive effects. It is also one of the main agents of deposition. Refer back to Grade 3 Unit 1, *Investigating Forces*, Grade 3 Unit 4, *Weather and Climate*, and Grade 4 Unit 1, *Energy Transfer and Transformation*.

The movement of water is another. Water can also break and move particles via frost wedging. Removal of material downhill can also increase the potential energy of uphill material because it now has less support. Discuss different scenarios involving slopes and sediment, and see whether students can identify why a landslide could occur. For example, ask: What could happen to the chance of a landslide occurring on a hill if a family of groundhogs moves in and digs a network of burrows into the hillside? (*The chance of landslide would increase because the burrows would make the hillside less solid, less supportive of itself.*)

Make Frequent Connections

Have students think about and describe examples from their background knowledge and previous learning of how water can cause changes. For example, water is part of the water cycle, it can contribute to changes in the environment, and it can carry energy in waves.

Page 46

After reading the page, ask a volunteer to summarize the ways that people can detect or predict landslides. (*looking for visible signs of erosion, such as new boulders at the base of a slope and tilted trees or poles*)

Online Resources

SUPPORT—If time permits, show a video of a geologist describing landslides and how they can be predicted or prevented. (See the Online Resources for a link to a suggested video: **www.coreknowledge.org/cksci-online-resources**)

Draw student attention to the concept of terracing. Discuss this technique, and use visuals to help students see how this works. Ask the following:

» What is the overall effect of carving a slope into a steplike series of flat surfaces? (*More of the surface area of the slope is flat.*)

» What is the problem with this approach? (*For every flat surface, there is a vertical wall that needs to support it.*)

Discuss the use of concrete pillars with steel reinforcement (rebar) to anchor structures into the bedrock of a slope. Ask: How do pillars anchored or drilled into the underlying rock of a slope help avoid the possibility of a landslide being hazardous to that structure? What do the pillars do? (*They basically connect the structure to the solid rock beneath the rock or sediment that might move. By connecting the structure to something that won't move, it means the land might slide under or around the structure without bringing it down.*)

3. Demonstrate examples and guide discussion. 10 MIN

Use a shoebox, construction paper or thin cardboard, and sandy soil or sand to model a terraced slope. The first and highest level can be built by using a sheet of paper as a retaining wall for a volume of sediment. A shorter wall, about two-thirds the height of the first, can be used as a retaining wall for the second level, and so on. On the other end of the shoebox, you can attempt to build a normal slope of the same material and see if it can be as tall as the terraced one. You will likely find that this is impossible. Ask the following:

» Why can't the normal slope be as tall as the one with terraces? (*There isn't enough support. The terraced slope has flat surfaces whose sediment is not being pulled downhill like it would be on the other hill, and the supporting walls keep those flat levels in place.*)

Use the structures in the model to simulate causes of landslides, such as earthquakes (shake the box), erosion at the base of the slope (cut or spoon the bottom of the slope away), burrowing (use fingers to poke holes in the slope), or the domino effect of knocking sediment loose at the top.

Discuss how household materials could be used to model another engineering approach to landslide prevention or avoidance, such as anchoring structures into the bedrock of a mountainside. Ask the following:

» How could you use the materials we have here as well as a few others to test whether building a house on concrete-and-steel pillars anchored to the rock of a mountain slope would spare the house during a mass movement event of the mountainside's sediment? (*Possible answer: Make bedrock slope out of cardboard, and anchor a model house to the carboard with long pins or popsicle sticks. Use the sand as the sediment around the supporting structures, and trigger a landslide to see if the house remains in place despite the loss of sediment around its foundation.*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms **landslide** and **mass movement**. Have students write each term in the upper left corner of an index card and underline it, one term per card.

Word Work

- **landslide:** (n. a form of mass movement in which a large section of a slope slides downhill all at once) Ask students which two words make up the larger word *landslide*. (*land, slide*) Have students write a definition for each word on their cards. (*example: land = the ground; slide = movement downward*) Then have students put the two definitions together for a basic definition of the word *landslide*. (*when the ground moves downward*)
- **mass movement:** (n. downhill movement of a mass of earth surface material) On their cards, have students give examples of mass movement. Allow students to refer back to Chapter 7 in the Student Reader if necessary. (*examples: landslides, mudslides*)

Have students review and revise the vocabulary cards. Students might find it helpful to draw small sketches of the terms or to compare them or determine how one nests within the other. For example, a landslide is a specific type of mass movement.

Students should store their deck of Core Vocabulary cards in alphabetical order. The cards can be organized with the rest of the cards from the unit. Students may benefit from reorganizing the cards into groups such as "major surface events" and "hazards" and "other terms." You can also lead students through examples or scenarios that ask them to place specific terms in order of occurrence in a natural disaster. For example, an *earthquake* caused vibrations in the rock surrounding Lituya Bay, causing a *landslide*. The landslide moved a huge volume of water in the bay, triggering a *tsunami*.

5. Check for understanding. 5 MIN

Activity Page

AP 12.1 and Answer Key

Formative Assessment Opportunity

Have students complete Lesson 12 Check (AP 12.1). Collect the assessment, and check students' answers to identify concepts with which they are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

Problem-Based Learning Progress

Review progress students have made in learning about quick-moving erosion events. Students have learned the following:

- that landslides and mudslides are quick-moving erosion events
- about specific landslides and how communities have dealt with them

Discuss with students whether or not landslide hazards pose a threat in your location. Explain that in Lesson 13, students will model erosion events and design a solution to prevent them or lessen their impact.

LESSON 13

Landslide Problems and Solutions

Big Question: How can people protect themselves from the hazards of landslides?

Problem-Based Learning Project: Learn more about the effects of quick-moving erosion events and how communities protect themselves from the effects in anticipation of the unit capstone project.

At a Glance

Learning Objective

✓ Describe the hazards posed by landslides and how humans can avoid and minimize the dangers of them.

Lesson Activities (2 days)

- writing
- discussion
- demonstrations
- student investigation

NGSS References

Performance Expectation 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Disciplinary Core Idea ESS3.B: Natural Hazards

Disciplinary Core Idea ETS1.B: Designing Solutions to Engineering Problems

Crosscutting Concepts: Cause and Effect; Influence of Engineering, Technology, and Science on Society and the Natural World

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions is important to this lesson as it focuses on generating and comparing design solutions that solve a potential problem. On Day 1, students will identify criteria and constraints of a problem related to landslides. On Day 2, students will generate and compare several solutions within their teams.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced in this lesson.

criteria constraints design solution landslide

Instructional Resources

Activity Pages

AP 13.1
AP 13.2
AP 13.3
AP 13.4
AP 13.5
AP 13.6
AP 13.7
AP 5.2

Activity Pages Investigating a Landslide Problem (AP 13.1)

Landslide Solutions Evaluation Guide (AP 13.2)

Using Scientific Information (AP 13.3)

Making a Landslide Model (AP 13.4)

Describing Criteria and Constraints (AP 13.5)

Brainstorming, Making, and Evaluating Design Solutions (AP 13.6)

Writing Your Engineering Report (AP 13.7)

Natural Hazard Solutions (AP 5.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

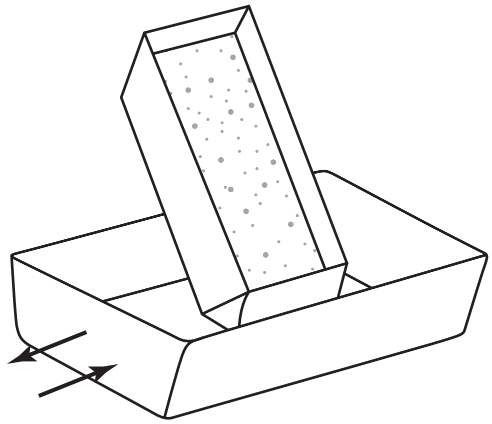
Collect or prepare the following items:

- empty half-gallon paper drink cartons (1 per team, with cap in place)
- scissors (1 per team)
- potting soil or sand (slightly moist)
- plastic bin (1 per team, large enough to hold the carton on its side at an angle)
- ruler

Advance Preparation

If you have already assigned students to teams for this unit, have them work in those teams for this lesson. If you have not yet assigned teams, groupings of three or four students will allow assignment of roles and accountability of all team members.

All materials are per team. Set up the materials as described in Activity Page 13.4, and test them before class. Consider using a box cutter to remove one side of each drink carton for students. If the potting soil or sand does not slide down the incline when the carton is shaken, try adding some water to it and testing it again. Collect ahead of time a variety of objects that students might want to use to prevent the loose Earth materials from sliding downhill in the model, such as blocks, rocks, netting, modeling clay or dough, glue, and dried flowers that can be used to model living plants. For assistance, see the diagram on the following page.



The Core Lesson Two days, 45 min each

1. Day 1: Focus student attention on the Big Question. 10 min

How can people protect themselves from the hazards of landslides? Remind students that this lesson is part of the **problem-based learning project**. In this lesson, students learn more about landslides and how to design solutions to combat landslides. This knowledge will support the unit capstone project, which is to publish or present a solution to Earth hazards that may affect their local community.

Show students images of the aftermaths of landslides. Focus a discussion on what students already know about this phenomenon. Ask the following:

- » In what ways are landslides a problem for people? (*They damage roadways and buildings and can injure people.*)
- » Who might be most affected by the hazards of landslides? (*anyone who lives or travels at the base of a slope that is prone to landslides*)
- » How do engineers design solutions to problems such as landslides? (*They learn about the causes of landslides. They come up with possible ideas to prevent them. They do investigations to test their ideas.*) (See **Know the Standards**.)

Know the Standards

Engineering Design: NGSS describes a three-phase engineering design process but emphasizes that the three phases do not always occur in the same order. The phases are Defining the Problem, Developing Possible Solutions, and Improving Designs. Performance Expectation **4-ESS3-2** integrates engineering with a Practice or Disciplinary Core Ideas. In this case, both the Practice and one of the Disciplinary Core Ideas describe specific engineering behaviors.

2. Preview the investigation. **5 MIN**

Activity Pages

AP 13.1

AP 13.2

Distribute Investigating a Landslide Problem (AP 13.1). If students have not yet been arranged in teams, this is a good time to do so. Read the fictitious scenario on the Activity Page with the class. Answer any questions students may have, and then ask students to record the names of their team members. Point out that *Las Colinas* is Spanish for "the hills."

Explain to students that each natural hazards team will use models of landslides to test different solutions for preventing them in this community.

Next, distribute Landslide Solutions Evaluation Guide (AP 13.2). Discuss with students that the first column identifies what they will do to complete the performance task. Provide students time to read the "expert" level for each skill/row.

Explain that, at the end of this two-day lesson, you will use this rubric to evaluate students' work. Note that the purpose of students' work on Day 1 of this activity is to help them understand how best to prevent landslides. This will help them build their landslide models on Day 2.

3. Support student analysis. **10 MIN**

Activity Page

AP 13.3

Distribute Using Scientific Information (AP 13.3). Explain to students that engineers usually need to do research and always think about the science related to a problem before proposing solutions. Point out that in the previous lesson, students learned about ways scientists have dealt with landslides in specific communities. Ask the following:

» What are some ways that engineers try to prevent landslides? (*planting certain types of vegetation on slopes; building retaining walls*)

» What is one way engineers try to prevent landslides from destroying human-made structures on slopes? (*attaching the structures' foundations to the rock beneath the dirt on a slope*)

Online Resources

Have students list causes of landslides in the left column and effects of landslides in the right column. Encourage students to use Chapter 7 in the Student Reader as a reliable source of information. You might also allow students to search for information about landslides on reliable websites for students, using the search terms *landslides* and *kids*. Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Once students have identified the causes and effects of landslides, tell them they are ready to think about ways to solve the landslide problem for the city of Las Colinas. This is also a good opportunity to remind students that engineers craft design solutions to solve everyday or ongoing problems. Part of the design process is brainstorming solutions, modeling them, and testing them to predict how they will work in real life. You may also want to point out that earthquakes and landslides are examples of cause and effect. The earthquake is the cause; crustal movement causes seismic waves to pass through the ground. These waves can shake loose dirt, rock, or other debris from steep or weak slopes. This is an effect of earthquakes.

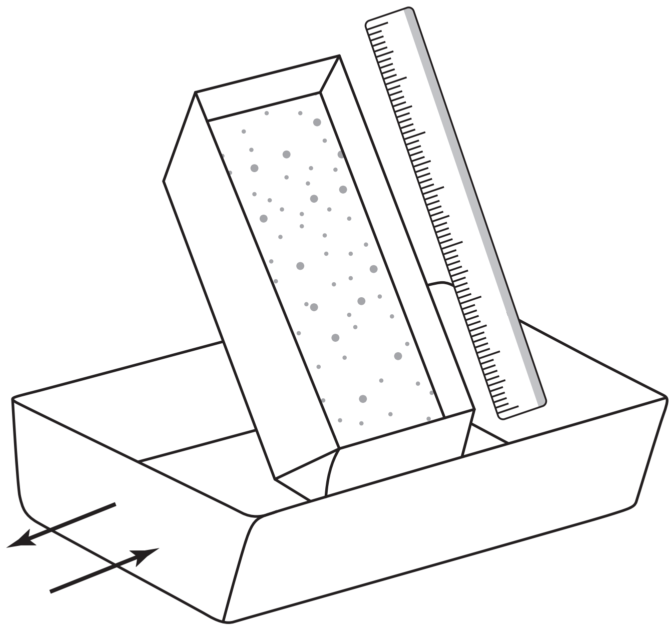
4. Demonstrate the investigation. 15 MIN

Activity Page

AP 13.4

Distribute Making a Landslide Model (AP 13.4). Demonstrate for the class how to follow the steps to set up the model and simulate an earthquake to trigger a landslide.

For step 7, show students how to hold the ruler to measure the distance the materials slid from their starting point at the top of the ramp.



Students may notice that the soil or sand does not start to slide right away. Explain that where the particles of sand or soil touch the carton, there is resistance to motion. Remind students that this is a force called friction. The shaking motion of the soil or sand particles reduces the friction, and then they will begin to slide down the model of the hillside. (See **Know the Science**.)

Assign a shaker for each team, and explain that the motion, duration, and intensity of the shaking should be the same each time they use the model. Students should make a note of how much soil moved down the slope each time they shook the bin. Have them report this back to the designated recorder. Ask each group to record the average amount of slide for the soil. Explain that students will need this as evidence for whether their solutions work in Day 2.

Know the Science

What role does friction play in landslides? ***For a landslide to occur, friction must be overcome.*** Students may recall from Grade 3 Unit 1, *Investigating Forces*, that friction is a force that opposes motion between surfaces in contact. Friction resists any changes in motion so that the particles stay in contact with one another and in place. Several factors can reduce the friction between the particles and result in a landslide. One factor is the addition of water. This is one reason landslides often occur during rainstorms. Vibrations, such as those from earthquakes or construction explosions, may also overcome friction. If friction between the particles is reduced or overcome, the force of gravity pulls the loosened particles down the slope.

5. Check for understanding. **5 MIN**

Activity Page

AP 13.5

Distribute Describing Criteria and Constraints (AP 13.5). Discuss this page as a class. The problem to solve should be written as a question. Use the Big Question (How can people protect themselves from the hazards of landslides?) for this lesson as a starting point.

Review the definitions of *criteria* and *constraints* with students. Make sure students understand that both are requirements for a successful solution.

> **SUPPORT**—If students struggle to distinguish criteria from constraints, have students think about criteria as rules to follow and constraints as restrictions. Ask students to explain how this is similar to lists of dos and don'ts. Guide students to recognize that criteria are the dos and constraints are the don'ts.

Discuss the criterion and constraints listed. Ask: Are there any other criteria and constraints that we should add to the list before designing solutions? (*Field all suggestions, and have the class vote to add any that seem reasonable.*)

1. Day 2: Support the investigation. **20 MIN**

Activity Page

AP 13.6

Have students arrange themselves in their teams. Distribute one copy of Brainstorming, Making, and Evaluating Design Solutions (AP 13.6) to each student. Direct students to carry out steps 1 and 2 on the Activity Page with their teams. Give students ample time to discuss their solutions, select their materials, and plan their solution to preventing landslides.

For step 3, each team should construct its own landslide model, like the one you demonstrated on Day 1 #4. Explain to students that their testing of the model to simulate a landslide would be a control setup. Later, students will compare each solution to the controlled landslide.

Have teams carry out steps 4 and 5, recording their results and conclusions. Emphasize that these answers will be important when students write their reports to the Las Colinas city council.

2. Support student writing. **20 MIN**

Activity Page

AP 13.7

Distribute one copy of Writing Your Engineering Report (AP 13.7) to each student. Have students read the directions, discuss how to respond in their teams, and write one to three paragraphs.

Remind students to apply writing skills such as including a topic sentence for each paragraph and using appropriate capitalization, punctuation, and spelling.

CHALLENGE—Some students may wish to present their reports in a simulated Las Colinas city council meeting. Assign roles to all students, such as mayor, councilperson, and citizen audience. If more than one team wishes to make a presentation, explain that cities often have more than one expert team or company make presentations and then decide which one they wish to follow. Allow presenters to use their written reports as notes, but encourage them to maintain eye contact with the councilpersons and use formal language.

3. Check for understanding. 5 MIN

Activity Pages

AP 13.1
AP 13.2
AP 13.3
AP 13.5
AP 13.6
AP 13.7
AP 5.2
Answer Key

Formative Assessment Opportunity

Have students place their completed Activity Pages 13.3, 13.5, 13.6, and 13.7 in a folder. Then have them staple or tape Activity Page 13.1 to the cover. Collect the folders.

Use Landslide Solutions Evaluation Guide (AP 13.2) to evaluate each student's work over the two days to meet Performance Expectation 4-ESS3-2.

Assess students' work in completing the T-chart on Using Scientific Information (AP 13.3). Look for understanding of the Crosscutting Concept (Cause and Effect).

Review Describing Criteria and Constraints (AP 13.5) to make sure that students checked off all criteria and constraints for the design solution.

Review Brainstorming, Making, and Evaluating Design Solutions (AP 13.6) to assist you in assessing how well students understood the Disciplinary Core Idea (Designing Solutions to Engineering Problems) that testing a design solution involves a scientific investigation and the Science and Engineering Practice (Constructing Explanations and Designing Solutions).

Review students' written reports on Writing Your Engineering Report (AP 13.7) to determine that they included all five requirements. Note: this piece of writing can also become part of English language arts instruction and evaluations.

Circulate around the room during each team activity to assess individual effort and teamwork.

Have students complete the fifth row of Natural Hazard Solutions (AP 5.2). Explain that students should think about whether this is or could be a hazard in their community and why. Do not collect the Activity Page. Instead, tell students to keep it in a safe place because they will be returning to it in the unit capstone.

Problem-Based Learning Progress

Review progress students have made in learning about landslides. Students have learned the following:

- how to design and test model solutions to combat landslides

Explain that in the capstone project, students will apply what they have learned about Earth's hazards and will publish or present their solution to any such hazards in their area.

PART E

Managing the Effects of Earth's Natural Processes in Our Area

Overview

Lesson	Big Question	Advance Preparation
Sharing Community Solutions Day 1: Determine Which Hazard Affects the Local Community Day 2: Develop and Practice Presentation Day 3: Publish or Present Findings Before Community Leaders	What solutions can we develop to reduce the impact of natural Earth processes where we live?	Complete and present problem-based learning project. (See Materials and Equipment, page 17.)

Part E: What's the Story?

Students learned in Parts B, C, and D (Lessons 2–13) about the many different types of Earth processes and the hazards associated with them. Students also learned that each of these hazards has its own unique causes, effects, and solutions, and students were tasked with determining whether the hazards could affect the students' own community.

In the unit capstone, as part of their **problem-based learning project**, students consider everything they have learned about natural hazards to create a summative presentation of their solutions to possible hazards in their area. Students decide upon a means of communicating the information they obtained to their peers, parents, and community leaders through a problem-based learning project, which they have been working toward throughout this unit. Students are then tasked with making a presentation and practicing that presentation. As part of the latter, students critique and revise their presentations. Finally, students publish or present their solution to any possible natural hazards that might affect their community, thus making it a public product that others can learn from. After the presentation is over, students reflect on what they learned.

So, to repeat, **natural hazards present dangers to every community, and each community must determine which are the biggest threats and how to deal with them**. Help your students obtain, combine, and present information to describe solutions that will keep the community safe from the natural hazards that threaten it, and you will lay the groundwork for meeting the NGSS expectations 3-ESS3-3 and MS-ESS2 as well as help students complete their problem-based learning project.

PROBLEM-BASED LEARNING UNIT CAPSTONE

Sharing Community Solutions

Big Question: What solutions can we develop to reduce the impact of natural Earth processes where we live?

Problem-Based Learning Project: Prepare a presentation that offers solutions to any natural hazards that might strike the local community.

At a Glance

Learning Objective

✓ Communicate solutions that can reduce the impacts of Earth hazards in the students' community.

Lesson Activities (3 days)

- research, discussion, and writing (Days 1 and 2)
- community presentation (Day 3)

NGSS References

Performance Expectation 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Disciplinary Core Idea ESS3.B: Natural Hazards

Disciplinary Core Idea ETS1.B: Designing Solutions to Engineering Problems

Crosscutting Concept: Influence of Engineering, Technology, and Science on Society and the Natural World

Science and Engineering Practice: Constructing Explanations and Designing Solutions

The **Influence of Engineering, Technology, and Science on Society and the Natural World** is important to this lesson as students present solutions to various hazards in their community. In this problem-based learning lesson, students are asked to describe and recommend engineered solutions for dealing with Earth hazards. In Day 1, step 3, students will decide which hazard is most significant to their community. Later, using Earth Hazards Presentation Evaluation Guide (AP UC.2) as a guide, students refer back to what they have learned about the influence of engineering, technology, and science when writing their information sheets.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Instructional Resources

Activity Pages

AP UC.1
AP UC.2
AP UC.3
AP UC.4

Activity Pages

Earth Hazards Project Checklist (AP UC.1)

Earth Hazards Presentation Evaluation Guide (AP UC.2)

How to Publish and Present Your Earth Hazards Information Sheet (AP UC.3)

Earth Hazards Project Reflection (AP UC.4)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- online image library for the entire unit
- internet access and the means to project images/video for whole-class viewing
- name tags for students and event attendees

Advance Preparation

Decide how you will group students for this performance assessment project. Small groups of three or four students will allow assignment of roles but allow accountability of all team members.

By this time, invitees from your community, including other students, parents, and school administrators, should have been identified and invited to the unit capstone project presentation. If not, this is the latest point at which to do so, given that the event is now only a few days away. Decide on a date and time that works for your class and school. Send out invitations. Be sure to allow students enough time to practice their presentations, especially if they are using presentation materials.

THE CORE LESSON THREE DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question. 10 MIN

Activity Page

AP 5.2

What solutions can we develop to reduce the impact of natural Earth processes where we live? Conclude work on this unit's **problem-based learning project**. Remind students that this unit is different from all the others because it contains a single capstone project that is designed to help them understand how to deal with a problem. In this lesson, students will use their understanding of natural hazards to design a solution for those hazards most likely to occur in their area.

In Lessons 1–13, students learned about several kinds of natural hazards and investigated engineering solutions that can reduce their impacts on people. Ask the following:

» What are some solutions we explored to reduce the impacts of natural hazards? (*Remind students that they proposed and tested design solutions to help communities deal with earthquakes, erosion, and landslides.*)

» What types of natural hazards might affect us in the region where we live? (*Answers will vary based on location.*)

» How could sharing what we have learned help our community? (*It could save lives, reduce property damage, and more.*)

Explain to students that in this unit capstone project, they will think about which of these hazards most affects their own community. Have them get out Natural Hazard Solutions (AP 5.2). Direct students to look over the natural hazards covered on the sheet. Ask students which hazard or hazards are most likely to occur in their area based on what they learned and discussed in the previous lessons. Then students will plan and carry out a presentation to explain to community members what actions can be taken to reduce their impacts.

2. Preview evaluation criteria. 5 MIN

Activity Pages

AP UC.1
AP UC.2

Distribute Earth Hazards Project Checklist (AP UC.1) to your students, and preview the directions with them. Explain that students will use this checklist as a guide over the next three days.

Now would be a good time to have students organize themselves into the same natural hazard teams they were in during other lessons in the unit. Then, for each step in the project checklist, make sure to assign roles.

Point out that students will have to think like engineers to identify and define a local problem, do research on solutions, compare the solutions to decide which ones are best, and communicate those solutions to the public. (See **Know the Standards**.)

Next, distribute Earth Hazards Presentation Evaluation Guide (AP UC.2). Remind students that they reviewed this same rubric in Lesson 1 and that they used similar rubrics in lessons throughout the unit. Make sure students understand that they should strive to reach the Expert level for each skill.

3. Guide discussion. 25 MIN

Online Resources

Guide a class discussion to determine which hazard or hazards of those explored in this unit are most likely to impact your local community. For example, communities with homes built on steep slopes or situated near a river may by subject to soil erosion. Communities near active faults may experience periodic earthquakes, and

Know the Standards

Engineering Design: NGSS at Grades 3–5 has three Performance Expectations that students should demonstrate mastery of before the end of Grade 5. The first, 3-5-ETS1-1, requires students to define a simple design problem. The second, 3-5-ETS1-2, has students generate and compare multiple solutions to a problem. The third, 3-5-ETS1-3, has students plan and carry out fair tests to optimize a design solution. The Performance Expectation for this lesson is followed by an asterisk, indicating that it integrates Earth content with engineering design content.

those along a coast might experience coastal erosion or tsunamis. Use online maps maintained by government or nongovernmental agencies to narrow down the level of hazard by state or even county. (See **Know the Science 1**.)

Depending on what region your school is in, there may be many Earth hazards or few Earth hazards. When in doubt, all communities are subject to some level of erosion, even if on a small scale.

> **CHALLENGE**—To cultivate further interest, encourage students to decide which natural hazard interests them the most and investigate solutions implemented in communities other than their own.

4. Check for understanding. 5 MIN

Activity Page

AP UC.2

Formative Assessment Opportunity

Collect any materials that students created for their presentations, and review the finished products for understanding of the science and engineering content of this unit and the use of appropriate writing skills.

Collect AP UC.2, to use in calculating a project score for each student.

1. Day 2: Support student writing. 25 MIN

Activity Page

AP UC.3

Distribute How to Publish and Present Your Earth Hazards Information Sheet (AP UC.3) to all students. Plan to have each team produce a solution on one hazard. Read the directions for completing the presentation with the class. Make sure students have access to all the chapters in their Student Reader for this unit. Allow teams leeway in how they present their solutions to the class.

Make available the images from the Student Reader for students to choose from and add to the information sheets. If possible, facilitate online searches for additional suitable images.

Teams may have to produce several drafts before they are ready to publish their work. Circulate among students, and provide guidance as needed.

Know the Science

1. How can you determine local geological hazards? ***Maps can be useful.*** Some regions of the United States are more prone to certain hazards than others. Maps can be useful to visual data about regional hazards. Earlier in this unit, students interpreted maps showing the locations of earthquakes and volcanoes. Use U.S. Geological Survey (USGS) maps showing the chance of earthquakes in the next 100 years and active U.S. volcanoes. USGS also has landslide maps and a tsunami map. A world erosion hazard map is also available from the U.S. Department of Agriculture. Use this link to download the CKSci Online Resources Guide where specific links may be found: **www.coreknowledge.org/cksci-online-resources**

SUPPORT—Some students may need extra help producing informational/explanatory writing for an intended audience. Work with these students to make sure they use clear headings, include concrete details, and use linking words and phrases (e.g., *for example, also, because*). Have students look through their Core Vocabulary cards for this unit and include relevant domain-specific terms.

To complete the presentation, students should draw upon the work they did in earlier lessons when they designed solutions for addressing individual hazards.

In addition, they may need to do some online or library research to identify other practical actions people can take. Remind students that solutions are not always objects that are built. Many solutions are actions people can take. For example, in an earthquake zone, people should avoid keeping heavy objects on high shelves from which they could fall and cause injuries during an earthquake. (See **Know the Science 2**.)

2. Practice presentations. 15 MIN

Activity Page

AP UC.2

Arrange students in the same teams as on Day 1. Have students get out their Earth Hazards Presentation Evaluation Guide (AP UC.2) and review it again, especially the rows about presenting to an audience.

Then have students take turns practicing their talks, with teammates taking the role of the audience. Tell the "audience" that after the student has finished speaking, they may ask questions.

Allow time for each team to use the rubric to evaluate their presentations. Students can score themselves or have the audience do the scoring.

Circulate among the teams to listen to each student speak. Use your own set of rubrics to evaluate each student.

At this point, you will have to make decisions about how many students will speak at the community event. Choose speakers so that the information they have to share is not repeated. Assign roles according to the strengths of the students.

Know the Science

2. What can people do about geologic hazards? Geologic hazards such as earthquakes, tsunamis, and volcanic eruptions are not preventable. Other types of hazards, such as landslides and erosion, can be prevented to a degree. Regardless of type, people can take actions to lessen the negative effects of geologic hazards on human life and property. A first step is to assess the risk. Reducing risk may include using warning systems that allow people enough time to move away from dangerous locations. Engineers can also design structures to withstand or reduce the forces of some hazards. Solutions also include passing laws and regulations that prevent people from living or building unsafely in hazard-prone areas. Educating the public about all these types of solutions is an important function of government at the local, state, and national levels.

CHALLENGE—Some students may enjoy writing opening and closing remarks for the presentation. Ask those students to work in small groups to draft and revise scripts. Invite those students to present to the class, expressing themselves clearly and in formal English.

3. Check for understanding. 5 MIN

Activity Page

AP UC.3 and Answer Key

Formative Assessment Opportunity

Give students an opportunity to express how they feel about their progress on the project so far. Allow each student on each team to state how he or she thinks the project is going. Encourage discussion, and foster positive communication.

1. Day 3: Facilitate student presentation. 30 MIN

Arrange the classroom or meeting space in a way that best fits the presentation format students have chosen. That may be with chairs facing a part of the room where students can project images, or it may be in some other format.

If students have chosen to present their findings to a live audience, suggest having one student introduce the presentation, explaining the purpose and how the class prepared. Allow three or four students to make presentations. Be sure to give the remaining team members other roles, such as escorting visitors or distributing the information sheets.

If students conduct a presentation to a live audience, also consider providing guests with a short list of questions they might consider asking students to prompt content-related engagement.

2. Support student reflection. 10 MIN

Activity Pages

AP UC.1
AP UC.2
AP UC.4

Once the presentation event is completed, have students take out Earth Hazards Project Checklist (AP UC.1). Review the items on the list, and discuss with the class whether all were accomplished and can be checked off. If you changed the steps in the project, have students edit the steps as needed.

Next, have students review Earth Hazards Presentation Evaluation Guide (AP UC.2) again. Ask the following:

» For which of these skills are you now at an expert level? (*Answers will vary.*)

» For which are you at an intermediate level? (*Answers will vary.*)

» For which are you at a beginner level? (*Answers will vary.*)

Distribute Earth Hazards Project Reflection (AP UC.4). Give students time to write answers to the questions about their own work during this project.

3. Check for understanding. 5 MIN

Activity Pages

AP UC.2

AP UC.4

Answer Key

Summative Assessment Opportunity

Collect the information sheets that students created for their presentations, and review the finished products for understanding of the science and engineering content of this unit and the use of appropriate writing skills.

Collect Earth Hazards Presentation Evaluation Guide (AP UC.2), and use it to calculate a project score for each student.

Collect AP UC.3, and use it to evaluate students' understanding of the process they used to complete this project.

Collect Earth Hazards Project Reflection (AP UC.4), and use it to evaluate students' understanding of the process they used to complete this project.

Problem-Based Learning Progress

Review progress students have made in designing solutions to natural hazards that might afflict the local community. They have done the following:

- prepared a report or presentation
- published their report or given their presentation

By the end of this lesson, students should have published or presented their findings determining the best solution for natural hazards in their community.

UNIT 4

Teacher Resources

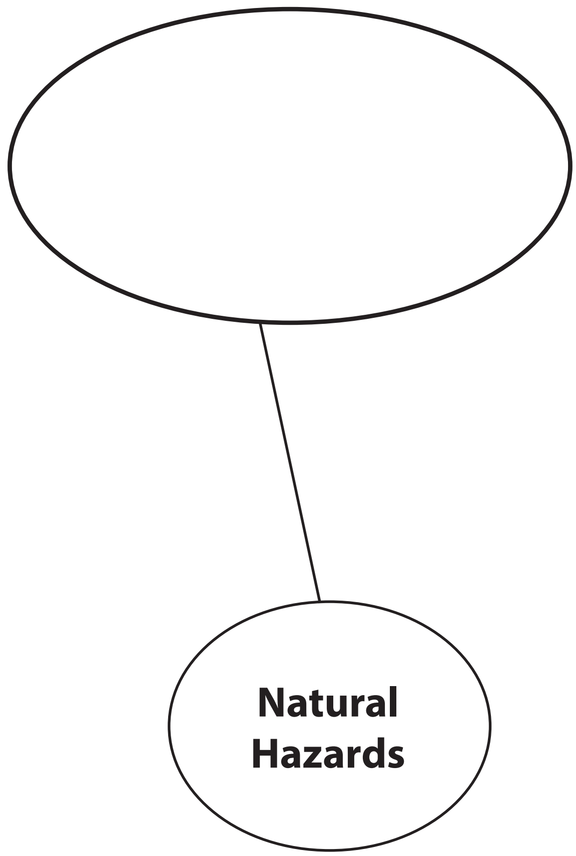
Activity Pages

Name ____ Date ________________________

Activity Page 1.1 Use with Lesson 1.

Natural Hazards Concept Map

Draw a concept map to show what you know about natural hazards. Write ideas and draw bubbles around the words *Natural Hazards*. Add lines or arrows to connect the ideas. Then use color to highlight the bubbles of geologic hazards.



Name ______________________________ Date ____________________

Activity Page 1.2 Use with Lesson 1.

The Consequences of Natural Hazards

Pick four of the natural hazards you described on Activity Page 1.1. For each one, describe at least two possible consequences. List one solution you have heard to deal with each one.

Natural Hazard 1: ______________________________

Consequence 1: ______________________________

Consequence 2: ______________________________

Solution: ______________________________

Natural Hazard 2: ______________________________

Consequence 1: ______________________________

Consequence 2: ______________________________

Solution: ______________________________

Natural Hazard 3: ______________________________

Consequence 1: ______________________________

Consequence 2: ______________________________

Solution: ______________________________

Natural Hazard 4: ______________________________

Consequence 1: ______________________________

Consequence 2: ______________________________

Solution: ______________________________

Name ______________________________ Date ____________________

Activity Page 1.3 Use with Lesson 1.

Natural Hazards Presentation Evaluation Guide

Read and discuss this rubric. Use it to plan and practice your presentation. After your presentation, your teacher will use it to evaluate your work.

Project Rubric			
	Expert	**Intermediate**	**Beginner**
Presentation explanation of the problem/ hazard	My presentation clearly describes the causes and effects of the Earth hazard for my community.	My presentation explains causes or effects but is missing a few important details.	My presentation is missing most important cause-and-effect details.
Presentation explanation of safety solutions	My presentation clearly describes safety solutions and identifies the best solutions to solve the problem.	My presentation describes most of safety solutions but does not try to pick the best one.	My presentation describes only one or two safety solutions and does not try to pick the best one.
Presentation behavior	I speak loudly and clearly, using formal language. I look at my audience when speaking.	I speak loudly and clearly most of the time. Some of my language is formal but not all of it. I do not always look at my audience when speaking.	I speak too softly and am not clear enough for people to understand. My language is not formal. I look away from my audience when speaking.
Presentation aids	I use media aids during my presentation that add to what I have to say.	I use media aids during my presentation that sometimes were not helpful.	I do not use media aids during my presentation.
Answering questions	I answer all questions from the audience clearly and completely.	I answer some questions from the audience but not always clearly and completely.	I do not answer questions from the audience.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________ Date ______________

Activity Page 1.4 Use with Lesson 1.

Natural Hazards Team Contract

Meet with your team. Read and talk about each point in the contract. When everyone agrees, write and sign your names. Give the signed contract to your teacher.

We Agree to

- listen with respect to the ideas of others,
- get our work done on time,
- meet as a team if a member does not follow the contract, and
- ask our teacher for help if we cannot solve a problem ourselves.

Print Name	Signature

Name ______________________________ Date ____________________

Activity Page 1.5 Use with Lesson 1.

Take-Home Letter

Dear Parent or Guardian,

Our class is about to begin an exciting science unit of study called *Processes That Shape Earth*. Our science focus will be on exploring the natural hazards caused by geologic forces in nature—earthquakes, tsunamis, volcanic eruptions, erosion, and landslides—and what people can do to be safe during/after these natural events. This unit is different from our other science units in that it will focus on a single problem. That problem is, **"How can people in our region reduce the impacts of natural hazards?"**

This unit will have a strong emphasis on students learning how engineers solve problems. The Next Generation Science Standards call this Engineering Design. Your student will learn how engineers develop solutions to problems that people face. They will test the designs they create to see how well they perform under different conditions.

At the conclusion of the unit, our class will give a presentation to members of the community.

The event will be held on ____________ at ____________ in the ____________. We hope you will be able to attend!

Students in our class have formed teams, in which all team members have important tasks to do at different points in the unit. Students have reviewed and discussed the attached rubric, which spells out the goals and levels of accomplishment for the final presentation. They will be graded individually based on this work.

Feel free to contact me if you have any questions.

Sincerely,

____

email or phone number

____

____

Name ______________________ Date ______________

Activity Page 2.1 Use with Lesson 2.

Lesson 2 Check

Answer the questions to show what you know from this lesson.

1. What is Earth's surface made of?

____

____

2. What is a geologist?

____

____

3. What are ways that scientists know Earth's surface is made up of plates?

____

____

4. What was the significance of finding fossils of the same types of plants on Antarctica, Australia, Africa, and South America?

____

____

5. In the space below, sketch what happens at one type of plate boundary.

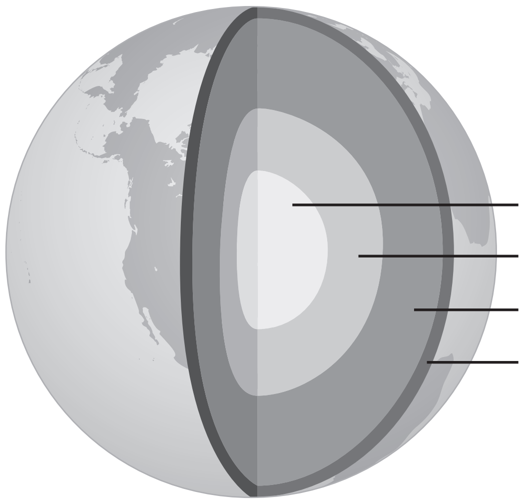
Name ______________________________ Date ____________________

Activity Page 3.1 Use with Lesson 3.

Planning a Model of Earth's Layers

A model is something people make to represent a real thing. A model is often smaller or bigger than the real object. You will make a small model of Earth to show its layers.

For every 1,000 kilometers on the real Earth, you will use about one centimeter on your model. For distances less than 1,000 kilometers, use decimals or fractions. The row for the inner core shows how to find the number of centimeters. **Complete the rest of the table with your team.**

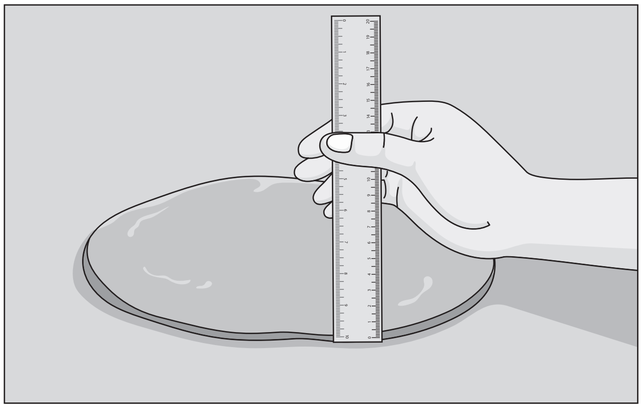


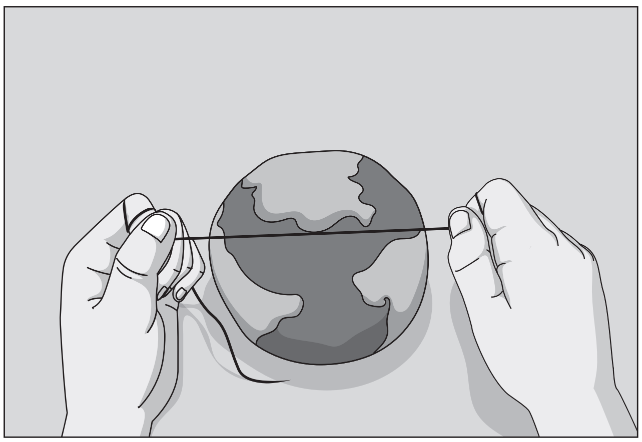
Earth Layer	Real Earth Thickness in Kilometers	Model Thickness in Centimeters (decimals)	Model Thickness in Centimeters (fractions)
Inner Core	About 2,400 km (1,000 + 1,000 + 400)	(1 + 1 + 0.4) 2.4 cm	$(1 + 1 + \frac{4}{10})$ $2\frac{4}{10}$ cm
Outer Core	About 2,300 km		
Mantle	About 2,900 km		
Crust			

Name ______________________ Date ______________

Activity Page 3.2 Use with Lesson 3.

Developing a Model of Earth's Layers





Work with a partner. Follow these steps to make your model.

1. Chose a color of clay or dough. Use your hands to roll a ball to model the inner core. Use a ruler and the table on Activity Page 3.1 to make sure it is the correct size in centimeters.
2. Choose a second color for the outer core. Using a rolling pin or soup can, flatten the clay. Use the ruler and the table to make sure it is the correct thickness in centimeters. Wrap the clay or dough around the inner core.
3. Choose a third color for the mantle. Using a rolling pin or soup can, flatten the clay. Use the ruler and the table to make sure it is the correct thickness in centimeters. Wrap the clay or dough around the outer core.
4. Choose a fourth color for the crust. Flatten the clay. Use the table to estimate how thin it should be. Wrap the clay or dough around the mantle.
5. Use the point of a straightened paper clip to lightly cut the crust into plates.
6. Use dental floss to cut the model in half through its center. You should see all the layers now!

Name ________________________________ Date ____________________

Activity Page 3.3 Use with Lesson 3.

Lesson Reflection

Follow the directions below to show what you learned.

1. Draw a cross section of your model from Activity Page 3.2.

2. Using the data on Activity Page 3.1, label the thickness of each layer.

3. Color each layer to match the colors on your clay or dough model.

4. Which layer of your model is the most different from all the others? Explain your reasoning.

____

____

____

5. What is one thing your model showed about Earth's layers?

____

6. Name something that your model does not show about Earth's layers.

____

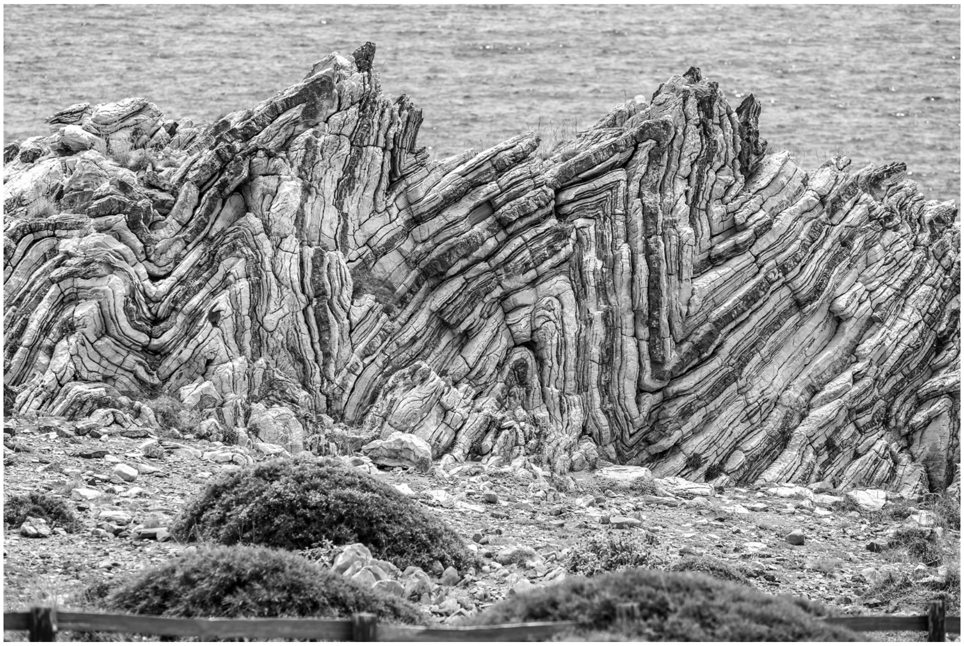
____

Name ______________________________ Date ____________________

Activity Page 4.1 Use with Lesson 4.

Lesson 4 Check

Answer the questions to show what you know from this lesson.



1. What do the layers in these rocks in the image represent?

____

____

2. How did the rocks in the image become folded?

____

____

3. How is heat involved in making both igneous rock and metamorphic rock?

____

____

4. How can fossils help geologists understand Earth's past?

____

____

Name ________________________________ Date ____________________

Activity Page 5.1 Use with Lesson 5.

Lesson 5 Check

<u>Answer the questions</u> to show what you know from this lesson.

1. Name the type of energy wave that is released during an earthquake.

____

2. Describe what can happen when two of Earth's plates push against each other.

____

____

____

____

____

3. What can happen to soil that is loose or wet during an earthquake?

____

____

____

____

____

4. Because of its location where plates meet, Japan suffers from many earthquakes each year. How has the nation prepared for future earthquakes?

____

____

____

____

____

Name ______________________ Date ______________

Activity Page 5.2 Use with Lesson 5.

Natural Hazard Solutions

<u>Complete</u> the table by writing two possible solutions to each natural hazard.

Natural Hazard	Solution 1	Solution 2
Earthquakes		
Tsunamis		
Volcanoes		
Erosion		
Landslides		

Name ________________________________ Date ____________________

Activity Page 6.1 Use with Lesson 6.

Earthquake Solutions Evaluation Guide

Read and discuss this rubric. Use it to guide your work. After you are done, your teacher will use it to evaluate your work.

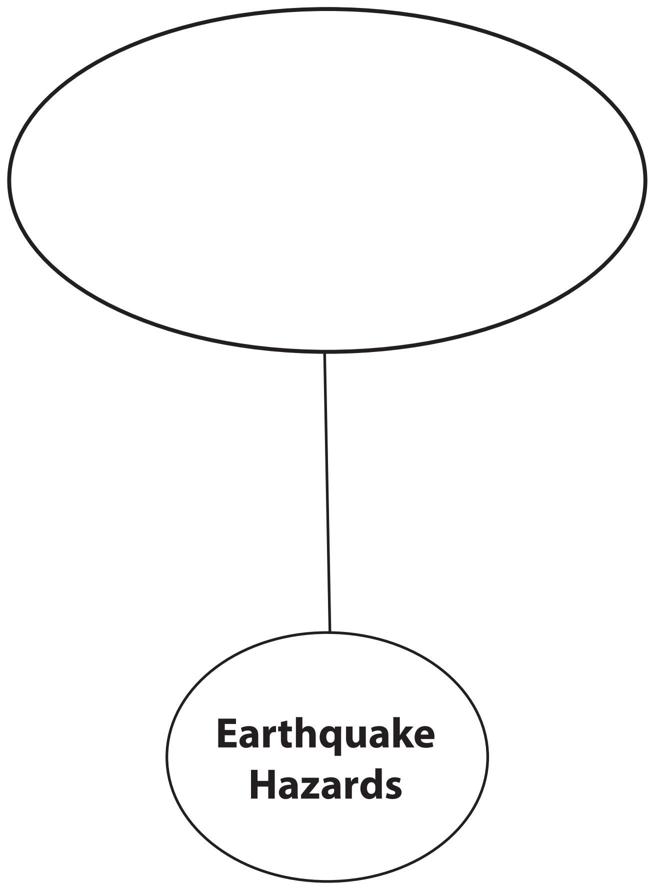
Rubric			
	Expert	**Intermediate**	**Beginner**
Identifying the problem	I clearly explain the causes of earthquakes and their effects on tall buildings.	I explain either the causes of earthquakes or their effects on tall buildings but not both.	I do not try to explain the causes of earthquakes or their effects on tall buildings.
Describing criteria and constraints	I state both criteria and constraints on solutions to preventing tall buildings from moving back and forth.	I state either criteria or constraints on solutions to preventing tall buildings from moving back and forth.	I do not try to describe criteria or constraints on solutions to the problem.
Suggesting solutions	I use cause-and-effect relationships to explain at least two solutions to the problem.	I use cause-and-effect relationships to explain at least one solution to the problem.	I do not try to use cause-and-effect relationships to explain a solution to the problem.
Testing and evaluating solutions	I test each solution and compare how well it meets the criteria and constraints.	I test each solution but do not always think about criteria and constraints.	I test some but not all solutions and do not think about criteria and constraints.
Presenting	I always look at my audience and speak loudly and clearly. I answer all questions clearly and completely.	I look at my audience and speak loudly and clearly most of the time. I answer some questions but not always clearly and completely.	I look away from my audience and speak too softly. I do not answer questions from the audience.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________ Date ______________

Activity Page 6.2 Use with Lesson 6.

Describing the Problem

<u>Draw</u> a concept map to describe the effects of earthquakes on buildings. <u>Write</u> ideas and <u>draw</u> bubbles around the words *Earthquake Hazards*. <u>Add</u> lines or arrows to connect your ideas.



Name ______________________________ Date ____________________

Activity Page 6.3 Use with Lesson 6.

Describing Criteria and Constraints

Read each item. Talk it over with your team.

What problem do you have to solve?

____

Think about the criteria and constraints of the problem.

Criteria are the things the solution MUST do or have. Without these criteria, a solution cannot be as successful. As you work on your model building, check off each criterion as you meet it.

Criteria:

- ☐ Models can only be built out of coffee stirrers and mini-marshmallows.
- ☐ Each model building must have three stories.
- ☐ Each model must be at least 30 centimeters tall.
- ☐ The building can sway but should not fall down or break during an earthquake.

Constraints are things that limit possible solutions. Size and weight limits can be constraints. Cost is often a constraint. Time is often a constraint. As you work on your model building, check off each constraint as you meet it.

Constraints:

- ☐ Each coffee stirrer costs $1. Each marshmallow costs $2. You can only spend $70 total on materials.
- ☐ The building must be built in twenty minutes.

On the lines below, explain what might make a building earthquake resistant.

____

____

____

____

Name ______________________________ Date ____________________

Activity Page 6.4 Use with Lesson 6.

Making and Evaluating Design Solutions, Part 1

<u>Get</u> the materials you think you will need. <u>Build</u> your model building. Then <u>answer</u> the questions below.

<u>Day 1:</u>

1. Which materials will you use to make your model building? How many will you use of each?

____

____

____

____

2. How will you put your building together?

____

____

____

3. What was the total cost of your materials? Did you meet the constraint for cost? Explain.

____

____

____

4. How tall is your building? Did you meet the criterion for the number of stories and height?

____

____

____

Name ________________________________ Date ____________________

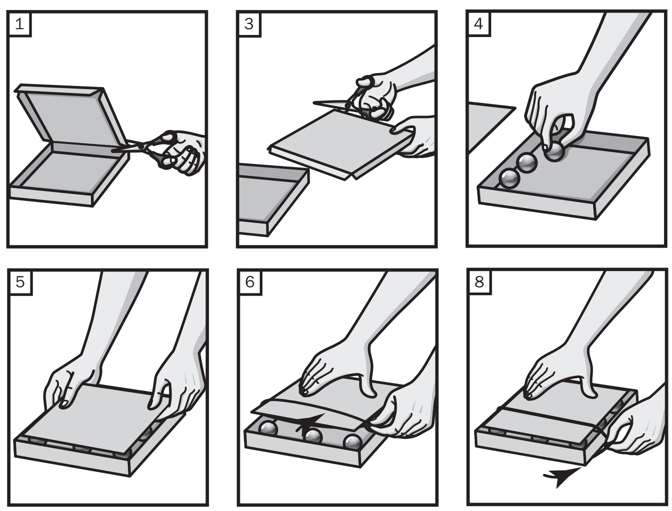
Activity Page 6.5 Use with Lesson 6.

Making an Earthquake Shaker

Get the materials from your teacher. Follow the steps to build a shake table that can model the side-to-side motion of earthquakes. Then, place your structure on the shaker to test it in an earthquake.

Materials you will need:

- pizza box
- scissors
- marbles (about 10–20 marbles per box, or enough to fill the box and be 4 cm apart from the other)
- ruler
- small rubber bands (4 per box)
- stapler



Steps

1. Use the scissors to carefully cut the top off the pizza box.
2. Use the ruler to draw straight lines on each edge of the top 2 cm from each edge.
3. Use the scissors to cut off the 2 cm on each edge of the top.
4. Arrange the marbles in the bottom of the box so that they are about 4 cm apart.
5. Put the top over the marbles. Pull on one side of the top. Make sure the marbles hold the top flat as it moves.
6. Staple a rubber band to each corner of the top (or enclose in one large band).
7. Then staple the other end of the rubber band to the matching corner of the bottom of the box.
8. Test the shaker by pulling one side of the top to the side. Let go, and observe the shaking. You are now ready to place a model building on the shaker to test it.

Name ______________________________ Date ____________________

Activity Page 6.6 Use with Lesson 6.

Making and Evaluating Design Solutions, Part 2

Have all team members test their building. Then talk in your team, and answer the questions below.

1. What happened to your building when you placed it on the shaker and modeled an earthquake?

____

____

2. How did the design solutions compare in the way the materials were used?

____

____

3. How did the solutions compare when they were shaken?

____

____

____

4. In conclusion, which solution best met all the criteria and constraints? Explain why.

____

____

____

5. How do engineers use shakers to help communities prepare for earthquakes?

____

____

____

Name ______________________________ Date ____________________

Activity Page 6.7 Use with Lesson 6.

Engineering Design Showcase

Your engineering team is invited to attend a showcase. A showcase is a meeting where people show and talk about their work. At this showcase, you will describe your earthquake design solution. You'll talk about it and explain the results of your tests.

Be prepared to answer the following questions. Write out your answers here.

1. What was your biggest challenge during this project?

____

____

2. What part did you like the best? Why?

____

____

3. Why is it helpful for engineers to work in teams?

____

____

Everyone attending the showcase needs an identification tag. Use scissors to cut out your tag. Fill it in, and use a tape loop or other fastener to attach it to your clothing.

Engineering Design Showcase

Team Name:

Engineer's Name:

Name ______________________________ Date ____________________

Activity Page 6.8 Use with Lesson 6.

Letter to Parents or Community Members

Dear Parent, Guardian, or Community Member,

Our class is studying ways that we can better protect our community from different kinds of natural hazards. In our current lesson, we are studying earthquakes. Students are learning about the problem, **"How can engineers reduce earthquake damage to buildings?"**

This lesson has a strong emphasis on students learning how engineers solve problems. The Next Generation Science Standards call this Engineering Design. Your student will learn how engineers develop solutions to problems related to earthquakes. They will test the designs they create to see how well they perform.

On Day 3 of the lesson, our class will give a presentation to members of the community. The event will be held on ______________ at ______________ in the ______________. We hope you will be able to attend!

Students in our class have formed teams in which all team members have important tasks to do at different points in the lesson. Students will be graded individually based on this work.

Feel free to contact me if you have any questions.

Sincerely,

____

email and/or phone number

____

____

Name ______________________ Date ______________

Activity Page 7.1 Use with Lesson 7.

Lesson 7 Check

Answer the questions to show what you know from this lesson.

1. What is the physical cause of a tsunami?

____

2. In the box, draw one event that can produce a tsunami.

3. Why are earthquakes and tsunamis often connected?

____

4. Why don't all earthquakes produce tsunamis?

____

5. Name two different ways people can avoid or be prepared for tsunamis.

a) ____

____

b) ____

____

6. How can nature help protect coastal areas from tsunami damage?

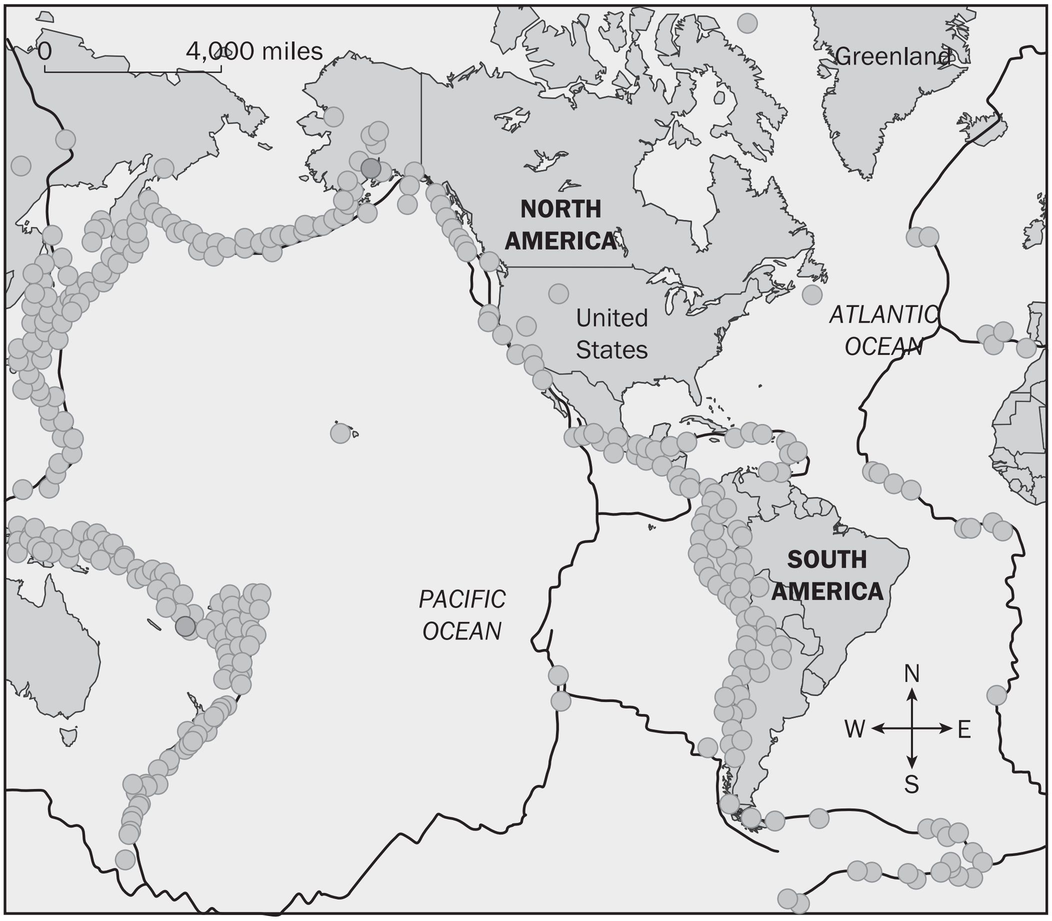
____

Name ______________________________ Date ______________________

Activity Page 8.1 (Page 1 of 2) Use with Lesson 8.

Lesson 8 Check

Answer the questions below.



1. Look closely at the pattern on this map. Where do most volcanoes form?

____

2. What do volcanoes release into the air?

____

3. What are two examples of hazards that can be caused by volcanoes?

____

____

4. Is a volcanic eruption likely in your area? Why or why not?

5. What tools can be used to help support your argument?

6. Describe what people should do in the event of an eruption.

Name ______________________________ Date ____________________

Activity Page 9.1 Use with Lesson 9.

Volcanoes Evaluation Guide

Read and discuss this rubric. Use it to guide your team's work. After you are done, your teacher will use it to evaluate your infographic.

Rubric			
	Expert	**Intermediate**	**Beginner**
Interpreting data from maps	All the requested data are accurately collected from an online map.	Most of the requested data are accurately collected from an online map.	Most of the requested data are not collected or not accurately collected.
Infographic title	The title is a clearly worded question that states the main idea.	The title is either not a question or not clear.	The infographic is missing a title.
Finding patterns	The infographic shows how the locations of states are related to the number of volcanoes.	The infographic is partially correct in showing how the locations of states are related to the number of volcanoes.	The infographic does not show how the locations of states are related to the number of volcanoes.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________________ Date ____________________

Activity Page 9.2 (Page 1 of 2) Use with Lesson 9.

State-by-State Volcano Data

<u>Find</u> the online map. <u>Use</u> the zoom tool on the map to zoom in until you can see the state boundaries. <u>Drag</u> the map around to visit each state. <u>Count</u> the number of volcanoes in each category. <u>Write</u> the data in the table for each state.

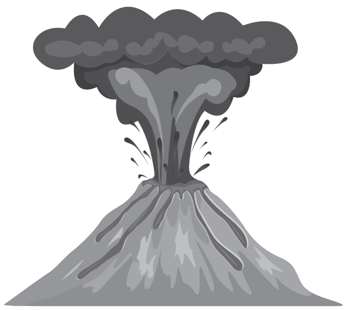
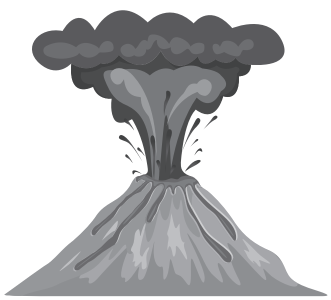
Date:						
STATE	**UNMONITORED (white)**	**NORMAL (green)**	**ADVISORY (yellow)**	**WATCH (orange)**	**WARNING (red)**	**TOTAL**
Alabama						
Alaska						
Arizona						
Arkansas						
California						
Colorado						
Connecticut						
Delaware						
Florida						
Georgia						
Hawaii						
Idaho						
Illinois						
Indiana						
Iowa						
Kansas						
Kentucky						
Louisiana						
Maine						
Maryland						
Massachusetts						
Michigan						
Minnesota						
Mississippi						
Missouri						
Montana						

Date:						
STATE	**UNMONITORED (white)**	**NORMAL (green)**	**ADVISORY (yellow)**	**WATCH (orange)**	**WARNING (red)**	**TOTAL**
Nebraska						
Nevada						
New Hampshire						
New Jersey						
New Mexico						
New York						
North Carolina						
North Dakota						
Ohio						
Oklahoma						
Oregon						
Pennsylvania						
Rhode Island						
South Carolina						
South Dakota						
Tennessee						
Texas						
Utah						
Vermont						
Virginia						
Washington						
West Virginia						
Wisconsin						
Wyoming						

Name ______________________ Date ______________

Volcanoes Infographic

Title: ______________________

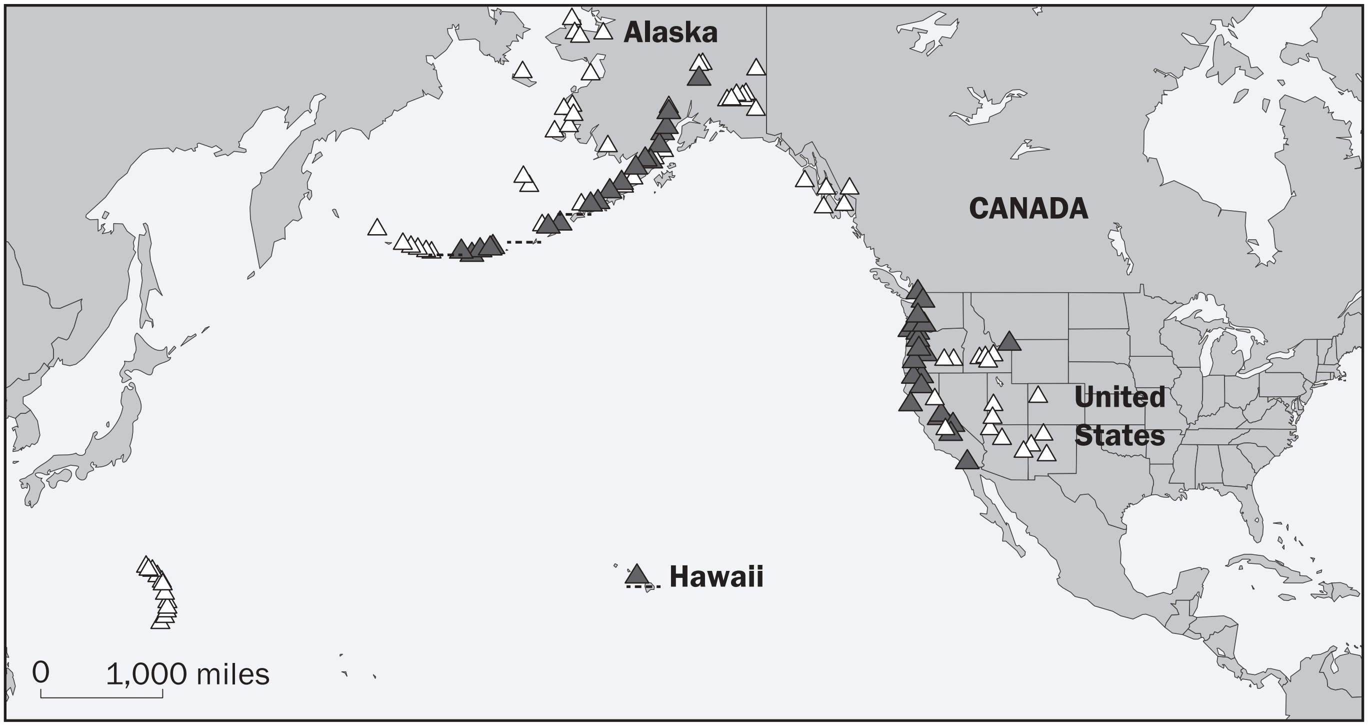
	**States with five or more volcanoes:**
	**States with one to four volcanoes:**
	**Number of states with no volcanoes:**
	**Ocean that states with the most volcanoes border** **This could mean that volcanoes mainly form where**

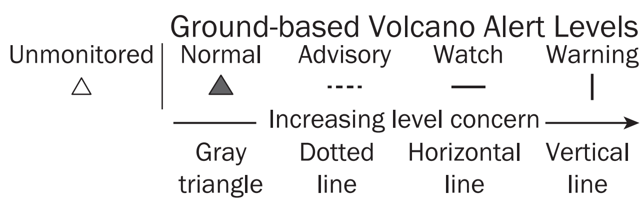
Name ____________________ Date ____________

Activity Page 9.4 Use with Lesson 9.

Volcanoes Map

Use the map to help you complete the State-by-State Volcano Data.





Name ______________________________ Date ____________________

Lesson 10 Check

1. Your house sits on a hill. At the bottom of the hill is a sidewalk. How could you prevent erosion from carrying the soil from your yard onto the sidewalk?

____

____

____

2. What are some other natural disasters or processes that can cause erosion?

____

____

____

____

3. What's an example of human activity that can make erosion worse, or more hazardous, on a slope?

____

____

____

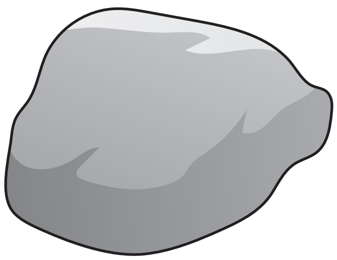
4. What's an example of human activity that can make erosion worse, or more hazardous, on flat land?

____

____

____

In the second box below, <u>draw</u> an image of a rock that has weathered over a short period of time. In the third box, <u>draw</u> an image of the same rock after it has weathered over a long period of time.

	Short Period of Time	Long Period of Time
		

<u>Explain</u> the differences in weathering you show in your cartoon.

What causes the change? What changes?

Name ______________________________ Date ____________________

Activity Page 11.1 Use with Lesson 11.

Erosion Investigation Evaluation Guide

Read and discuss this rubric. Use it to guide your team's work. After you are done, your teacher will use it to evaluate how well you carried out the investigation.

Erosion Investigation Rubric			
	Expert	**Intermediate**	**Beginner**
Identifying the purposes of investigations	I write a description of the purpose of an investigation clearly and accurately.	I write a description of the purpose of an investigation clearly, but there are more inaccuracies.	I do not attempt to write a description of the purpose of an investigation clearly or accurately.
Discussing evidence	I identify the data to collect and how to collect them and use the data as evidence in my explanation.	I identify the data to collect or how to collect them. I attempt to use data as evidence in my explanation.	I do not identify the data to collect or how to collect them. My explanation does not discuss data.
Collecting and recording data	I help my team use measurement tools properly, and I accurately record the data in a table.	I help my team, but we make a few mistakes when measuring or recording the data in a table.	I do not try to help my team measure or record accurately.
Testing solutions	I propose several ways to prevent stream bank erosion and plan how to test one solution using the stream table.	I propose at least one way to prevent stream bank erosion and plan how to test it using the stream table.	I do not try to propose solutions or do not plan a test for a solution.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________________ Date ____________________

Activity Page 11.2 (Page 1 of 2) Use with Lesson 11.

Erosion Investigation Notebook

Planning

1. What is the purpose of your stream table investigation?

____

____

2. What will your team observe or measure using the stream table?

____

____

3. What variable will you change during the investigation?

____

4. Which variables will you control so that they do not change?

____

____

____

Steps

A. Push all the sand to one end of the stream table, and pat it down with your hands. The sand should be about five centimeters deep.

B. Use a ruler to scrape the top of the sand until it is flat.

C. Place small blocks under the table to make a low slope.

D. Fill the flow cup with water, holding your finger over the hole.

E. Hold the flow cup over the uphill end of the stream table. Release your finger. Allow all the water to flow onto the sand.

F. Pour off the water from the catch bucket.

G. Measure the amount of sand that was deposited in the catch bucket. Write your measurement into the table.

H. Put all the sand back on the stream table. Repeat steps A through G, but use bigger blocks to make a medium slope. Write your measurement into the table.

I. Put all the sand back on the stream table. Repeat steps A through G, but use the biggest blocks to make a steep slope. Write your measurement into the table.

Observations/Measurements

Slope	Amount of Deposition
low	
medium	
steep	

Explanation

5. Make a claim about the effect of slope on erosion.

____

____

6. What evidence did you gather that supports your claim?

____

____

____

7. What is the rule? How does your evidence support your claim?

____

____

____

Name ______________________ Date ______________

Activity Page 11.3 Use with Lesson 11.

Testing Erosion Solutions

<u>Look at a photo</u> of a sandy or muddy stream bank. You can see that the next heavy rainstorm will flood the banks. This will cause more erosion and problems for the community. How can people solve this problem?

1. Talk with your team. List possible solutions to the problem than can be tested with the stream table. You should use the same steps as before but add one more step.

____

____

____

2. Which solution do you think is best to test?

____

3. List the additional materials you will need to do the test.

____

____

4. What is the purpose of this investigation?

____

____

5. Write the step you will need to add to test your solution.

____

____

Name ______________________________ Date ____________________

Activity Page 12.1 (Page 1 of 2) Use with Lesson 12.

Lesson 12 Check

1. What is a landslide?

____

____

____

2. What is a mudslide?

____

____

____

____

____

3. Describe the roles played by gravity and water in a landslide.

____

____

____

____

____

4. List three agents of erosion.

____

____

____

5. Describe some warning signs that a hilly area is vulnerable to landslides.

Unterraced Slope	Terraced Slope
	

6. Look closely at each picture. How likely do you think an erosion event is in the first picture? How likely do you think an erosion event is in the second picture?

7. What are other ways you can reduce the likelihood of an erosion event?

Name ______________________________ Date ____________________

Activity Page 13.1 Use with Lesson 13.

Investigating a Landslide Problem

Read about the problem below. Then talk with your team about how to solve it.

The city of Las Colinas, California, is known for its many steep hills. Most of the city's roadways and homes are at the bottoms of the hills. Because of earthquakes in the area, landslides can occur at any time. This is dangerous for people, homes, and roadways.

Las Colinas is governed by a city council. The council makes decisions about making the city safer. It has hired several teams to investigate how best to prevent landslides. It hopes to compare the results from each. Then it will choose the best solutions.

Your natural hazards team has been hired by the Las Colinas city council. Your task is to investigate the problem. You will then need to write a report to the council. Your report must explain how the city can reduce the number of landslides. This will take some engineering know-how!

List the names of your team members:

____

____

Name ______________________________ Date ____________________

Activity Page 13.2 Use with Lesson 13.

Landslide Solutions Evaluation Guide

<u>Read and discuss</u> this rubric. Use it to guide your team's work. Your teacher will also use it to evaluate your work.

Rubric			
	Expert	**Intermediate**	**Beginner**
Using scientific information	I use information from the last lesson about the causes and effects of landslides to propose solutions to the problem.	I use information from the last lesson about either the causes or effects of landslides to propose solutions to the problem.	I do not try to use causes and effects to propose solutions to the problem.
Describing criteria and constraints	I state both criteria for and constraints on possible solutions.	I state either criteria for or constraints on possible solutions.	I do not try to describe criteria for or constraints on possible solutions to the problem.
Suggesting solutions	I use cause-and-effect relationships to explain at least two solutions to the problem.	I use cause-and-effect relationships to explain at least one solution to the problem.	I do not try to use cause-and-effect relationships to explain a solution to the problem.
Testing and evaluating solutions	My team tests each solution and compares how well it meets the criteria and constraints.	My team tests each solution, but we do not always think about criteria and constraints.	We test some but not all solutions and do not think about criteria and constraints.
Writing a report	I use claim-evidence-reasoning thinking to write a report explaining the best solution to the problem.	I write a report explaining the best solution to the problem but do not describe the evidence.	I write a report claiming the best solution but do not describe the evidence or provide any reasoning.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________________ Date ____________________

Activity Page 13.3 Use with Lesson 13.

Using Scientific Information

<u>Write</u> to complete the chart. List the causes of landslides on the left. List the effects of landslides on the right.

Landslides	
Causes	**Effects**

Name ______________________________ Date ____________________

Activity Page 13.4 Use with Lesson 13.

Making a Landslide Model

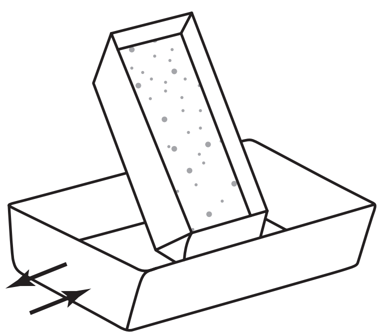
<u>Get</u> the materials from your teacher. <u>Follow</u> the steps to <u>model</u> a landslide.

Materials you will need:

- half-gallon empty paper drink carton, with cap in place
- scissors
- potting soil or sand
- plastic bin (large enough to hold the carton at an angle)

Steps:

1. Use the scissors to carefully cut one of the long sides off the carton.
2. With the open side up, fill the bottom of the carton with potting soil.
3. Use the scissors to cut off two centimeters of each edge of the top.
4. Put the carton flat in the bin with the open side up.
5. Use the side of the bin to position the carton to make a steep slope.
6. Model an earthquake by shaking the bin side to side. Stop when the soil slides down the slope. Do this four times, and record how much soil slides each time.
7. Use a ruler to measure the distance the soil moved from the top of the carton.



Name ______________________________ Date ____________________

Activity Page 13.5 Use with Lesson 13.

Describing Criteria and Constraints

Describe the problem your team will try to solve.

___

___

___

Criteria are the things the solution MUST do or have. Without these criteria, a solution cannot be successful. **Check off the criterion** as you meet it.

☐ Solutions should reduce the amount of Earth materials that slide down the hill onto the roads.

Constraints are things that limit possible solutions. Cost is often a constraint. Time is often a constraint. **Check off each constraint** as you meet it.

☐ Solutions should be durable enough that they not need to be replaced for at least two years.

☐ Solutions should be ready to report to the city council in one or two days.

Name ______________________ Date ______________

Activity Page 13.6 Use with Lesson 13.

Brainstorming, Making, and Evaluating Design Solutions

Follow the steps below, and record your answers to the questions.

1. Talk with your team. Brainstorm possible solutions for preventing landslides on your model. List all your ideas.

2. Discuss the list of solutions with your team. Think about the time you have. Think about the materials you can find. List three or four solutions you can test in your classroom.

3. Get the materials listed on Activity Page 13.4. Follow the directions to build the model. What is the distance the soil moved when you modeled a landslide?

4. Test each design solution on your model. How did the solutions compare?

5. Which solution best met all the criteria and constraints? Explain why.

Name ______________________________ Date ____________________

Activity Page 13.7 Use with Lesson 13.

Writing Your Engineering Report

Your engineering team has completed its investigation. The Las Colinas city council is waiting for your report! Include the following in your report as you write one to three paragraphs:

1. an introduction to the problem
2. your claim about the best solution to prevent landslides
3. the evidence you gathered during your modeling to support your claim
4. your reasons that the evidence supports your claim
5. a concluding sentence that sums up your report

Name ______________________________ Date ____________________

Activity Page UC.1 Use with Unit Capstone.

Earth Hazards Project Checklist

After weeks of work, you are becoming an expert in Earth hazards. You also know about solutions for reducing their impacts on people. Now it's time to help your community by sharing what you know.

Check off each step as you complete it.

- ☐ Identify an Earth hazard that could be a problem for your community. ____________________
- ☐ Write a first draft of your information sheet.
- ☐ Edit your information sheet.
- ☐ Add images to your sheet.
- ☐ Choose a date and time for your event.
- ☐ Invite community members to your event.
- ☐ Set up your event space.
- ☐ Practice your presentations.
- ☐ Hold your event.
- ☐ Thank community members for coming.
- ☐ Write your reflection of this project.

Name ________________________________ Date ____________________

Activity Page UC.2 Use with Unit Capstone.

Earth Hazards Presentation Evaluation Guide

Read and discuss this rubric. Use it to plan and practice your presentation. After your presentation, your teacher will use it to evaluate your work.

Project Rubric			
	Expert	**Intermediate**	**Beginner**
Fact sheet explanation of the problem/ hazard	The front of my fact sheet clearly describes the causes and effects of the Earth hazard for my community.	The front of my fact sheet explains causes or effects but is missing a few important details.	The front of my fact sheet is missing most important cause-and-effect details.
Fact sheet explanation of safety solutions	The back of my fact sheet clearly describes safety solutions and identifies the best solutions to solve the problem.	The back of my fact sheet describes most of the safety solutions but does not try to pick the best one.	The back of my fact sheet describes only one or two safety solutions and does not try to pick the best one.
Presentation behavior	I speak loudly and clearly, using formal language. I look at my audience when speaking.	I speak loudly and clearly most of the time. Some of my language is formal but not all of it. I do not always look at my audience when speaking.	I speak too softly and am not clear enough for people to understand. My language is not formal. I look away from my audience when speaking.
Presentation aids	I use media aids during my presentation that add to what I have to say.	I use media aids during my presentation that sometimes were not helpful.	I do not use media aids during my presentation.
Answering questions	I answer all questions from the audience clearly and completely.	I answer some questions from the audience but not always clearly and completely.	I do not answer questions from the audience.
Teamwork	I always work well with my team. All members of the team get to participate equally.	I sometimes work well with my team. Members of the team sometimes get to participate equally.	I do not work well with my team. Some team members did not get to participate.

Name ______________________________ Date ____________________

Activity Page UC.3 (Page 1 of 2) Use with Unit Capstone.

How to Publish and Present Your Earth Hazards Information Sheet

After weeks of work, you are becoming an expert in Earth hazards. You have looked at many different kinds of hazards. You have also studied solutions to each kind. Now it is time to help your community by sharing what you know.

Now you have to decide how to publish and present your Earth hazard solution.

Check the method that most interests you:

- ☐ Make a poster to show to your audience.
- ☐ Write a booklet to pass out to your audience.
- ☐ Write a report, and put it on the internet for your audience.

Make sure that your report has the following parts:

- ☐ It has images to help make it visually interesting.
- ☐ The Earth hazard you selected or were assigned is covered.
- ☐ The Earth hazard has at least one solution.

Do each of the following before you present and publish your analysis:

- ☐ Choose a date and time for your event.
- ☐ Invite community members to your event.
- ☐ Set up your event space.
- ☐ Practice your presentations.
- ☐ Hold your event.
- ☐ Thank community members for coming.
- ☐ Write your reflection of this project.

Which Earth hazard were you assigned, or which did you select?

How will each person on your team contribute to the presentation of your Earth hazard?

How likely is your Earth hazard to occur in your community?

List the information you want to present about your Earth hazard to your community.

What solution or solutions will you present to your community?

Name ______________________________ Date ____________________

Activity Page UC.4 Use with Unit Capstone.

Earth Hazards Project Reflection

Think about what you and your team did during this project. Answer each question.

What problem were you trying to solve?	
What were some important tasks you completed during this project?	
What was the most important thing you learned?	
What part of the project did you enjoy the most?	
Do you think your solution/ presentation will make a difference in your community and why?	
What is one thing you would change about this project?	

Activity Pages Answer Key: *Processes That Shape Earth*

This answer key offers guidance to help you assess your students' learning progress. Here you will find descriptions of the expectations and correct answers for each Activity Page of this unit.

Natural Hazards Concept Map (AP 1.1) (page 131)

Student concept maps will vary, but should include key elements such as floods, hurricanes, mudslides, tornadoes, volcanoes, earthquakes, ice storms, windstorms, and wildfires.

The Consequences of Natural Hazards (AP 1.2) (page 132)

Students should refer to the natural hazards they identified on the concept map, include two consequences, and one possible solution. Accept any reasonable consequences and solutions students reference.

Lesson 2 Check (AP 2.1) (page 136)

1. plates that move around and interact with each other in different ways
2. a person who studies what Earth is made of and how it formed
3. They can see the way the continents fit together on maps. They can use GPS devices to measure their movement.
4. It suggested that these landmasses had once been together.
5. Sketches should show two plates interacting in one of the following ways: subduction (one plate diving under another), collision (plates colliding head on, with one or both crumpling), sliding past each other, or diverging and exposing molten material from Earth's interior.

Planning a Model of Earth's Layers (AP 3.1) (page 137)

Real Thickness: Crust, about 30 km

Model Thickness, decimal: Outer Core, 1 + 1 + 0.3 = 2.3 cm; Mantle, 1 + 1 + 0.9 = 2.9 cm; Crust, 0.03 cm

AP 3.1, continued

Model Thickness, fraction: Outer Core, $1 + 1 + \frac{3}{10} = 2\frac{3}{10}$ cm; Mantle, $1 + 1 + \frac{9}{10} = 2\frac{9}{10}$ cm; Crust, $\frac{3}{100}$ cm

Lesson Reflection (AP 3.3) (page 139)

1. Student cross sections should match to their clay model.
2. Students should label the thickness as per Activity Page 3.1.
4. Sample answer: The crust was the most different because it is the thinnest layer and it is broken into plates.
5. Sample answer: the positions and thicknesses of Earth's layers.
6. Sample answer: It does not show what each layer is made of or how hot it is.

Lesson 4 Check (AP 4.1) (page 140)

1. Each one represents a different time in Earth's history when sediment was laid down and later became pressed into rock.
2. Over thousands to millions of years, the rocks may have been pushed together by natural forces. These may have included mountain building forces such as two of Earth's plates pushing together.
3. Igneous rock is made of lava, which starts as hot molten magma below Earth's crust. Metamorphic rock is made of sedimentary or igneous rock that is changed by heat and pressure.
4. Some fossils can become the particles of sediment that are compacted into rock. For example, marine organisms' remains can become limestone. Those sediments can also bury the remains of other organisms, which then become fossils in the sedimentary rock.

Lesson 5 Check (AP 5.1) (page 141)

1. seismic
2. Mountains can form.
3. It can move, resulting in a landslide.
4. The construction industry developed new designs to make buildings more resistant to seismic waves.

Natural Hazard Solutions (AP 5.2) (page 142)

Students will populate the table throughout the course of the unit. Student answers may come from the content found throughout the unit, but accept other plausible answers which students may think of. Upon completion, answers may approximate these:

Earthquakes

Solution 1: Design buildings to be more earthquake damage resistant.

Solution 2: Listen to warning systems to avoid aftershock dangers.

Tsunamis

Solution 1: Listen to warning systems and have an emergency plan for when tsunami danger is present.

Solution 2: Live above the height tsunami damage can reach.

Volcanoes

Solution 1: Follow warning systems and have an emergency plan for when volcano danger is present.

Solution 2: Avoid areas that are more recently active with volcanoes and tremors.

Erosion

Solution 1: Plant plants in areas that are more prone to eroding.

Solution 2: Terrace the land so the water can move downhill more slowly.

AP 5.2, continued

Landslides

Solution 1: Plants trees with deeper root systems that spread out to stabilize the soil.

Solution 2: Develop ways for water to drain out of the soil.

Describing the Problem (AP 6.2) (page 144)

Student concept maps will vary, but should include key elements such as buildings shake back and forth, buildings collapse, lights sway, foundations crack, and chairs roll.

Describing Criteria and Constraints (AP 6.3) (page 145)

Sample answers: bigger foundations, more "stirrer" beams

Making and Evaluating Design Solutions, Part 1 (AP 6.4) (page 146)

Answers for all questions will vary based on which and how many materials students used and how they chose to put their model together. This will also affect the cost of the materials. Their model buildings may vary in size but should be at least 30 centimeters.

Making and Evaluating Design Solutions, Part 2 (AP 6.6) (page 148)

1. The structures will either stay standing, bend, or collapse.
2. Some students may have cut the stirrers or used stirrers to make corner braces.
3. One solution might have survived shaking better than the others.
4. Accept all answers in which students use the criteria and constraints to support their conclusion.
5. Engineers use shakers to better understand how to build structures that can withstand the effects of earthquakes.

Engineering Design Showcase (AP 6.7) (page 149)

1–2. Student answers will vary. Accept any well-written explanations of their biggest challenge and the part they liked best.

3. Engineers help each other when they work in teams because they can provide ideas, feedback, and solutions to each other to solve their problems.

Lesson 7 Check (AP 7.1) (page 151)

1. displacement of a large volume of water
2. Student drawings should show one of the following: uplift of seafloor, landslide in or into water, underwater volcanic eruption, explosion of volcanic island.
3. Earthquakes and tsunamis are caused by movements of Earth's crustal plates. If an earthquake occurs, it could be a sign that a tsunami is developing.
4. Not all earthquakes occur under or near the ocean. Some earthquakes occur without displacement of water.
5. Examples: They can study the history of tsunamis in a location and avoid building homes in areas that are likely to be flooded during a tsunami. They can receive warnings about tsunamis from a network of tsunameters.
6. If mangrove forests and other wetlands are left in place they can act as a buffer between tsunami waves and coastal land. They can also prevent erosion related to the tsunami's waves or the receding water after the tsunami.

Lesson 8 Check (AP 8.1) (pages 152–153)

1. around the Pacific plate
2. gases, ash
3. Sample answers: lava, gases, ash
4. Answers will vary based on where students live.
5. Answers will vary based on where students live. Seismometers, seismographs, and tiltmeters may help.
6. Follow directions from government officials. Evacuate to a safe area.

State-by-State Volcano Data (AP 9.2) (pages 155–156)

Student tables will vary based on current USGS volcano data, but the following states will have volcanoes: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Volcanoes Infographic (AP 9.3) (page 157)

- 5 or more volcanoes: 5 states: Alaska, California, Hawaii, Oregon, Washington
- 1–4 volcanoes: 7 states: Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, Wyoming
- No volcanoes: 38 states
- Ocean that states with the most volcanoes border: the Pacific Ocean
- This could mean that volcanoes mainly form where oceans and continents meet.

Lesson 10 Check (AP 10.1) (pages 159–160)

1. Answers will vary, but students may say that they could build a retaining wall between their yard and the sidewalk.
2. earthquake, flood, tsunami, hurricane, volcanic eruption
3. cutting into a hillside to build a roadway
4. Removal of plants from natural habitat or farmland can expose more soil to erosion.

- Quality answers will focus on little changes at first and then larger changes over more time. Students should be able to describe a specific agent of weathering as the cause of the change, and they should be able to identify the rock as losing material to cause the change in its appearance.

Erosion Investigation Notebook (AP 11.2) (pages 162–163)

1. to learn how the slope of the land affects sediment erosion
2. the relative amounts of sediments transported by the water

AP 11.2, continued

3. the steepness of the slope
4. the speed at which water enters the stream table, the kind and amounts of sediments, the amount of water that is poured onto the stream table
5. The greater the slope (angle) of the land, the more sand will be carried away by flowing water.
6. When the slope was low, few sediments were carried away. When the slope was medium, more sediments were carried away. When the slope was the steepest, the most sediments were carried away.
7. The rule is, the steeper the slope of the land, the more sediments it can carry downstream.

Testing Erosion Solutions (AP 11.3) (page 164)

1. Students should list possible solutions their team brainstorms.
2. Students should list the solution they feel is best. Students may list the reason for their decision.
3. Students should list any additional materials they will need.
4. Students should note that the purpose of the investigation is to develop a way to reduce erosion.
5. Students should list the additional step.

Lesson 12 Check (AP 12.1) (pages 165–166)

1. a form of mass movement in which a large section of a slope slides downhill all at once
2. a form of mass movement that occurs when water saturates the ground, causing it to turn into mud
3. Gravity is the force that pulls material downhill or to a lower point. Water can loosen material on a slope in several ways, including wedging things apart when water freezes, eroding material by moving, and saturating a slope with so much water that it gives way.
4. human activity, burrowing or herding animals, flowing water
5. Things on the slope are tilted over as though the sediment is flowing downhill. There are boulders or other forms of debris at the base of the slope, indicating that material is already falling.

AP 12.1, continued

6. The slope in the first image is more likely to have an erosion event such as a landslide. It is not terraced, and there is not much vegetation to hold its surface together. The slope in the second image is less likely to have an erosion event because it has retaining walls. These hold a certain amount of material in each part of the slope.
7. Possible answers: Stronger vegetation can be planted on slopes. Water can be drained better. Structures can be anchored to rock under the hillside.

Using Scientific Information (AP 13.3) (page 169)

Causes: the force of gravity along with earthquakes, erosion at the base of a hill, too much water, too little water, or construction activity by people such as building roads and removing vegetation from a hillside

Effects: Roadways can be blocked or damaged. Buildings can be buried or break. Tsunamis can occur. People can be injured.

Brainstorming, Making, and Evaluating Design Solutions (AP 13.6) (page 172)

1. Students should list any ideas.
2. Students should list testable solutions.
3. Students should list the distance the soil moved during the landslide.
4. Students should compare the solutions they tested.
5. Students should list the solution that best meets the criteria and constraints.

Writing Your Engineering Report (AP 13.7) (page 173)

Student reports should have an introduction and claim about the best solution to the landslide problem. Students should support their claim with evidence they gathered and reasons they believe their evidence supports their claim. Finally, students should have a conclusion that sums up their report.

How to Publish and Present Your Earth Hazards Information Sheet (AP UC.3) (pages 176–177)

- Students should identify the hazard they were assigned.
- Student should list roles and responsibilities for their presentation.
- Students should research and identify how frequently the hazard occurs in their area.
- Students should list the information to be presented.
- Students should list at least one solution to the problem. Accept emergency response plans where appropriate.

Earth Hazards Project Reflection (AP UC.4) (page 178)

Accept all reasonable student reflections to the project.

Appendix A

Glossary

Blue words and phrases are Core Vocabulary terms for the unit, and Student Reader page numbers are listed in parentheses. **Bold-faced words and phrases** are additional vocabulary terms related to the unit that you should model for students during instruction and that are often used within the Student Reader, and these latter terms do not have specific page numbers listed. Vocabulary words are not intended for use in isolated drill or memorization.

A

agent, n. a thing that has a role in producing an effect

analyze, v. to study carefully to determine the relationship among the parts of something

B

boundary, n. the edge or limit of something; in geology, the place where plates meet

C

cause and effect, n. a thing that brings about a result and its outcome

converging, v. moving together

core, n. the innermost part of Earth

creep, v. to move slowly, often escaping notice

criteria and constraints, n. required factors and limitations

crust, n. the outer part of Earth's surface

D

data, n. pieces of factual information

debris, n. the remains of something broken apart

design solution, n. an engineered remedy to a want or need

displace, v. to push out of position

diverging, v. moving apart

downstream, adj. in the direction to which liquid flows

E

earthquake, n. shaking of the ground caused by a seismic wave **(13)**

energy, n. the ability to cause change

erosion, n. movement of sediment from one location to another **(33)**

F

fossil, n. the remains of an organism preserved in rock form **(1)**

G

geologic, adj. related to the study of Earth's makeup and formation

geologist, n. a scientist who studies what Earth is made of and how it changes over time **(1)**

geology, n. the study of Earth's makeup and formation

H

hot spot, n. in geology, a plume of magma that causes eruptions through Earth's crust without plates interacting **(29)**

I

igneous rock, n. rock made of magma or lava that has cooled and hardened **(7)**

L

landslide, n. a form of mass movement in which a large section of a slope slides downhill all at once **(41)**

lava, n. molten material from Earth's mantle after it has reached Earth's surface **(27)**

M

magma, n. molten material from Earth's mantle below Earth's surface **(27)**

magnitude, n. the size or extent of an earthquake **(17)**

mantle, n. the part of Earth's interior that is between the crust and the core

map, n. a representation of an area and locations or objects within it

mass movement, n. downhill movement of a mass of earth surface material **(41)**

metamorphic rock, n. rock that forms when igneous or sedimentary rock is placed under tremendous heat or pressure **(7)**

molten, adj. liquefied by heat

N

natural hazard, n. an extreme event in nature that can cause harm to living organisms and structures

P

plate, n. in geology, a large fragment of Earth's crust and upper mantle **(3)**

S

scale, n. relative size, extent, or incremental measure

seamount, n. a mountain emerging from the ocean floor that does not emerge above the surface of the water

sediment, n. small pieces of rock or other hard material that has broken down over time **(33)**

sedimentary rock, n. rock made of sediment compacted together **(6)**

seismic, adj. related to vibration of Earth

sinkhole, n. a hole in Earth's surface that develops when the ground collapses into space beneath it **(37)**

survey, v. to determine land boundaries

T

tsunami, n. a wave or series of waves caused by displaced water **(19)**

U

upstream, adj. in the direction from which liquid flows

V

volcano, n. an opening in Earth's crust through which lava erupts onto the surface **(25)**

W

weathering, n. the process of breaking rock into smaller pieces **(36)**

Appendix B

Classroom Safety for Activities and Demonstrations

In the Core Knowledge Science program (CKSci), activities and demonstrations are a vital part of the curriculum and provide students with active engagement related to the lesson content. The activities and demonstrations in this unit have been selected and designed to engage students in a safe manner. The activities and demonstrations make use of materials and equipment that are typically deemed classroom safe and readily available.

Safety should be a priority when engaged in science activities. With that in mind, observe the following safety procedures when the class is engaged in activities and demonstrations:

- Report and treat any injuries immediately.
- Check equipment prior to usage, and make sure everything is clean and ready for use.
- Clean up spills or broken equipment immediately using the appropriate tools.
- Monitor student behavior to ensure they are following proper classroom and activity procedures.
- Do not touch your eyes, ears, face, or mouth while engaging in an activity or demonstration.
- Review each step of the lesson to determine if there are any safety measures or materials necessary in advance.
- Wear personal protective equipment (e.g., safety goggles, aprons, etc.) as appropriate.
- Check for allergies to latex and other materials that students may have, and take appropriate measures.
- Secure loose clothing, hair, or jewelry.
- Establish storage and disposal procedures for chemicals as per their Safety Data Sheet (SDS), including household substances, such as vinegar and baking soda.

Copy and distribute the Student Safety Contract, found on the next page, for students to read and agree to prior to the start of the first unit so students are aware of the expectations when engaged in science activities.

Online Resources

For additional support for safety in the science classroom, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Student Safety Contract

When doing science activities, I will do the following:

- Report spills, breakages, or injuries to the teacher right away.
- Listen to the teacher for special instructions and safety directions. If I have questions, I will ask the teacher.
- Avoid eating or drinking anything during the activity unless told to by my teacher.
- Review the steps of the activity before I begin. If I have questions, I will ask the teacher.
- Wear safety goggles when working with liquids or things that can fly into my eyes.
- Be careful around electric appliances, and unplug them, just by pulling on the plug, when a teacher is supervising.
- Keep my hands dry when using tools and devices that use electricity.
- Be careful to use safety equipment like gloves or tongs when handling materials that may be hot.
- Know when a hot plate is on or off and let it cool before touching it.
- Roll or push up long sleeves, keep my hair tied back, and secure any jewelry I am wearing.
- Return unused materials to the teacher.
- Clean up my area after the activity and wash my hands.
- Treat all living things and the environment with respect.

I have read and agree to the safety rules in this contract.

____ ________/________/________/

Student signature and date

____

Print name

Dear Parent or Guardian,

During science class, we want to create and maintain a safe classroom. With this in mind, we are making sure students are aware of the expectations for their behavior while engaged in science activities. We are asking you to review the safety rules with your daughter or son and sign this contract. If you have any questions, please feel free to contact me.

____ ________/________/________/

Parent or guardian signature and date

Strategies for Acquiring Materials

The materials used in the Core Knowledge Science program (CKSci) are readily available and can be acquired through both retail and online stores. Some of the materials will be reusable and are meant to be used repeatedly. This includes equipment such as scales, beakers, and safety goggles, but also items such as plastic cups that can be safely used again. Often these materials can be cleaned and will last for more than one activity, or even one school year. Other materials are classified as consumable and are not able to be used more than once, such as glue, baking soda, and aluminum foil.

Online Resources

The Material Supply List for this unit's activities can be found online. Follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Ways to Engage with Your Community

The total cost of materials can add up for an entire unit, even when the materials required for activities and demonstrations have been selected to be individually affordable. And the time needed to acquire the materials adds up too. Reaching out to your community to help support STEM education is a great way to engage parents, guardians, and others with the teaching of science, as well as to reduce the cost and time of collecting the materials. With that in mind, the materials list can be distributed or used as a reference for the materials teachers will need to acquire to teach the unit.

Consider some of the following as methods for acquiring the science materials:

- School Supply Drive—If your school has a supply drive at any point in the year, consider distributing materials lists as wish lists for the science department.
- Open Houses—Have materials lists available during open houses. Consider having teams of volunteers perform an activity to show attendees how the materials will be used throughout the year.
- Parent Teacher Organizations—Reach out to the local PTO for assistance with acquiring materials.
- Science Fair Drive—Consider adding a table to your science fair as part of a science materials drive for future units.
- College or University Service Project—Ask service organizations affiliated with your local higher education institutions to sponsor your program by providing materials.
- Local Businesses—Some businesses have discounts for teachers to purchase school supplies. Others may want to advertise as sponsors for your school/programs. Usually you will be asked for verifiable proof that you are a teacher and/or examples of how their sponsorship will benefit students.

Remember: if your school is public it will be tax exempt, so make sure to have a Tax Identification Number (TIN) when purchasing materials. If your school is private, you may need proof of 501(c)(3) status to gain tax exemption. Check with your school for any required documentation.

Advance Preparation for Activities and Demonstrations

Being properly prepared for classroom activities and demonstrations is the first step to having a successful and enriching science program. Advance preparation is critical to effectively support student learning and understanding of the content in a lesson.

Before doing demonstrations and activities with the class

- Familiarize yourself with the activity by performing the activity yourself or with a team, and identify any issues or talking points that could be brought up.
- Gather the necessary materials for class usage. Consider if students will gather their materials at stations or if you will preassemble the materials to be distributed to the students and/or groups.
- Identify safety issues that could occur during an activity or demonstration, and plan and prepare how to address them.
- Review the Teacher's Guide before teaching, and identify opportunities for instructional support during activities and demonstrations. Consider other Support and/or Challenge opportunities that may arise as you work to keep students engaged with the content.
- Prepare a plan for postactivity collection and disposal of materials/equipment.

While engaged in the activity or demonstration

- Address any emergencies immediately.
- Check that students are observing proper science safety practices as well as wearing any necessary safety gear, such as goggles, aprons, or gloves.
- When possible, circulate around the room, and provide support for the activity. Return to the Teacher Guide as students work, to utilize any Support and Challenge opportunities that will make the learning experience most meaningful for your students.

After the activity or demonstration

- Use your plan for students to set aside or dispose of their materials as necessary.
- Have students wash their hands after any activity in which they could come in contact with any potentially harmful substances.

When engaging students in activities and demonstrations, model good science practices, such as wearing proper safety equipment, never eating during an investigation, etc. Good science practices at a young age will lead to students observing good science practices themselves and being better prepared as they move into upper-level science classes.

What to Do When Activities Don't Give Expected Results

Science activities and experiments do not always go according to plan. Microwave ovens, super glue, and X-rays are just some of the discoveries made when people were practicing science and something did NOT go according to plan. In your classroom, however, you should be prepared for what to do when activities don't give the expected results or when an activity doesn't work.

When going over an activity with an unexpected result, consider these points in discussion with your students:

- Was there an error in following the steps in order? You or the student may have skipped a step. To help control for this, have students review the steps to an investigation in advance and make a check mark next to each step as they complete it.
- Did students design their own investigation? Perhaps their steps are out of sequence, or they missed a step when performing the activity. Review and provide feedback on students' investigation plans to ensure the work is done in proper sequence and that it supports the lesson's Big Question.
- When measurements were taken, were they done correctly? It is possible a number was written down incorrectly, a measurement was made in error, such as a wrong unit of measure or quantity, or the starting or ending point of a measurement was not accurate.
- Did the equipment or materials contribute to the situation? For example, chemicals that have lost their potency or a scale that is not measuring accurately can contribute to the success or failure of an activity.

One of the greatest gifts a student can learn when engaged in science is to develop a curiosity for *why something happened*. Students may find it challenging or frustrating to work through a problem during an activity, but guiding them through the problem and figuring out *why* something happened will help them to develop a better sense of how to do science.

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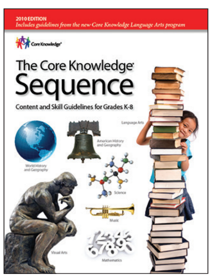
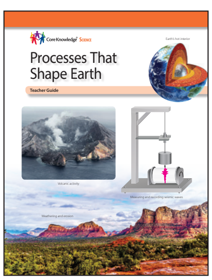


What is the Core Knowledge Sequence?

The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including earth and space, physical, and the life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.



For which grade levels is this book intended?

In general, the content and presentation are appropriate for readers from the middle to upper elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Grade 4 and is part of a series of **Core Knowledge SCIENCE** units of study.

For a complete listing of resources in the **Core Knowledge SCIENCE** series, visit **www.coreknowledge.org**.

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