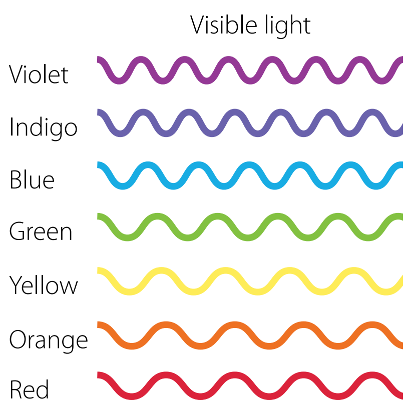
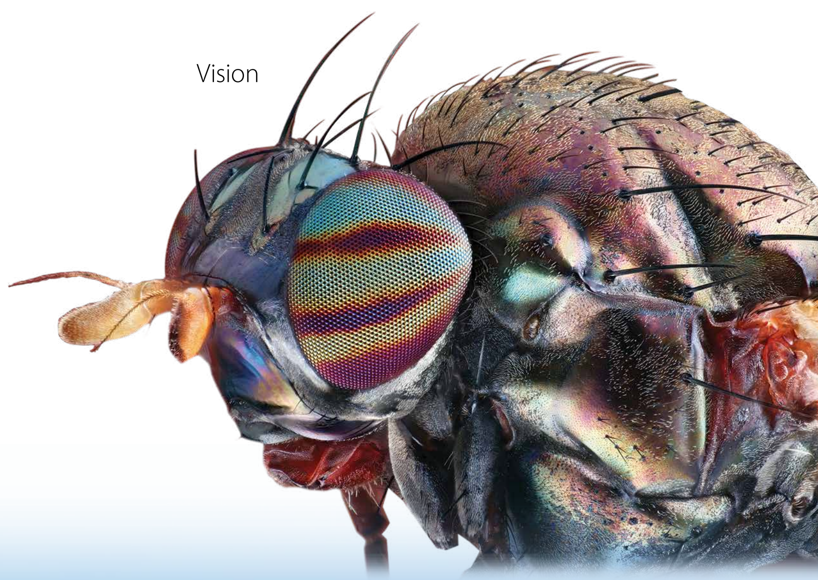
Core Knowledge® SCIENCE

Investigating Waves

Patterns and communication

Teacher Guide



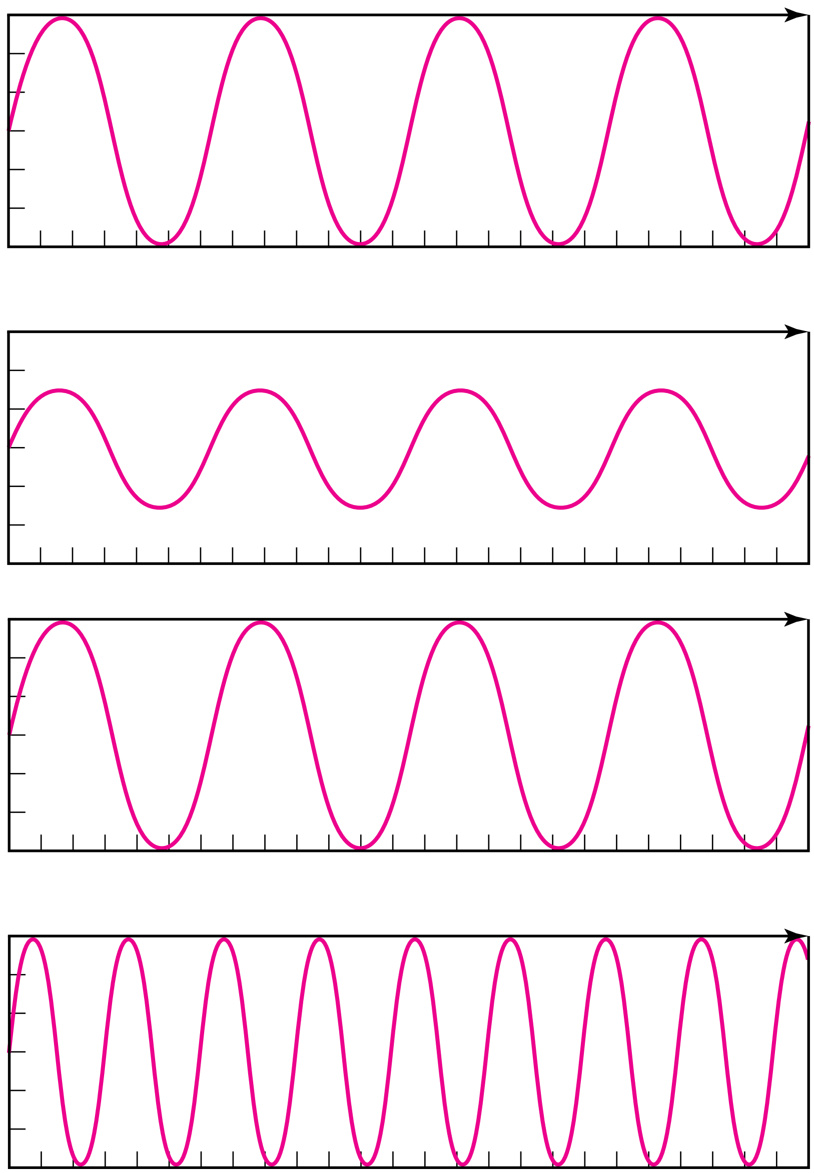


Vision

Water waves

Investigating Waves

Teacher Guide



Core Knowledge®

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Investigating Waves

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Teacher Guide

Core Knowledge Science™ 4

UNIT 2

Introduction

About this Unit

The Big Idea

This unit focuses on the transfer of energy as waves and how patterns of waves can be useful.

Students can investigate waves all around them. A light wave travels from the sun and strikes a solar panel on Earth. The energy of that wave is transformed to the energy of electricity. An intense sound wave travels across a room and breaks a glass. A seismic wave produced by an earthquake travels underground for miles and destroys a house. All waves transfer energy from one place to another and cause a change. We can describe and measure all of these types of waves in terms of frequency, amplitude, and wavelength.

In this unit, students will begin to investigate structures of living things that allow for the detection of waves. For example, eyes are adapted to capturing incoming light waves, and ears are adapted to capturing incoming sound waves.

Engineers use knowledge of waves as they develop solutions to problems and build things that are useful to people. This unit incorporates learning goals that support the principles and practices of engineering design (such as defining problems and evaluating and optimizing possible solutions).

Note to Teachers and Curriculum Planners

This unit introduces Grade 4 students to real-world examples and fundamental concepts of waves, which will be explored in greater depth in later grades. Students will learn about mechanical and electromagnetic waves within the context of how those waves transfer energy from one place to another, through matter or space. The following are preliminary considerations for planning and instruction relative to this unit:

- This unit extends learning from the CKSci Grade 4 Unit 1 *Energy Transfer and Transformation* by providing in-depth examples of light and sound waves as examples of energy transfer.
- In the next unit, Grade 4 Unit 3 *Structures and Functions of Living Things*, students study how human ears and eyes work, with an emphasis on the relation between specific structures and functions related to hearing and seeing.

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**
Light & Sound (Grade 3) • Light travels in straight lines (as can be demonstrated by forming shadows). • The spectrum: use a prism to demonstrate that white light is made up of a spectrum of colors. • Sound is caused by an object vibrating rapidly. • Qualities of sound: pitch and intensity **The Human Body (Grade 3)** • Vision: How the eye works • Hearing: How the ear works	**Waves Transfer Energy** • Waves transfer energy from one place to another. For example: Light and Sound • Waves are characterized by amplitude, frequency, and wavelength. **Light and Sound Waves Transfer Energy** • Animals have specialized structures for detecting light and sound waves. *(Additional learning objectives about the eyes and ears of humans are found in Grade 4 Unit 3.)*
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**	

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

Online Resources

This unit addresses the following Grade 4 Performance Expectations for the NGSS topic *Investigating Waves*.

Students who demonstrate understanding can

4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.

4-PS4-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

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:

PS4.A: Wave Properties

Grades K–2 Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave—observe, for example, a bobbing cork or seabird—except when the water meets the beach. Sound can make matter vibrate, and vibrating matter can make sound.

PS4.B: Electromagnetic Radiation

Grades K–2 Objects can be seen only when light is available to illuminate them. Very hot objects give off light (e.g., a fire, the sun). Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them (i.e., on the other side from the light source), where the light cannot reach. Mirrors and prisms can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)

PS4.C: Information Technologies and Instrumentation

Grades K–2 People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch. People also use a variety of devices to communicate (send and receive information) over long distances.

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. Waves Transfer Energy — Lessons 1–3

- Waves transfer energy from one place to another.
- A wave has energy and can cause a change.
- Waves are characterized by amplitude, frequency, and wavelength.

B. Sound Waves Transfer Energy — Lessons 4–7

- Sound waves transfer energy from one place to another and can causes changes.
- Sound waves are produced when objects vibrate.
- Sound waves can travel through solids, liquids, and gases.
- Properties of sound waves: pitch and intensity
- Animals have specialized structures for detecting sound waves (for example, the ears of bats, lateral line in fish).

C. Light Waves Transfer Energy — Lessons 8–11

- Light waves transfer energy from one place to another and can cause changes.
- Sources of light, including the sun and electrical devices (such as light bulbs)
- Light waves can travel through empty space and through some solids, liquids, and gases.
- Light waves are characterized by amplitude, frequency, and wavelength.
- Animals have specialized structures for detecting light (for example, the eyes of a hawk).

D. People Use Waves to Transfer Information — Lessons 12–14

- Patterns of sound waves can transfer information (for example, Morse code and drum signals).
- Patterns of light waves can transfer information (for example, smoke signals and ship-to-ship signals of light).
- Sound and light waves can be converted to digital signals for information transfer (for example: cell phones).

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 *Investigating Waves* Student Reader has six 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.

Pacing

The *Investigating Waves* 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 14 and a blank Pacing Guide on pages 15–16, 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 days teaching the *Investigating Waves* 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. Waves Transfer Energy (4-PS4-1)	**1.** Investigating Water Waves	How do waves move through water?
	2. Describing Water Waves	How does the energy of water waves cause a change?
	3. Modeling Water Wave Features (two class sessions)	What are the characteristics of water waves?
B. Sound Waves Transfer Energy (4-PS4-1)	**4.** Exploring Sound	What is sound?
	5. Sound and Matter	How do sound and matter interact?
	6. Sound, Energy, and Change	What is the relationship among vibration, sound, and energy?
	7. Investigating Sound	What are the characteristics of sound waves?
C. Light Waves Transfer Energy (4-PS4-2)	**8.** Light	What is light?
	9. Light Waves	How does light behave?
	10. Investigating Light and Change (two class sessions)	How does light cause change?
	11. Invisible Energy	What are some different kinds of light waves?
D. People Use Waves to Transfer Information (4-PS4-3)	**12.** Codes and Signals	What is a code?
	13. Investigating Transfer of Information (three class sessions)	How can signals transfer information?
	14. Using Signals	How are waves used to send signals?
Unit Review and Assessment	Unit Review	What have I learned about waves?
	Unit Assessment	What have I learned about waves?

Activity Pages and Unit Assessment

Activity Pages

AP 1.1
AP 2.1
AP 3.1
AP 3.2
AP 4.1
AP 4.2
AP 5.1
AP 6.1
AP 6.2
AP 7.1
AP 7.2
AP 7.3
AP 8.1
AP 9.1
AP 10.1
AP 10.2
AP 11.1
AP 12.1
AP 13.1
AP 14.1
AP UR.1
AP UR.2

Black line reproducible masters for Activity Pages and a Unit Assessment, as well as an Answer Key, are included in Teacher Resources on pages 114–161. 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. However, a combined Unit Assessment is provided as a summative close to the unit.

Lesson 1—Making and Using a Wave Tank (AP 1.1)

Lesson 2—Wave Model (AP 2.1)

Lesson 3—Modeling a Water Wave (AP 3.1)

Lesson 3—Testing a Wave Model (AP 3.2)

Lesson 4—Making a Shoebox Guitar (AP 4.1)

Lesson 4—Investigating Sound Waves with a Shoebox Guitar (AP 4.2)

Lesson 5—Sound Observations (AP 5.1)

Lesson 6—What Does It Sound Like? (AP 6.1)

Lesson 6—Lesson 6 Check (AP 6.2)

Lesson 7—Sound Words (AP 7.1)

Lesson 7—Modeling Sound Waves (AP 7.2)

Lesson 7—Testing Sound Waves (AP 7.3)

Lesson 8—Find the Light (AP 8.1)

Lesson 9—Light Behaviors (AP 9.1)

Lesson 10—Build a Solar Oven (Day 1) (AP 10.1)

Lesson 10—Test Your Solar Oven (Day 2) (AP 10.2)

Lesson 11—Invisible Energy (AP 11.1)

Lesson 12—Decoding (AP 12.1)

Lesson 13—Sending Coded Messages (AP 13.1)

Lesson 14—Develop Models of Signals (AP 14.1)

Unit Review—Race the Board (AP UR.1)

Unit Review—Vocabulary Crossword Puzzle (AP UR.2)

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 162–163.

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 Assessment at the end of the unit (see pages 148–155) 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

Online Resources

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 164–168, 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

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: Waves Transfer Energy

Lesson 1

- ropes or cords, 2 feet in length (1 rope per 2 students)
- small desk fan
- clear plastic bins (ideally 5–7 inches deep; 1 per group of students; 1 for teacher demonstration)
- colored ribbon (1 per team)
- water (enough to fill each bin with 2–3 inches of water)
- corks or other floating objects (1 per group)
- rulers (1 per group)
- black markers (1 per group)
- small cardboard or plastic panels (1 per student)
- paper towels/cloths
- internet access and the means to project images/video for whole-class viewing

Lesson 2

- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (5 per student)

Lesson 3

- poster board (assorted colors)
- construction paper (assorted colors)
- markers
- scissors
- glue bottles/glue sticks
- shoeboxes (or small box/container; 1 per student)
- colored pencils (or crayons)
- yarn
- spring toy
- stopwatch (1 per group)
- measuring tapes or rulers (2 per group)
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

Part B: Sound Waves Transfer Energy

Lesson 4

- shoebox with lid (1 per student; 1 for teacher demonstration)
- rubber bands (4–6 per student/box)
- unsharpened pencil (1 per student)
- scissors (1 per student)
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (4 per student)

Lesson 5

- pairs of different-sized water bottles, 0.5 liter and 2 liter, for example (1 for each pair of students)
- block of wood (1 for each pair of students)
- cell phone tone or music box
- books
- string phone made with paper cups and 20 feet of string
- shoebox guitars from previous lesson
- internet access and the means to project images/video for whole-class viewing

Lesson 6

- medium-size container
- water
- cup or pitcher
- musical chimes or bell
- rattle or musical shaker
- textbook
- variety of recorded sounds and an electronic device for playback
- portable fan or hair dryer
- internet access and the means to project images/video for whole-class viewing
- index card for student vocabulary deck (1 per student)

Lesson 7

- shoebox guitars (from Lesson 4)

Part C: Light Waves Transfer Energy

Lesson 8

- lamp with light bulb
- candle (for teacher demonstration only)
- matches/candle lighter
- glow sticks
- prism
- flashlight
- glow-in-the-dark stickers
- white poster board sheets (2)
- piece of clear glass
- wooden block
- index cards for student vocabulary deck (5 per student)

Lesson 9

- tracing paper
- flashlight
- clear glass
- water
- straw
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

Lesson 10

- 3 clear balloons
- black balloon
- magnifying glass
- scissors
- glue bottles/glue sticks
- pizza box (or similar small box)
- aluminum foil
- black construction paper
- ruler
- transparent plastic wrap
- pencils
- crayons (with paper removed)
- small amount of butter
- rock
- (optional) other objects that will change in a solar oven
- internet access and the means to project images/video for whole-class viewing

Lesson 11

- microwave
- food item or liquid in a cup
- internet access and the means to project images/video for whole-class viewing

Part D: People Use Waves to Transfer Information

Lesson 12

- flashlight
- smoke alarm
- index cards for student vocabulary deck (4 per student)

Lesson 13

- penlights
- flashlights
- hand mirrors
- colored fabric
- colored paper
- colored films
- plain paper
- grid paper
- string
- cardboard tubes
- pencils
- scissors
- tape
- rubber bands
- paper clips

Lesson 14

- coded message
- code key
- index cards for student vocabulary deck (4 per student)

Unit Review

- front board
- front board markers (or chalk)
- question and answer cards/sheets
- timer (or phone)

Sample Pacing Guide

The sample Pacing Guide suggests use of the unit's resources across a twenty-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 15–16 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
Investigating Water Waves TG Lesson 1 AP 1.1	*Describing Water Waves* TG Lesson 2 SR Chapter 1 AP 2.1	*Modeling Water Wave Features* DAY 1 TG Lesson 3 AP 3.1	*Modeling Water Wave Features* DAY 2 TG Lesson 3 AP 3.2	*Exploring Sound* TG Lesson 4 AP 4.1, 4.2

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
Sound and Matter TG Lesson 5 AP 5.1	*Sound, Energy, and Change* TG Lesson 6 SR Chapter 2 AP 6.1, 6.2	*Investigating Sound* TG Lesson 7 AP 7.1, 7.2, 7.3	*Light* TG Lesson 8 AP 8.1	*Light Waves* TG Lesson 9 SR Chapter 3 AP 9.1

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
Investigating Light and Change DAY 1 TG Lesson 10 AP 10.1	*Investigating Light and Change* DAY 2 TG Lesson 10 AP 10.2	*Invisible Energy* TG Lesson 11 SR Chapter 4 AP 11.1	*Codes and Signals* TG Lesson 12 SR Chapter 5 AP 12.1	*Investigating Transfer of Information* DAY 1 TG Lesson 13 AP 13.1

Week 4

Day 16	Day 17	Day 18	Day 19	Day 20
Investigating Transfer of Information DAY 2 TG Lesson 13 AP 13.1	*Investigating Transfer of Information* DAY 3 TG Lesson 13 AP 13.1	*Using Signals* TG Lesson 14 SR Chapter 6 AP 14.1	Unit Review TG Unit Review AP UR.1, UR.2	Unit Assessment AP Unit Assessment

Pacing Guide

Twenty days have been allocated to the *Investigating Waves* unit to complete all Grade 4 science units in the *Core Knowledge Curriculum Series*™. If you cannot complete the unit in twenty 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

Waves Transfer Energy

Overview

Lesson	Big Question	Advance Preparation
1. Investigating Water Waves	How do waves move through water?	Gather materials for teacher demonstration and student hands-on activity. (See Materials and Equipment, page 12.)
2. Describing Water Waves	How does the energy of water waves cause a change?	Read Student Reader, Chapter 1.
3. Modeling Water Wave Features (2 days)	What are the characteristics of water waves?	Gather materials for hands-on investigation. (See Materials and Equipment, page 12.)

Part A: What's the Story?

Waves transfer energy, and in doing so, they cause change. The change occurs distant from the origin of the wave. This section allows students to learn about the different ways that waves cause a change, including causing an object to move.

In Lesson 1, students investigate water waves and the changes they can cause. The goal is for students to describe how waves move through water by studying the origin of the wave, the wave itself, and the change that it causes at a distance as a result of energy. By doing this, they can see that waves transfer energy from one place to another.

In Lesson 2, students reinforce their understanding as they read about how water waves cause change. Students begin to learn how waves are characterized and described in scientific terms (e.g., amplitude, frequency, and wavelength).

In Lesson 3, students conduct a two-day investigation in which they build a model and describe the characteristics of water waves. They will explore how waves vary and explain that waves have amplitude, frequency, and wavelength.

So, to repeat, **waves transfer energy, causing observable changes**. Help your students grasp this concept, and you will lay the groundwork for meeting the NGSS expectations addressed across this unit.

LESSON 1

Investigating Water Waves

Big Question: How do waves move through water?

At a Glance

Learning Objectives

✓ Describe, through examples, that waves can cause a change, including causing an object to move.

✓ Discuss the cause-and-effect relationship between the motion of a wave and the motion of an object affected by the wave.

Lesson Activities

- hands-on activity, discussion
- vocabulary instruction
- teacher demonstration

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concepts: Patterns, Cause and Effect

Patterns and **cause-and-effect** relationships are important to this lesson as students investigate concrete examples of both concepts: the transfer of energy in patterns known as waves. Students begin this lesson by observing examples of waves caused by energy, which they then explore further by creating more waves and discussing the relationships of the changes that are observed.

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 162–163 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.

crest	**wave**	**wavelength**
trough	wave speed	

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards, which 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 on the previous page. (**Note:** Lesson 1 is introductory in nature. These terms and others will be taught within additional context, and added to the deck, in subsequent lessons.)

Instructional Resources

Activity Page

AP 1.1

Activity Page
Making and Using a Wave Tank (AP 1.1)

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

Materials and Equipment

Collect or prepare the following items:

- ropes or cords, 2 feet in length (1 rope per 2 students)
- small desk fan
- clear plastic bins (ideally 5–7 inches deep; 1 per group of 3–4 students and 1 for teacher demonstration)
- colored ribbon (1 per 2 students)
- water (enough to fill each bin with 2–3 inches of water)
- corks or other floating objects (1 per group)
- rulers (1 per group)
- black markers (1 per group)
- small cardboard or plastic panels (1 per student)
- paper towels/cloths
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Prepare the hands-on activity materials in advance so you can begin the demonstration as soon as class starts. Cut pieces of rope or cord into lengths of about two feet each. Have one piece for every two students.

Prepare the demonstration in advance so you can begin the activity once class starts. Before class begins, have one shoebox-sized plastic bin filled with about two to three inches of water. This should be stationed on a desk or table in full view of the entire class. Near the bin of water, place the small desk fan, and have it pointing toward the water.

THE CORE LESSON 45 MIN

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

How do waves move through water? Open the lesson with a hands-on demonstration/activity of how energy passes through objects, which will show that waves transfer energy. (See **Know the Standard** for suppport.)

- Separate students into pairs, and station them in an open area. Ask them to sit a little over two feet apart, facing each other. Provide each pair with a piece of rope or cord about two feet in length.
- Have each student grasp his or her end of the rope or cord. The rope should be either flat against the floor or held level a short distance above the floor.
- Ask one student to move the rope quickly from side to side while the other student holds his or her end of the rope firmly in place. Have students switch roles and perform the action again.
- Direct students to think about and describe how the rope moved. Then, point out that what they saw with the rope can also happen with water.
- Tie a ribbon at any point along the rope, and repeat the movement of the rope.
- Ask students to discuss if the ribbon moved down the rope or stayed in the same place.

2. Encourage student questions. 10 MIN

Ask students to imagine they are on a ship, boat, or raft in water. Lead a discussion about how waves in the water affected their movement.

» Did they move up and down with the waves? (*Yes, the waves make the boat move up and down.*)

» Did they move from one location to another on the waves? (*It did not seem like the boat moved to a different location.*)

Online Resources

See the Online Resources to access an animation of the up-and-down movement of objects floating on waves. Affirm correct examples of wave movement in water. (*Surface waves carry floating objects up or down but do not move them from one location to another.*)

Know the Standard

Waves and Their Application in Technologies for Information Transfer This series of lessons deals with properties, features, and models of waves. The key point of learning about waves is to understand that waves transfer energy. Water waves, sound waves, light waves, and other types of waves move energy from place to place, but they do not move objects from place to place. This critical understanding is what has enabled modern technologies including both conventional and cellular telephones, microwave ovens, radios, laser discs, and fiber optics.

- Ask students how their experience of the ribbon on the rope applies to this.
- Have students discuss how water waves are similar to and different from the waves they saw in the rope demonstration.
- Reinforce that in this lesson, students will explore waves on the surface of the water. Other kinds of waves will be addressed in later lessons.

SUPPORT—Emphasize that although energy moves from place to place in the form of waves, objects along the path stay in the same place. (See **Know the Science 1** for support.) Have students repeat the rope activity with ribbons and observe that the rope moves up and down but otherwise stays in the same place. Lead students to the conclusion that it is energy that is transferring in waves, not objects.

Also see the Online Resources to access video of a wave machine demonstration. If time permits, consider showing the video to reinforce the movement of energy in waves.

Online Resources

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to the recommended resources may be found:

www.coreknowledge.org/cksci-online-resources

Preview Core Vocabulary Terms

Display the following Core Vocabulary words on the board or chart paper.

crest **trough** **wave** **wavelength**

Let students know they will make Core Vocabulary cards for these terms during the next lesson, but introduce the terms here so students have access to the language they need to discuss what they observe about waves in the demonstration.

Help students understand that waves have repeating patterns and that each part has a specific name. For example, the *crest* is the highest part of the wave, while the *trough* is the lowest part of the wave. A *wavelength* is the distance between the crests of two waves. The speed of a wave is the time it takes two subsequent crests to pass the same point. Use these terms during your discussion, but make energy transfer the focus. Students will learn more about the parts of a wave in the next lesson.

Know the Science

1. Do waves move objects or just energy? ***Energy.*** Although it appears that surface waves in the ocean are moving toward a shore, the water volume through which a wave transfers is actually moving up and down. Tides and currents change the location of volumes of water, but surface waves do not. Just like generating waves with a rope, the rope does not move from place to place, just the energy. Waves that crash toward a beach do so because their crest reaches a height that causes them to tumble against the sloping shore.

3. Demonstrate examples and guide discussion. **5 MIN**

- Demonstrate for students how waves form in water. Point students to the prepared plastic bin and the fan nearby. Be sure that the desk fan is facing the water, and then turn it on to the lowest setting.
- Have students observe and describe what they see. Be sure to discuss with students the cause-and-effect relationships that can be identified in this example. Next, turn the fan to the highest setting.
- Ask students to explain what is different about how the water reacts to the air blown by the fan. Help students understand that when the air contacts the water, it causes a change to the water. This change provides evidence that the wind transfers energy to the water, causing it to move.
- Remind students of the rope/cord activity, and have them explain where the energy came from that caused the waves in the rope/cord. (*It transferred from the motion of their hands to patterns of movement in the rope.*) (See **Know the Science 2** and **Know the Standard** for support.)

4. Preview the investigation. **10 MIN**

Activity Page

AP 1.1

Separate students into small groups of three or four students each. Provide each group with a clear plastic bin and each student with one cardboard or plastic panel. Each group should also have one black marker and one ruler. Pass out Making and Using a Wave Tank (AP 1.1), and instruct students to complete the activity using the materials that have been provided. On the side of each plastic bin, students should use the marker to draw a five-by-seven grid, which will help them record their observations and discuss their learning about waves. Prepare these beforehand, if time is short.

Know the Science

2. What causes waves in water to form? *Energy.* There are different ways to create waves in water, such as dropping an object into water or pushing an object through the water, but all waves involve energy transfer. Many water waves form when moving air, wind, transfers energy into the water. The stronger the wind, the more energy it has to transfer, and the larger the waves. But wind is not the only way to transfer energy to water to make waves. Undersea earthquakes can transfer so much energy that tsunamis, very large waves of water, form. When tsunamis crash into shorelines, the water can move ashore, causing great damage. Volcanoes and landslides can also cause waves and sometimes tsunamis. In each, movement of the ground can cause objects such as land or mud to enter the water, transferring energy. To demonstrate how objects can transfer energy into water, have students drop small objects into a bin of water from a few inches above. Note how ripples form, moving away from the object in all directions through the water. These ripples are waves of energy that have transferred the object's energy of motion to cause the water to move as a result.

When ready to start the investigation, groups should fill the bins with water up to two or three inches deep. Have the groups move to an area with a hard, flat surface, where any spills can be easily cleaned up. Have paper towels or dry cloths ready to clean up any accidental spills.

5. Support the investigation. **10 MIN**

Activity Page

AP 1.1

Pass out the remaining materials to each group. Instruct students to complete the activity using the materials they have been provided. Allow them to determine how they are going to make the waves, with the criteria that they cannot touch the object in the water, so they can observe its movement. To reinforce quantitative thinking and measurement, you may want students to use the wave tanks as graphs using different-colored markers to draw the different wave strengths.

Discuss with students the concepts of Patterns and Cause and Effect as they relate to waves.

- When energy is transferred to water, it passes through the surface of the water in patterns called waves.
- The energy itself moves from one place to another as a wave, but objects floating at the surface remain mostly stationary. That is, the object bobs in place but should not move from one side of the water tank to the other.

> **SUPPORT**—Emphasize again that, although energy moves from place to place in the form of waves, objects along the path bob up and down but stay in the same place.

6. Check for understanding. **5 MIN**

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 1.1) for correct answers and sample student responses.

- As a class, review Making and Using a Wave Tank (AP 1.1), and compare different groups' results.
- Have students explain how waves show patterns in the way they form. Check for understanding of these concepts:
    - Waves transfer energy from one place to another.
    - Energy transfers in waves, but objects remain stationary.
    - Waves themselves show patterns in the way they form. They have specific parts and characteristics known as crests, troughs, amplitudes (wave heights), and wavelengths.
- Prompt students to ask new questions that have arisen. Discuss and answer questions as a class. Correct any misconceptions as needed.

LESSON 2

Describing Water Waves

Big Question: How does the energy of water waves cause a change?

At a Glance

Learning Objective

✓ Describe how water waves are formed and how a wave transfers energy.

Lesson Activities

- reading
- observation
- discussion and writing

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Cause and Effect

Science and Engineering Practices: Developing and Using Models

Developing and Using Models is important to this lesson because waves are often represented by models. In this lesson, students read about waves and observe wave models and then develop their own simple drawing of waves based on what they have learned. This helps prepare students to build a physical model of a wave in Lesson 3.

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

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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 162–163 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.

crest	**wave**	wave speed
trough	**wave height**	**wavelength**

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 on the previous page.

Instructional Resources

Student Reader

Ch. 1

Student Reader, Chapter 1
"Describing Water Waves"

Activity Page

AP 2.1

Activity Page
Wave Model (AP 2.1)

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 (5 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

Online Resources

How does the energy of water waves cause a change? To build on what students learned in Lesson 1, open this lesson with a brief video that shows water waves and gives a quick explanation for how and why they occur. This will act both as a refresher for students' prior knowledge and to pique their interest in what they will learn in the Student Reader. The first five minutes of the video give a good overview of waves, wind, and wave motion.

Ask what students can observe in the video. Then use the following questions to prompt discussion:

» What waves did you see in the video? (*water waves*)

» How was energy transferred to the waves? (*by wind and gravitational forces*)

» How can we model waves?

SUPPORT—Explain to students that in this lesson, they will not focus on what causes the waves. Instead, they will focus on how energy moves through water and how waves are structured, though causes of water waves will be touched on. Have students act out the motion of a ball in the ocean, moving in a circular motion.

Have students keep the video in mind as they go through the remainder of the lesson. They will be asked to compare what they have learned in the video to what they will learn from their Student Reader.

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

2. Read and discuss: "Describing Water Waves." 20 MIN

Student Reader

Ch. 1

Read together, or have students read independently, "Describing Water Waves," Chapter 1 in the Student Reader. The selection reinforces the idea that all waves are patterns of energy transfer, including patterns of motion in water, and that all waves, regardless of their cause, have a specific structure.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read.

crest **wave** **wavelength**

trough **wave height**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 1

After students have read the page, ask them if they have ever thrown a pebble or rock into a body of water such as a puddle or stream. This creates a smaller disturbance than jumping in a puddle. Ask the following:

» What happened around the pebble when it went into the water? (*Ripples, or waves, formed.*)

Online Resources

- Show a slow-motion video of a rock or a drop of water causing wave motion.

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

- What do the ripples, or waves, tell us about energy? (*Energy causes the water to change, and energy is transferred from the moving pebble or rock to cause the water to start moving in a pattern.*)

  SUPPORT—To help students explore the concepts of Patterns and Cause and Effect in this example, prompt them to describe any patterns seen in the waves created.

  » Which direction do the waves move? (*The waves move in circles, away from the rock.*)

  » Do you think this direction ever changes if you change how the rock is dropped or by dropping something else? (*If you skip a rock across the water, the waves move away from the rock to make a trail.*)

  » What changes would you expect to see if you drop a much larger rock into the water or if you drop the same small rock from a higher position? (*The waves will still be in circles, but the size and force will be larger.*)

Page 2

Prompt students to reflect on their hands-on activity from Lesson 1. Ask them if there is anything they learned in that activity that they can apply here. Have them identify ways that energy from sources other than the wind transfer to the water. (They may recall the example of the pebble from the previous page and their personal experiences. Other examples may be boats or ships moving on and through the water, people splashing or swimming in the water, and so on.)

Page 3

Discuss with students the various parts of the wave. To help them remember each part in anticipation of the Activity Page exercise to come next, ask the following:

- What is the crest of the wave? (*the highest part of a wave*)
- What is the trough of the wave? (*the lowest part of a wave*)
- What is the wavelength of the wave? (*the distance from one crest to the next crest of a wave*)
- How do we measure wave speed?

SUPPORT—If needed and if there is time, allow students to watch the video about waves again and consider pausing the video for students to describe what is happening at one point in time. Ask students to focus on looking for the parts of the waves they learned about in the Student Reader.

Page 4

Point out to students that the crests, troughs, and wavelengths can vary in water waves depending on the amount of energy transferred through them. Ask students if there are differences between the waves they saw when the pebble was dropped into the water compared to when the wind moved the water in the video. Have them describe the differences in as much detail as possible.

SUPPORT—Tell students that to *vary* means to differ from one example to another. For example, the height of students in your class varies. Some students are taller than others. Measurements of the characteristics of waves also vary.

If any students have visited the ocean, have them describe the difference in the energy they can feel when standing on the beach when the waves are small and slow and when the waves are large and fast.

SUPPORT—Have students recall a recent hurricane, such as Maria or Florence. Have them describe hurricane-force winds and how those winds affect trees and buildings. Then have them consider the types of waves those winds create in the ocean. Ask students what they might predict about the speed of the waves that the winds create.

3. Encourage discussion. 10 MIN

Activity Page

AP 2.1

Introduce Wave Model (AP 2.1). Explain to students that they will complete the Activity Page based on what they have learned so far in this lesson but that they can also use what they learned in Lesson 1 if they choose. Go over the directions with students, but do not model the structure of the wave for them, as this activity is designed to help them remember the structure of waves on their own. Explain that these models will help them prepare for their next lesson, where they will learn to develop a physical model of a wave.

SUPPORT—If needed, help students by writing words related to waves on the board or chart paper, but do not place them in any kind of context. These can include *wavelength*, *crest*, and *trough*. Explain to students that they may use these as they work on their wave models.

Lead a discussion about the examples students drew on their Activity Page. Ask volunteers to share their wave models. Point out that student drawings are similar because all waves are structured in the same way. However, there can be variations in crest height, trough depth, and wavelength. Use the models to illustrate these variations, and point toward the objects in each drawing as showing the relative sizes of the waves. (See **Know the Science** for support.)

» How is what you read in the Student Reader similar to what you saw in the video at the beginning of the lesson?

» How is what you read in the Student Reader different from what you saw in the video at the beginning of the lesson?

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students write each term in the upper left corner of an index card and underline it (one term per card).

crest **wave** **wavelength**

trough **wave height**

Word Work

- **wave:** (n. a disturbance that transfers energy through matter or through space) Have students identify an example of a real-world wave and an example of a model of a wave. Have students draw an example of a wave.
- **crest:** (n. the highest part of a wave) Using student examples of waves, have students identify where the crest is on the wave. Have students write on their card a definition of *crest*.

Know the Science

How do we know that a water wave has energy? ***A wave causes a change.*** The concept of energy is one many students struggle with. At the Grades 3–5 level, what teachers should strive for is to get students to associate *any* change with energy. Water waves hit the shore and cause the sand to move. That is a change. The waves crash against rocks, causing a loud roar, and that is a change too. Waves carry energy, and we know this because waves can cause changes.

- **trough:** (n. the lowest part of a wave) Using student examples of waves, have students identify where the trough is on both examples of a wave and write those on their cards.
- **wavelength:** (n. the distance from one crest to the next crest of a wave) Using the definition in the Student Reader, have students relate the energy in a wave to its wavelength.
- **wave height:** (n. the vertical distance from the top of the crest to the bottom of the trough of a wave) Instruct students to draw a simple line diagram of a wave and label the wave height.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 2.1) for correct answers and sample student responses.

- Collect the completed Wave Model (AP 2.1). Scan the models that students made. If models contain missing labels, engage in further discussion, emphasizing the parts that are missing and why they are important to the wave.
- Check to see if students understand that waves carry more energy when they have greater height and shorter wavelengths. If understanding is insecure, compare waves created from hurricane-force winds and those from gentle winds. Hurricane waves will be bigger and come faster, which means they have greater size and shorter wavelengths.

LESSON 3

Modeling Water Wave Features

Big Question: What are the characteristics of water waves?

At a Glance

Learning Objectives

✓ Develop a model to demonstrate that waves have amplitude, frequency, and wavelength.

✓ Describe the relationship between the energy of a wave and its characteristics.

Lesson Activities (2 days)

- hands-on modeling
- discussion

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Science and Engineering Practices: Developing and Using Models, Scientific Knowledge Is Based on Empirical Evidence

Developing and Using Models is important to this lesson because waves are easier to understand using models. In this lesson, students build a physical model of a wave as they apply and extend what they have learned in previous lessons. They then add different amounts of energy to a model and describe how that energy affects the characteristics of the wave.

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

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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 162–163 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.

amplitude **frequency** wavelength

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

Activity Pages
Modeling a Water Wave (AP 3.1)

Presenting a Wave Model (AP 3.2)

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

Materials and Equipment

Collect or prepare the following items:

Day 1

- poster board (assorted colors)
- construction paper (assorted colors)
- markers
- scissors
- glue bottles/glue sticks
- shoeboxes (or small box/container; 1 per student)
- colored pencils (or crayons)
- yarn

Day 2

- spring toy
- stopwatch (1 per group)
- measuring tapes or rulers (2 per group)

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

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

What are the characteristics of water waves? Begin the lesson by reminding students what they learned in the previous lesson about the structure of all waves, including water waves. Ask the following:

» What is the crest of the wave? (*the highest part of a wave*)

» What is the trough of the wave? (*the lowest part of a wave*)

» What is the wavelength of the wave? (*the distance from one crest to the next crest of a wave*)

Online Resources

Reinforce the idea that we use models to help understand how complex systems work by showing a video of a wave model simulation. Students can see that greater wind produces bigger, more turbulent ocean waves, even in the middle of the ocean. But the class will simplify models even more to think about a single wave instead of many waves.

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

Tell students that in Day 1 of this lesson, they will extend what they learned about waves in both Lessons 1 and 2. They will also learn more terms related to the properties of waves and build a physical model representing a water wave. Students will work individually to make their models.

Reassure students that there will be enough time to build these models. On the first day, they will work on the wave models. On the second day, they will demonstrate and test their models in order to answer questions about the characteristics of water waves and waves in general.

2. Encourage student questions. 5 MIN

Activity Page

AP 2.1

In the previous lesson, students completed Wave Model (AP 2.1), in which they drew a wave model. Return these to students, but make sure that any mistakes have been corrected. Tell students that they may refer to these as they make their physical wave models. Lead a discussion about the structure of waves based on Wave Model (AP 2.1). Specifically explore student thinking about comparing different waves and the cause-and-effect relationship of wave size relative to the amount of energy passing through the water. Answer student questions, and assure students that you will go around the room to answer more questions once they begin building their physical models.

3. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Display the following Core Vocabulary words on the board or chart paper. Have students write each term in the upper left corner of an index card and underline it (one term per card).

amplitude **frequency**

Word Work

Students will likely lack familiarity and may struggle to understand the terms *amplitude* and *frequency*. You may wish to equate them at first with *size or height* and *speed* and move to the proper terms as students' understanding progresses. (See **Know the Science 1**.) As students work through the activity, call out these terms so that students begin to become familiar with them. Explain that these terms are characteristics of waves, and instruct students to add illustrated notes to their cards.

- **amplitude:** (n. the height or distance from the crest to either the mid-point or the trough of a wave)
- **frequency:** (n. the number of times a wave peaks over a period of time)

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

4. Support student modeling. 30 MIN

Activity Page

AP 3.1

Introduce Modeling a Water Wave (AP 3.1), and provide each student with a shoebox containing the materials they will need to complete the activity. Go over the directions, and tell students that they will make a physical model to represent a water wave using the materials in the box. Explain that they do not need to use all the materials. However, their model must include all the characteristics of the wave.

SUPPORT—Assure students that it's okay if other students make their models differently. As long as the models are physical and include all the characteristics of the wave, the models should be okay. Tell students that they will be graded not on their artistic ability, but rather on how well they understand the structure and characteristics of water waves (and waves in general).

Know the Science

1. What is the importance of amplitude? *Size and speed.* Amplitude is the measure of the distance between the wave's crest and trough. In sound, a greater amplitude means a louder sound. For light, greater amplitude means brighter light. For water waves, greater amplitude means a more powerful wave. (All the above statements are true if the frequency of the wave is the same.)

Give students time to think about their models and decide on the exact materials they want to use, and allow them to begin. Reinforce the idea of energy transfer. (See **Know the Standard**.)

> **SUPPORT**—If students get stuck or need help constructing their models, ask them questions to get them to think creatively about a solution, or model for them how to put together the kind of model they've chosen. Remind students of the wave model they saw in Lesson 2.

Tell students that in the next class period, they will test the characteristics of waves.

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

What are the characteristics of water waves? Discuss with students the following characteristics of a wave: amplitude, frequency, and wavelength. Explain the following:

- Amplitude is the height of the wave.
- Wavelength is the length of the wave from crest to crest.

Have students discuss how they will demonstrate amplitude, frequency, and wavelength with their models. (See **Know the Science 2**.)

Online Resources

Watch the video for an overview of waves to enhance your instructional capability with the content.

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

Know the Standard

Waves and Their Application in Technologies for Information Transfer While this lesson specifically deals with models of waves, students should discuss and understand that all waves are examples of energy transferring from place to place in patterns. Water waves, sound waves, and light waves are examples of waves moving energy from place to place in regular patterns.

Note about future lessons: The patterns and characteristics of waves can also carry information. Students will study this later in the unit. Scientists and engineers have developed technologies to transfer information by waves. Cell phones, radios, the internet, satellites, and so much more use energy waves to carry information from one place to another.

Know the Science

2. Can we perceive frequency differences in waves without specifically measuring them? ***Yes, we can.*** Frequency is a measure of how many wave crests pass a point in a certain amount of time. For sound waves, a greater frequency means a higher pitch. For visible light, different frequencies are seen by humans as different colors. Water waves will seem closer together if you stand on a shore and watch them.

2. Encourage student questions. 5 MIN

Remind students that the goals of this activity are as follows:

- become familiar with the characteristics of waves
- describe how the energy of a wave is reflected by its characteristics

Before students begin, have them share any questions they may have. These questions can be about the model they made or how to demonstrate a wave's characteristics. Engage in a short class discussion, encouraging other students to answer the questions to which they know the answers. If any questions remain after the allotted time, save them for the Check for Understanding.

3. Support the investigation. 25 MIN

Activity Page

AP 3.2

Separate students into groups of four. Then, pass out Testing a Wave Model (AP 3.2). Go over the directions. Explain to students that they have been placed in groups because the modeling requires more than one person to conduct. For example, when testing how fast the wave is moving, one student will need to transfer energy into the model, one student will need to time how fast the energy moves through the model, one student will need to measure the height of the crests, and one student will need to measure the wavelength. Students should take turns performing specific tasks.

Before students begin, make sure that each group has at least one stopwatch and two measuring tapes or rulers. They will use these to record the results of their test.

> **SUPPORT**—Circulate around the room, providing support when necessary. If students get stuck or confused or need help testing their models, ask them questions that get them to think creatively about a solution, or model for them how to perform the test.

4. Encourage discussion. 5 MIN

Remind students that engineers need to know the characteristics of water waves to help protect populations that live alongside large bodies of water. Knowing when and how much energy is transferred into the water from strong winds, storms, or undersea earthquakes enables scientists to help predict how much water (and energy) may be moved onto the shore later. Then, scientists are better able to provide warnings to those populations. Ask the following:

» What are other examples of scientists using their knowledge of waves to solve a problem?

> **SUPPORT**—If students struggle to answer the question, remind them that more and more information is transmitted through waves. Provide students with a couple of examples of technology that relies on information transferred through waves, and then ask them to name more.

5. Check for understanding.

5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 3.1 and 3.2) for correct answers and sample student responses.

- Ask students if they have any remaining questions (or refer to any questions that were not understood during the hands-on activity), and then choose one or two to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and to correct any remaining misconceptions.
- Ask students what amplitude measures. (*the height of the crest and depth of the trough of a wave*)
- Ask students what frequency measures. (*the speed at which crests of a wave move past a point of reference, which depends on wavelength*)
- Ask students what the relationship is between energy and the amplitude and frequency of waves. (*The greater amplitude and frequency are, the greater the energy of the wave.*)
- If understanding is insecure, have students demonstrate their tests and break down these relationships.

PART B

Sound Waves Transfer Energy

Overview

Lesson	Big Question	Advance Preparation
4. Exploring Sound	What is sound?	Gather materials for hands-on activity. (See Materials and Equipment, page 12.)
5. Sound and Matter	How do sound and matter interact?	Gather materials for teacher demonstration. (See Materials and Equipment, page 12.)
6. Sound, Energy, and Change	What is the relationship among vibration, sound, and energy?	Read Chapter 2 in the Student Reader.
7. Investigating Sound	What are the characteristics of sound waves?	Gather materials for hands-on modeling. (See Materials and Equipment, page 12.)

Part B: What's the Story?

Sound waves transfer energy from one place to another. As such, the energy of sound waves causes change. This section helps students learn and investigate how sound waves are produced when objects vibrate, as well as the changes caused by the energy of sound waves. By addressing this content, this series of lessons solidifies and extends previous learning, such as the early-grade NGSS expectations regarding sound, vibrations, and waves in 1-PS4-1 and 1-PS4-4, and prepares students to meet or exceed Performance Expectation 4-PS4-3 later in this unit.

In Lesson 4, students begin by exploring different sounds and vibrations. Sounds exist all around us, and this lesson engages students to explore those sounds and identify their sources. The goal is for students to describe the relationship between vibration, sound, and energy.

In Lesson 5, students observe and discuss teacher demonstrations related to sound waves traveling through different media—solids, liquids, and gases—and discuss predictable patterns. This lesson is intended to prompt students to address the question, "How do sound and matter interact?"

In Lesson 6, students read and reinforce their understanding about sound as energy and explore firsthand evidence that sound waves cause change. The lesson addresses the concept of the speed of sound (on a scale they can relate to) and the fact that sound must travel through a medium.

In Lesson 7, students conduct a hands-on investigation in which they build an instrument that can change in volume and pitch. The goal of this lesson is for students to recognize the characteristics of different sound waves in terms of firsthand experience. Exploring variations in sound waves also supports the connection between wave characteristics and variables they can control as they produce sound.

So, to repeat, **sound waves transfer energy and cause changes**. Help your students grasp this concept, and you will lay the groundwork for meeting the NGSS expectations addressed in the rest of this unit.

LESSON 4

Exploring Sound

Big Question: What is sound?

At a Glance

Learning Objective

✓ Describe the relationships among vibrations, sound waves, and energy.

Lesson Activities

- student demonstration
- video and discussion
- hands-on activity, discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concepts: Energy and Matter

Energy and Matter interactions are important to the lesson because energy moves through objects, including air, water, and solid matter, in patterns known as waves. These waves include sound, which occurs when objects vibrate because of energy transfer. Students begin this lesson by listening for and identifying sounds, and then they discuss ways they can make sounds (by applying energy and causing vibrations).

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 162–163 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.

intensity	**sound wave**	wave
pitch	**vibrate/vibration**	wavelength

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 on the previous page.

Instructional Resources

Activity Pages

AP 4.1
AP 4.2

Activity Pages
Making a Shoebox Guitar (AP 4.1)

Investigating Sound Waves with a Shoebox Guitar (AP 4.2)

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

Materials and Equipment

Collect or prepare the following:

- shoebox with lid (1 per student; 1 for teacher demonstration)
- rubber bands (4–6 per student/box)
- unsharpened pencil (1 per student)
- scissors (1 per student)
- internet access and the means to project images/videos for whole-class viewing
- index cards for student vocabulary deck (4 per student)

Prepare the hands-on activity materials in advance so you can begin the activity once class starts. Before class begins, have one shoebox guitar completed for students to look at as an example. The remaining materials should be placed in bundles/sets for students.

Students will use their shoebox guitars again in Lesson 7 and can use them in Lesson 5 to explore sound.

The Core Lesson 45 min

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

What is sound? Have students be very quiet. Then have them listen for any sounds they might hear. These could be the sounds of traffic or birds outside, the chatter of people in the distance, the hands of a clock ticking, or something else in or around the classroom. Point out that sounds are all around us.

- Ask students if they can identify the source of the sounds they hear and how they know what the sources are.
- Challenge students to name as many ways that they can make sound as possible in one to two minutes, from talking to clapping to walking. Then have each student make a sound from his or her desk that isn't too loud. Encourage students to make a different sound than the students before them.

Consider that some students may have hearing impairments or know people who do, and tailor instruction accordingly.

2. Demonstrate examples and guide discussion. 10 MIN

Online Resources

Show a video that explains how sound waves are created. 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

Remind students of the activities they performed in Lessons 1–3, noting that waves can pass through air, liquids, and solids. Lead a discussion that clarifies the concept of sound and how it is different from the concept of a sound wave. (See **Know the Science** for support.)

> **SUPPORT**—Emphasize that what we perceive as sounds are the evidence that sound waves are moving through matter. Sounds are the vibrations that travel in waves that can be heard when they make parts of your ears vibrate. Sound waves are formed when a sound occurs and carry the sound to your ear.

3. Preview the investigation. 10 MIN

Activity Page

AP 4.1

Provide each student with the items needed to make a shoebox guitar. Pass out Making a Shoebox Guitar (AP 4.1) to students, and instruct them to complete the activity using the materials they have been provided. Provide enough time for students to complete the construction of their guitars. Circulate among students as they work, encouraging questions and providing assistance as needed.

Know the Science

How do sound waves form? *From the motion energy of vibrations.* When people talk, air from their lungs passes over vocal cords, which causes the vocal cords to vibrate. The vibrations disturb the surrounding air to make sound waves. These waves travel through air to our ear and are detected. We hear them as sound. All sound waves originate as vibrations. Hence, when the rubber bands on the shoebox guitar are plucked, they vibrate and make sounds. The waves from the vibration then enter students' ears so that students hear the waves as sounds. Our perception of sound is evidence of sound waves.

Give specific examples of sounds, and ask students to distinguish, in each, the difference between the sound and the sound wave. For example:

- people talking
- musical drumming
- a balloon popping
- a car horn blaring
- paper crumpling

Then, in each case, ask them what object is vibrating to produce the sound wave.

4. Encourage discussion. 5 MIN

Before having students use their shoebox guitars, review with them how sound waves form. Discuss vibrations, and have them come up with ways that they can make objects vibrate to make sound waves. As a demonstration, gently rap your desk with your hand, and explain that energy from your hand entered the desk, causing particles in the desk to vibrate. The vibrations caused waves to form and travel through the air, and students' ears picked up these waves and then sent a signal to the brain, which then recognized the sound.

Now, have students gently rap their own desks in unison. Encourage questions, and have students come up with other examples to demonstrate how sound waves form.

SUPPORT—Relate waves that carry sound energy to other types of waves. Remind students of different types of waves they have already explored. It is the energy that transfers on the waves. The waves carry the energy but are not the energy.

5. Facilitate the investigation. 5 MIN

Activity Page

AP 4.2

Pass out Investigating Sound Waves with a Shoebox Guitar (AP 4.2) to students, and instruct them to complete the activity using the guitars they have built. The activity begins with students making a prediction. If students struggle with this, ask guiding questions to move them in the right direction. For example:

- What are vibrations? (*quick back-and-forth or side-to-side motions*)
- What is a sound? (*invisible energy vibrations*)
- How are sound waves created? (*When a sound is made, waves form to carry the sound. When it reaches an ear, the sound can be heard.*)

6. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Display the following Core Vocabulary words on the board or chart paper. Have students write each term in the upper left corner of an index card and underline it (one term per card).

intensity **pitch** **sound wave** **vibrate/vibration**

Word Work

Ask students to use each term in a sentence and to write the sentence on the appropriate card.

- **intensity:** (n. the measurable strength or power of a vibration)
- **pitch:** (n. the quality of sound that is described as high or low and is related to a wave's frequency)

- **sound wave:** (n. a transfer of energy through a material as it is disturbed by vibrations)
- **vibrate/vibration:** (v. to move back and forth quickly)/(n. the motion of an object or material that is vibrating) Below the *vibration* sentence, have them draw a diagram showing an object making a sound. They should also show how that sound travels to the human ear. Encourage them to use arrows to indicate the direction(s) in which the sound moves.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

7. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 4.2) for correct answers and sample student responses.

- Collect the completed Activity Pages. Scan the responses to see if students understand the following:
    - Sound energy travels on waves.
    - Sounds are created by a vibration of matter.
    - Waves are created by the vibration of matter to carry sound energy from the source.
- Choose one or two questions to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and correct misconceptions.

LESSON 5

Sound and Matter

Big Question: How do sound and matter interact?

At a Glance

Learning Objectives

✓ Compare how sound waves can travel through solids, liquids, and gases.

✓ Describe the qualities of different sounds based on the types of matter energy is transferring through.

Lesson Activities

- student observation
- teacher demonstrations
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Energy and Matter

Energy and Matter are the focus of this lesson. Students observe and discuss how sound energy travels on sound waves through solids, liquids, and gases. Sound waves occur when matter vibrates because of energy transfer.

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 162–163 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.

intensity	**sound wave**	wave
pitch	vibration	wavelength

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards, which 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 Page

AP 5.1

Activity Page
Sound Observations (AP. 5.1)

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

Materials and Equipment

Collect or prepare the following items:

- pairs of different-sized water bottles, 0.5 liter and 2 liter, for example (1 for each pair of students)
- block of wood (1 for each pair of students)
- cell phone tone or music box
- books
- string phone made with paper cups and 20 feet of string
- shoebox guitars from previous lesson
- internet access and the means to project images/videos for whole-class viewing

Prepare the water bottles beforehand by filling one with water and leaving the other bottle empty. Seal both bottles with their caps.

Prepare the hands-on activity materials in advance so you can begin the observations and demonstrations once class starts.

THE CORE LESSON 45 MIN

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

How do sound and matter interact?

- Ask students if they think a sound might be affected by the matter it travels through. Distribute a pair of same-size bottles to each student.
- First have students listen to a sound traveling through air. Have them hold the empty water bottle to one ear while they cover the other. Ask their partner to tap the bottle with a pencil. Have students describe the sound as you write the descriptions on the board.
- Then ask them to listen to the same sound traveling through water, holding the full water bottle against one ear while their partner taps it with the pencil. Have students refer to the descriptive words on the board and compare the sounds.
- Then have pairs of students trade with another pair for a different-size water bottle and repeat using the different-size bottles. The groups of four students can then compare the sounds between the two different-size bottles.

- Have pairs of students then repeat, using the block of wood as a solid. After completing this, ask students the following:
    - » How did the sound change between what you heard with air and what you heard with water? (*The tapping sound is louder through the bottle filled with water than the bottle with air.*)
    - » How did the sound change between what you heard with water and the solid? (*The sound is louder through the solid than through the bottle of water.*)
    - » How did the sound change between what you heard with air and the solid? (*The sound through the solid is louder than the sound through the bottle of air.*)

Encourage students to retry the sounds to help them answer the questions.

Consider that some students may have hearing impairments or know people who do, and tailor instruction accordingly.

2. Encourage student questions. 5 MIN

Relate understanding of the previous lesson about what sound is to the different types of sounds students heard through air and water.

- Discuss how and why the sounds were different in their model guitars. Inspire students to generate questions about sound waves moving through different materials.

Online Resources

Play videos of dolphin sounds under and above water. 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

- Compare the different sounds, and discuss how loud the sounds are and how far the sounds might travel in waves in the different types of matter.

    SUPPORT—Holding the shoebox guitar students made in the last lesson in the air, pluck one string. Then place the guitar on a solid table, and pluck the string. Discuss the difference in sounds.

3. Demonstrate examples and guide discussion. 15 MIN

Activity Page

AP 5.1

Distribute the Sound Observations (AP 5.1). Prompt students to write their observations of the different sounds from the pencil tap activity. They should write terms such as *loud*, *louder*, *loudest*, *clear*, *clearer*, and *clearest* in each box to compare the sounds. Then, demonstrate at least two of the following sound examples, and have students add their observations to the Activity Page.

- Cell Phone Tone or Music Box
    - ◦ Holding it in the air, play a sound, and have students listen and then describe the sound they hear through air.
    - ◦ Then place the music box or cell phone on a desk or solid table, and play a sound. Compare the sounds.

    - Next, hold it against a water bottle placed against the ears of different students, and have them experience the difference in sound.
- String Phone
    - Choose one student to help demonstrate the string phone. Extend the string across the room.
    - Play the music box or cell phone tone. Have students in different locations in the room describe the sound. Discuss how those closest to the sound can hear it most clearly.
    - Then hold the two cups so that the string is taut. Play the cell phone tone or music box inside the cup you are holding. Ask students to take turns listening to the sound in the other cup.
    - As a class, compare the sound of the music box or cell phone through air and the sound through the string phone.
    - As you play the music box through the string phone, ask students to take turns touching the string and feeling the sound vibrations. Discuss what happens to the sound in the cup when the string is held.

Online Resources

- Whale Song
    - Play a video of a whale song. 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

    - Explain that a whale's low-frequency sounds can travel many miles through the water, so they can communicate through vast distances. Discuss how far the sound would travel through air.

Explain that sound travels even faster and farther through solids than through water. Ask students to compare plucking their shoebox guitars in air, against the water bottle, and on a table. Discuss how an earthquake or explosion can be detected even far away. (See **Know the Science 1**.)

Know the Science

1. How do sound waves interact with different forms of matter? ***Sound waves move most quickly through solids, less quickly through liquids, and slowest through gases.*** All types of matter can vibrate! Molecules in solids are much denser than in water and even more dense than in air. Sound waves vibrate from molecule to molecule in solids faster than in other types of matter. The closeness of the molecules in a solid requires less energy to cause the wave of vibration to travel through it than in a liquid or gas. Sound waves travel about thirteen times faster through solids than in air (depending on the properties of the solid). In water, sound waves travel four times faster and farther than they do in air. The closer the molecules in matter, the faster the waves travel as the molecules vibrate in patterns as energy is transferred through the medium.

SUPPORT—Emphasize that sound waves move through matter, whether the matter is solid, liquid, or gas. In space, where there is no air and almost no matter, energy cannot be transferred by sound waves because there is almost nothing that can vibrate.

4. Encourage discussion. 5 MIN

Discuss each of the following experiences. Ask students to identify and explain the type of matter through which sound waves are traveling. Then ask them to predict the characteristics of the sound they would hear as a result.

- In a thunderstorm, do you see, hear, or feel the thunder first? How does thunder as a phenomenon show that sound travels differently through different states of matter? (*You may feel a vibration around you or under your feet because sound travels faster through the ground than through the air; you hear the thunder after this vibration because sound travels more slowly through air.*)
- Think of dropping a marble in a bowl of water. How would the sound be different under and above the water?
  - » Which direction(s) do sound waves travel from their source? (*Sound waves spread out from the source that is vibrating, like the ripples from a pebble dropped in water.*)
- Think of a fire engine with siren blaring passing by the school. How does the distance between the source of a sound wave and you change the characteristics of the sound you hear? Make predictions about why. (*The farther the waves go, the weaker they become, until they fade completely regardless of the state of matter they are traveling through.* [See ***Know the Science 2*** *for support.*])

Online Resources

SUPPORT—Show the first two minutes of the video to introduce students to the Doppler effect. 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 students to describe and imitate the sound of an ambulance going by to reinforce how sound waves travel to your ear from their source.

Know the Science

2. What is the Doppler effect? ***Sound waves travel outwardly from their source, but the waves change if an object is moving.*** A fire alarm sends waves through the air just like a marble causes ripples if you drop it in a bowl of water. As long as you don't move, the alarm will sound the same until it is turned off. If you stand next to a parked fire truck with the siren going off, you will have the same experience. But if the truck moves, the sound will seem to get louder and have a higher pitch as it comes closer and get quieter and have a lower pitch as it drives past. Inside the truck, the siren doesn't change. The sound waves in front of the moving truck bunch up with less space between them. That's the Doppler effect.

5. Revisit Core Vocabulary 5 MIN

Word Work

Have students pull out their vocabulary cards for the words **intensity** and **sound wave**.

- **sound wave:** (n. a transfer of energy through a material as it is disturbed by vibrations) Ask students to write descriptions of what they have learned about how sound waves travel through different states of matter. Their cards should include descriptions of sound waves interacting differently in different types of matter, including solids, liquids, and gases. If time allows, challenge students to add examples or drawings to help illustrate their understanding of sound waves and different examples of sounds that they perceive.
- **intensity:** (n. the measurable strength or power of a vibration) Explain that something that is intense is something with a lot of force. Ask students to think of something they can describe that can be done with *intensity*, such as running and running very fast. Then ask students to explain what it might mean if sound has more intensity. Encourage students to use examples. Then have students write the definition in their own words on their vocabulary card.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

6. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 5.1) for correct answers and sample student responses.

- Collect the completed Sound Observations (AP 5.1). Scan the observations to see that students understand how sound waves interact differently with different states of matter. Students should have observed that sounds are louder and clearer through solids, such as the string phone, and softer and less clear through air.
- Scan students' conclusions about how sound waves travel through different types of matter. Check for misconceptions about the following concepts students may have:
    - Energy, whether sound, light, or motion, is moving in waves. Waves transport energy through matter.
    - Liquid, gas, and solid matter vibrate when waves move through the matter, but the matter is not transported by waves.
    - Sound waves travel at different rates through different types of matter. They travel faster in solids than in liquids. They travel faster in liquids than in air.
- Choose one or two questions to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and correct misconceptions.

LESSON 6

Sound, Energy, and Change

Big Question: What is the relationship among vibration, sound, and energy?

At a Glance

Learning Objectives

✓ Describe the relationship between vibration, sound, and energy.

✓ Discuss how sound waves can travel through solids, liquids, and gases.

✓ Provide examples of changes caused by the energy of sound waves.

Lesson Activities

- teacher demonstration
- student observation
- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Patterns are important to this lesson because they teach students that the observable qualities of sound can be described and measured to better understand the natural phenomena caused by sound waves. Students will read about sound waves and the characteristics of volume and pitch and build an early understanding of the speed of sound through experiential examples.

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

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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 162–163 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.

frequency	**pitch**	**vibrate**	**volume**
intensity	**sound wave**	**vibration**	

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
"Sound, Energy, and Change"

Activity Pages

AP 6.1
AP 6.2

Activity Pages
What Does It Sound Like? (AP 6.1)

Lesson 6 Check (AP 6.2)

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

Materials and Equipment

Collect or prepare the following items:

- medium-size container
- water
- cup or pitcher
- musical chimes or bell
- rattle or musical shaker
- textbook
- variety of recorded sounds and an electronic device for playback
- portable fan or hair dryer
- internet access and the means to project images/videos for whole-class viewing
- index card for student vocabulary deck (1 per student)

The Core Lesson 45 MIN

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

Activity Page

AP 6.1

What is the relationship among vibration, sound, and energy? Introduce the directions for What Does It Sound Like? (AP 6.1). Let students know that they will be listening to a variety of sounds and describing what they hear to answer the questions. Before playing each sound, ask the following questions:

» What are examples of sounds? (*clock ticking, talking, siren*)

» How can sounds be different? (*high, low, loud, soft*)

» What causes/creates a sound? (*vibration*)

» Can sounds cause changes? (*Sound waves cause changes in ears that allow you to hear sounds.*)

- Make a variety of sounds for students using the musical chimes/bell and rattle/musical shaker.
  - Use the cup or pitcher to pour water into a container or bowl, and allow students to listen to the sound of poured water.
  - Drop a textbook on the desk to make a loud *thump*.
  - Additionally, make *shhh* noises and whispers to give students examples of soft sounds.

- Students should record and describe the sounds that they hear with as much detail as they can. As students listen to each sound, ask them if the sound came from a vibrating object. Then ask whether the sound caused a vibration or shaking sensation.
- Continually emphasize the difference between a sound and a sound wave. (See **Know the Science 1**.)

Safety Note: Make sure that the sounds are not too loud for students' ears.

Preview Core Vocabulary Terms

Before reading, write the following terms on the board or chart paper:

frequency	**pitch**	**vibrate/vibration**
intensity	**sound wave**	**volume**

Ask students to pay attention to these words as they read. Tell students that you will stop and discuss the meaning of each term in context as they read the chapter.

2. Encourage student questions. 5 MIN

Lead a discussion about the sound examples that students heard and described on What Does It Sound Like? (AP 6.1). Draw attention to the types of observations students used to describe qualities of the sounds, and without prompting, record on the board or chart paper any key words used by students. For example, students may already feel comfortable describing sounds in terms of "loudness," "softness," or even pitch.

Make a note whether there are any similarities between student responses, such as a general focus on just a few properties. Discuss other types of observations that could be used to describe sound, such as the following:

» Does it sound soothing or screeching?

» Does it hurt my ears?

» Was it loud enough to make other objects vibrate?

» Could you hear it from across the room?

Draw students' attention back to the Big Question, and introduce Chapter 2 of the Student Reader.

Know the Science

1. What is the difference between a sound and a sound wave? *Vibrations and waves.* As was discussed in previous lessons, sound is the evidence that invisible sound waves have carried sound energy vibrations from the source of the sound to be heard. The sound is what we hear.

3. Read and discuss: "Sound, Energy, and Change." 15 MIN

Student Reader

Ch. 2

Read together, or have students read independently, "Sound, Energy, and Change," Chapter 2 in the Student Reader. This selection reinforces the concept of sound waves being created by vibrations, as well as other properties of sound, such as volume and pitch.

Guided Reading Supports

When reading together, pause for discussion of the key terms and questions found in the text to check for understanding. Include suggested questions and prompts:

Page 5

After reading page 5, ask students to place their fingertips against their throats and hum. Ask them if they can feel the vibration. Ask students whether they can feel (without touching) other students' humming sounds or just their own.

SUPPORT—If needed, prompt students to reread the section that says sound results from vibrations. Then ask: What are five objects right now that are vibrating and producing a sound? Give students one minute. (See **Know the Science 2**.)

Online Resources

SUPPORT—Show a slow-motion video of a tuning fork being placed in water to further demonstrate how sounds cause change. Explain that we can't see the vibrations that produce sound but that in water we can see the waves that are made from the sound vibrations. Discuss how the vibrations affect the water. 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 6

Prompt students to consider how sound waves travel through a solid, liquid, or gas. Although we are used to hearing sounds traveling through air, students can consider whether sounds would be louder or clearer when heard through other forms of matter. Ask them to think about the activities they experienced with water bottles in Lesson 5 and other experiences, such as putting your ear to a wall and hearing sounds through the wall. For example, ask the following questions:

» Has anyone ever heard a sound while they were underwater? (*Possible sounds may include sloshing, the motor of a boat, or sounds that are above the water.*)

» What did it sound like? (*fuzzy, muffled, not very loud*)

Know the Science

2. What is sound? *What we hear!* Sound is something that we hear as a result of sound waves entering our ears. Vibrations produce sound waves, and living things perceive these waves as sound when the wave reaches the ear canal (or other structures used to aid the sense of hearing). The brain then interprets the vibration as a sound. Chapter 2 of the Student Reader concludes with a brief discussion of structures and functions of living things that aid the sense of hearing. CKSci Grade 4 Unit 3, *Structures and Functions of Living Things*, explores how the ear works in greater depth to extend learning about our perception of sound.

» How was it different from hearing sounds in air? (*It is difficult to hear what is being said by someone above the water, but the boat motor sounded very loud.*)

Online Resources

Show a video of whale sounds, and discuss how sound waves travel through liquids. 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

SUPPORT—If needed, provide additional support to students by demonstrating the concept of vibrations traveling through a solid state of matter. Take students outside to the playground equipment, and invite students to press their ears against the pole of a swing set. Lightly tap on the pole with a stick, and have students tell how the vibrations felt and what they heard. Then tap on the pole again, this time with more force (but not too much!). Have students compare the heavier tap to the light tap. If playground equipment is not available, this activity can also be carried out in the classroom on a large table or using the surfaces of a cabinet or bookshelf.

Pages 7–8

- Relate the waves on page 8 to waves students learned about previously. Review the parts of the wave, including crest, trough, and frequency.
- Draw student attention back to the sound wave graphs in the Student Reader. Provide four sample sounds for students to try to match with these wave line models, such as a chirping cricket, a train engine, a blowing car horn, and a piano keystroke.
- Remind students that the higher and lower the wave line, the louder the sound. This means less vertically large wave lines represent a softer sound. For each of the sample sounds that you provide, first have students tell whether the sound is loud or soft. Then, they can match the sound to the correct sound wave on the Student Reader page. (See **Know the Standard**.)

SUPPORT—Reinforce that loudness and intensity of sound is the same thing. In a graph of sound waves, intensity is shown by the height of the crests and troughs. Ask students to identify the sounds with the least intensity from among the graphs on the page.

Know the Standard

Properties of Waves We introduce Grade 4 students to the idea that waves are regular patterns of motion. The patterns from sound waves can be studied and used to tell us how to sort or classify sound. The NGSS Performance Expectation 4-PS4-1 does not expect students to be able to quantify models of amplitude and wavelength. However, teachers may use models of amplitude and wavelength to show students how different patterns produce different results in natural phenomena. For additional information about the Assessment Boundaries for 4-PS4-1, please refer to the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Make Connections

Page 9

- As students read about the speed of sound, encourage them to calculate how long it would take a sound to be heard a half mile away. (*2.5 seconds*) Emphasize that using mathematics, including data and graphs, scientists model scientific phenomena.

Online Resources

- Explain to students that some objects can travel faster than the speed of sound. This is known as supersonic travel. Show students some online examples of supersonic vehicles, including cars and planes. (See the Online Resources Guide for this lesson for links to suggested images.) Make the point to students that when an object travels faster than the speed of sound, it makes a sonic boom. A sonic boom is a thunderous sound that results from the sound waves when an object goes from the speed of sound to beyond the speed of sound. Students should understand that supersonic speeds are very, very fast!

 SUPPORT—Provide additional support calculating how long it would take to hear different sounds, such as an explosion that occurred 5 miles away. (*25 seconds*) Discuss the importance of the ability to hear alarms and sirens quickly in the event of an emergency. Emphasize that scientists use mathematics and computational thinking in all kinds of applications.

Page 10

Online Resources

After reading page 10, show students a video of sound shattering glass. 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

- Explain that if you tap a crystal wine glass with a pencil, you can hear the natural pitch. It will be the same every time you tap it. If you generate a sound that has the same pitch of that sound, the glass will vibrate. It will just barely vibrate if the pitch is not the same. To break a glass, the sound you generate has to be the same pitch and loud enough to make the glass vibrate enough to shatter.
- Ask students if sound from a voice could break a glass. Explain that if you can match the pitch of your voice to that of the glass, the vibrating air will cause the glass to vibrate, too. With enough volume at the right pitch, the glass will break.

 SUPPORT—Ask if students have seen a band leader or musician tune instruments or use a pitch pipe to find a matching pitch. Demonstrate by singing a note and asking students to match your pitch. Then change the note, and repeat the exercise. Remind students that in order to break a glass, the pitch of the sound has to be the same as the glass.

Pages 11–12

Show students pictures and/or videos of animals that use vibrations to communicate. 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

Online Resources

To preview learning in future units and to encourage student wonder, select examples of various kinds of animals that use very different structures to help them hear sounds. (See the Online Resources Guide for this lesson for links to suggested images.) For example:

- Gardiner's frog
- snakes
- birds

Explain that these animals do not have eardrums, unlike humans, but depend on other structures to allow them to "hear" and sense waves of vibrations in their environments.

4. Demonstrate examples and guide discussion. 5 MIN

Use the following or a similar example to stimulate further discussion. Analyze with students 1) the different types of matter observed in the "system" and 2) properties of matter.

- Divide students into three groups. Assign each group to represent one of the states of matter: gas, solid, and liquid. Have the groups act out how vibrations travel through their assigned state of matter by bumping into one another. Make sure that they bump into each other gently, and direct them to bump shoulders against shoulders. (See **Know the Science 3**.)
- Next, ask students in each group to show how one sound wave passes through air. Discuss how students are farther apart.
- Then, ask them to show a sound wave passing through water with students closer together.
- Finally, have them show a sound wave passing through a solid with them closest together.
- Afterward, invite students to discuss their human models.
  - » What happens to the vibrations in the gas group? (*The sound vibrations are far apart and take longer to bump together.*)
  - » What happens to the vibrations in the liquid group? (*There should be more collisions than modeled for the gas.*)

Know the Science

3. What are we showing by having students act out states of matter? *Vibrations!* Sound vibrations travel best through solid states of matter. In gases, sound vibrations do not travel as easily. This is because gas molecules are spaced farther apart. Students in this group should be standing far apart and take longer to bump into each other as the sound vibration travels. Liquid molecules are a little better for transferring sound vibrations than gas, as liquid molecules are more closely packed together. Solid is the best state for transferring sound vibrations because the molecules are tight together, so the vibrations can move easily and quickly.

- » What happens to the vibrations in the solid group? (*The solid molecules are much closer together and bump into one another quickly.*)
- » Does sound travel best through gas, liquid, or solid? (*solid*)
- » How do the properties of each state of matter affect how vibrations travel through them? (*The sound vibrations travel slowly if they are far apart and fast if they are close together.*)

Online Resources

Show a video of sound and vibrations. 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

After watching, you may want to have students experience this activity. Ask what students can conclude about sound waves and how they travel through matter.

- » What is the best type of matter for sound to travel through? (*a solid*)
- » What would happen without solid matter? (*sound would not be as loud*) Would sound still be able to travel? (*Yes. Sound also travels through air and liquid.*)

Use additional guiding questions to help students link details in this discussion back to the Activity Page and the reading selection.

- » Did you write any observations on your Activity Page that are similar to the stereo hanger demonstration? (*Students should be able to draw conclusions about sounds traveling slower through air, faster through liquids, and even faster through solids. Sounds are louder through liquids than air and louder through solids than liquids.*)
- » How are these examples similar?
- » Encourage students to ask their own questions and answer others' questions during the discussion.
- » What changes are caused by the energy of sound waves?

CHALLENGE—If there is time, challenge students to explain or demonstrate how they would test how far a particular sound travels.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students prepare a new card for the term *volume* and add additional notes to their existing cards for the other terms.

frequency	**pitch**	**vibrate/vibration**
intensity	**sound wave**	**volume**

Word Work

- **pitch:** (n. the quality of sound that is described as high or low and is related to a wave's frequency) Point out that *pitch* is a noun. Students may be familiar with the more common use of *pitch* as a verb meaning throw or toss (as in baseball). Have students write the definition of *pitch*. Then write a sentence on the board: *That screeching sound has a high pitch.* Ask volunteers to read the sentence aloud and explain how they know *pitch* is a noun in this sentence.
- **sound wave:** (n. a transfer of energy through a material as it is disturbed by vibrations) *Sound wave* is a noun. In day-to-day life, many students may have heard the word *wave* being used as a verb. (*We wave hello and goodbye to our friends. We wave the flag.*) In science, *sound wave* refers to a wave that carries vibrations in patterns through different types of matter. Have students write a sentence as you dictate it: "Sound waves start from vibrations." Then have them write their own sentence using the term *sound wave*. Ensure that they are writing about the correct meaning of the term. (*We cannot hear vibrations without sound waves.*)
- **vibrate/vibration:** (v. to move back and forth quickly)/(n. the motion of an object or material that is vibrating) Explain to students that these terms mean similar things but that *vibrate* is a verb and *vibration* is a noun. Make sure students can differentiate between the two and their correct uses by having them write one sentence that uses *vibrate* and another that uses *vibration* (*e.g., The object vibrates when . . . ; The vibration of a ________ creates a sound.*) Ask volunteers to read their sentences aloud, and have other volunteers explain how they know whether the term is a noun or a verb in each sentence.
- **volume:** (n. the way humans perceive loudness from the intensity of a sound wave) Many students may already be familiar with the use of the term *volume* in everyday language, as it relates to things such as music or classroom noise. Point out that *volume* is a noun. Have students write the definition of *volume*. Explain that it is the same as sound intensity. A sound wave with greater volume has greater intensity with higher crests and troughs. Then write a sentence on the board: *Please turn the volume of the music down so I can concentrate.* Ask a volunteer to tell the meaning of *volume* in the sentence.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

6. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 6.1 and 6.2) for correct answers and sample student responses.

- As students finish the Core Vocabulary task, collect their completed What Does It Sound Like? (AP 6.1). Scan the observations that students made of the sounds, and review the questions that they had about their examples.
- Distribute the Lesson 6 Check (AP 6.2) to students, introduce the directions, and have them complete it as a formative assessment. Collect the pages, and, either during this lesson or before starting Lesson 7, go over the answers with students to explore student thinking.

LESSON 7

Investigating Sound

Big Question: What are the characteristics of sound waves?

At a Glance

Learning Objective

✓ Develop a model of sound waves using the terms *amplitude*, *frequency*, and *wavelength*.

Lesson Activities

- hands-on modeling activity
- student observation
- discussion

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Science and Engineering Practices: Developing and Using Models

Patterns and **Developing and Using Models** are important to this lesson because sound energy moves through solids, liquids, and gases in patterns known as sound waves. In this lesson, students consider patterns of energy transfer as they make models of sound waves, similar to and extending the ideas depicted in their models of water waves from Lesson 3. Students then consider the characteristics and properties of sound waves.

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 during this lesson.

amplitude	pitch	wavelength
frequency	vibration	
intensity	volume	

Instructional Resources

Activity Pages

AP 7.1
AP 7.2
AP 7.3

Activity Pages
Sound Words (AP 7.1)

Modeling Sound Waves (AP 7.2)

Testing Sound Waves (AP 7.3)

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

Materials and Equipment

Collect or prepare the following items:

- shoebox guitars (from Lesson 4)

Prepare for this lesson by making sure that each student has his or her shoebox guitar on hand. The shoebox guitars were constructed during Lesson 4 and will be needed again to help students complete Testing Sound Waves (AP 7.3). If any of the shoebox guitars were damaged since the completion of Investigating Sound Waves with a Shoebox Guitar (AP 4.2), repair the damage or have students repair their guitars before this new lesson begins. Repairing the instruments before this class session starts will help keep each step on time.

Also, display or draw a copy of Sound Words (AP 7.1) for the whole class to reference throughout this lesson. Students will use this concept map to scaffold and support their use of terms and Core Vocabulary as they build/discuss their models of sound waves.

The Core Lesson 45 min

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

What are the characteristics of sound waves? Demonstrate or challenge different students to demonstrate making different sounds with a shoebox guitar. Have students describe the differences in sound: louder, softer, faster, slower, lower, higher.

Remind students of the difference between sound and sound waves. Sounds are vibrations that are carried on sound waves. Hearing a sound is evidence of sound waves.

Remind students that in Part A "Waves Transfer Energy" of this unit, Lessons 1–3, they learned about the structure of water waves. Ask them how the structures of water waves and sound waves are alike. Provide students with prompts to pique their prior knowledge:

» What is the crest of the wave? (*the highest part of a wave*)

» What is the trough of the wave? (*the lowest part of a wave*)

» What is the wavelength of the wave? (*the distance from one crest to the next crest of a wave*)

Explain that with sound waves, the crest is often called the peak. Previously, students learned that the aspects of water waves could vary depending on the amount of energy transferred into them. Point out that, in previous lessons, they learned about characteristics related to and properties of sound waves, including wavelength, pitch, and volume (intensity). (See **Know the Science 1**.) Ask:

» Does the volume (intensity) of a sound wave change depending on the amount of energy transferred into it? (*Yes, it is louder when there is more energy.*)

» How would you describe the vibrations that cause a lower-volume (intensity) sound? (*Softer/less intense sounds are often the result of slower vibrations; less motion energy of the object that vibrates creates less intense sound waves.*)

» Does the pitch of a sound wave change depending on the amount of energy transferred into it? (*No, it is dependent on the frequency of the sound waves and wavelength, not the amplitude of the sound waves.*)

Tell students that in this lesson, they will develop models of sound waves, describing each of the wave's parts. Then they will determine how sound waves change when different amounts of energy are transferred into the vibrating object that made them.

2. Encourage student questions. 5 MIN

Activity Page

AP 7.1

Use Sound Words (AP 7.1) to lead a discussion about the structure and characteristics of a sound wave. Complete the Activity Page as a class to promote discussion and understanding. Include definitions of *frequency*, *amplitude*, *volume* (*intensity*), *pitch*, and *wavelength*. (See **Know the Science 2**.) Students will have had these defined in previous lessons, but repetition will help them remember the definitions in the long term. Students will also need to know these definitions as they complete the Activity Pages. Encourage students to ask questions, and allow other students to answer them if they can. For questions that other students cannot answer, answer them yourself (or capture these on the board or chart paper), and assure students

Know the Science

1. How is energy related to sound? *Sound is energy.* When more energy is transferred into sound waves, as when you hit a drum hard, the sound is louder. A light tap on the drum results in a quieter sound. The loudness is related to the amplitude of the sound waves. Pitch is how high or low a sound is.

2. What is amplitude in a sound wave, and what is its relationship to sound? *It is a measure of how far the particles in a medium are displaced by the transfer of sound energy.* The graphic in Sound Words (AP 7.1) shows that sound waves have crests (peaks) and troughs, just like water waves and other kinds of waves. The distance from the lowest point of the trough to the point of equlibrium is the amplitude. (The point of equlibrium is halfway between the crest and the trough of a wave line.) Amplitude is a measure of a wave's intensity, which we perceive as volume.

The greater the amplitude of the sound, the greater the volume (intensity) of the sound.

that you will go around the room to answer more questions once they get started on the activity. If there is not time to answer all the questions, hold some back for the Check for Understanding section of this lesson.

3. Support student modeling. 25 MIN

Activity Page

AP 7.2

Introduce Modeling Sound Waves (AP 7.2), and explain to students that they will complete this activity individually. Introduce the directions, and answer any questions that students have about the criteria for their models. Explain that the first wave is a model of a sound wave. Compare it to water waves from previous lessons, and have students identify its crest, trough, wavelength, and amplitude. Students will draw models of waves that have greater amplitude and greater frequency than this model. Circulate throughout the room as students complete the activity, providing feedback as necessary.

> **SUPPORT**—As necessary, return student attention to examples that have been explored during previous lessons. Students may benefit from rereading key passages from Chapters 1 and 2 in the Student Reader, or you might repeat one or two demonstrations, such as the cell phone and/or string phone examples introduced in Lesson 5. Returning to these examples can help connect direct observations/experiences to the core ideas being explored and extend learning for deeper understanding.

When students have completed their models, briefly review two or three student models to ensure that students have labeled them correctly and given careful consideration to the questions. If there is anything missing, point it out to students so that they can correct the mistake(s). Tell them that they may refer to these models while completing the second activity.

Activity Page

AP 7.3

Have students get out the shoebox guitars made during the hands-on activity for Lesson 4. Introduce Testing Sound Waves (AP 7.3), and introduce the directions. Tell students that they may work with a partner for this activity. Prompt them to keep in mind the wave line models drawn for Modeling Sound Waves (AP 7.2). Then, allow them time to complete the new activity using their own shoebox guitars.
(See **Know the Science 3**.)

Know the Science

3. What affects pitch? *Changes in the source of the sound.* As students explore their instruments, they can place their fingers on different spots on the rubber bands. A longer rubber band with the same tension as a shorter rubber band will have a lower pitch. If they hold a band, like using a fret on a guitar, they can change the pitch of the shorter band.

SUPPORT—Have partners provide support to each other by going over each other's models, comparing their models in relation to the sounds they made on their shoebox guitars. If there are disagreements, have students replicate the sound they made for each model, and then ask guiding questions about the frequency, pitch, and amplitude (volume/intensity) of the waves.

4. Check for understanding.

5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Keys (AP 7.1, 7.2, and 7.3) for correct answers and sample student responses.

- Ask students if they have any remaining questions (or refer to any questions that were not answered previously and recorded on the board or chart paper), and choose one or two to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and to correct any remaining misconceptions. Misconceptions may include the idea that when more energy is transferred into a sound wave, the wavelength is larger. In fact, the opposite is true.

PART C

Light Waves Transfer Energy

Overview

Lesson	Big Question	Advance Preparation
8. Light	What is light?	Gather materials for teacher demonstration. (See Materials and Equipment, page 13.)
9. Light Waves	How does light behave?	Read Chapter 3 in the Student Reader.
10. Investigating Light and Change (2 days)	How does light cause change?	Gather materials for hands-on investigation. (See Materials and Equipment, page 13.)
11. Invisible Energy	What are some different kinds of light waves?	Read Chapter 4 in the Student Reader.

Part C: What's the Story?

Light waves, like sound waves, transfer energy from one place to another. As such, light can cause changes. This section helps students learn about the characteristics of light and describe the changes caused by the energy of light waves.

In Lesson 8, students begin with an overview of light sources and develop their understanding of light through teacher demonstrations. Students learn that different sources emit different varieties of the phenomenon we call light and begin to discuss how light interacts with matter.

In Lesson 9, students read more about light and light waves to pique their interest through engaging examples of how light behaves. This lesson elaborates on the qualities of light, including amplitude (brightness) and specific frequencies (which humans sense as different colors). Students also consider additional examples of how light interacts with matter through absorption and reflection.

In Lesson 10, students conduct a two-day investigation with solar ovens to explore how light causes changes. This lesson also extends learning from CKSci Grade 4 Unit 1 *Energy Transfer and Transformation* to build understanding of forms of energy and the conversion of one form (light) to another (heat).

In Lesson 11, students are introduced to observable evidence of the spectrum of light, although they will not explore electromagnetism or the spectrum in detail. The goal of this lesson is for students to understand that color is an observable property of different waves of light and that some wavelengths are invisible to the human eye.

LESSON 8

Light

Big Question: What is light?

At a Glance

Learning Objectives

✓ Identify sources of light.

✓ Describe different characteristics of light seen in the world.

✓ Describe the kinds of matter that light can travel through.

Lesson Activities

- teacher demonstration
- student observation
- writing, discussion

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Science and Engineering Practices: Asking Questions and Defining Problems

Asking Questions and Defining Problems is important to this lesson because students are expected to have questions about concepts, including how light behaves, as they learn about them. As students discover the behaviors and qualities of light in this lesson, they will be asked to come up with questions that help them better understand how light travels and works.

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 162–163 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.

light	**light wave**	**transparency/transparent**
light source	**reflect**	

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 Page

AP 8.1

Activity Page
Find the Light (AP 8.1)

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

Materials and Equipment

Collect or prepare the following items:

- lamp with light bulb
- candle (for teacher demonstration only)
- matches/candle lighter
- glow sticks
- prism
- flashlight
- glow-in-the-dark stickers
- white poster board sheets (2)
- piece of clear glass
- wooden block
- index cards for student vocabulary deck (5 per student)

If the clear piece of glass is not in a frame, place foam around the edges. Be sure to tape it solidly so that it is unlikely to come off and cut students. You may also wish to use a clear glass bottle as an alternative for the activity.

The Core Lesson 45 min

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

Activity Page

AP 8.1

What is light? Go over the directions for Find the Light (AP 8.1). Prompt students to look at familiar light sources in and around the classroom—as well as think about light sources that exist elsewhere or outside—while asking themselves, "How do I know that these things give off light?"

Review the Activity Page with students. In answering the question, "How can you describe the light?" students should be encouraged to write any quality of light that comes to mind. Let students know that there is not one correct answer for this column and that all they need to do is describe light.

Give students time to make and record their observations.

SUPPORT—Some students may confuse things that emit light—or light sources—for light itself. For example, they may refer to a light bulb as light itself. Be sure to help students understand that sources of light are where the light comes from or are what emits/transforms other forms of energy to light and not the light itself. The light itself moves/transfers out of the thing that emits it, which is why students are able to see it.

Prepare Core Vocabulary Cards

Write the following terms on the board. Have students prepare cards for their Core Vocabulary decks by writing each term in the upper-left corner of a card. Remind students to pay special attention for these terms and to add notes and definitions to their cards over the next three lessons.

light **light wave** **transparency/transparent**
light source **reflect**

2. Encourage student questions. 5 min

Lead a discussion about the examples that students recorded. Ask volunteers to share some of their examples, and write them on the board or chart paper. Draw attention to the ones that are the same or similar. Then have students state any questions they have about light. As students ask questions, encourage them to think about how the questions could best be answered. Ask: Can the question be tested scientifically? If so, how?

SUPPORT—Go back to the Big Questions about waves from Lessons 1–7. Have students reflect on and discuss how they came up with answers to these questions. In many cases, they conducted tests or learned about tests that other people conducted to answer those questions. Have students apply some of those tests to the questions about light. Which ones work, and which ones do not?

SUPPORT—Remind students of the vocabulary words they learned in Unit 1, including *evidence*, *observation*, and *predict*. If they need a refresher, have them pull out their Core Vocabulary card for *evidence*. Ask students how these words could be used to determine the answers to the questions they have formed.

3. Demonstrate examples and guide discussion. 25 MIN

Demonstrate the first activity to show students an example of a light source. Then set up stations for the remainder of the activities to help students understand light sources and stimulate further discussion. You may wish to write simple directions for each activity and place those directions at each station. Then separate students into small groups, and have them move from station to station, performing each activity for themselves. If time permits, perform the sixth demonstration. Students may not be able to complete a full cycle through all the stations, so choose a specific number, such as three or four, that students have to complete. You may also wish to have a different student turn off the lights for each round of students cycling through the stations. Analyze the following with students: 1) the qualities of light, 2) how the light behaves, and 3) how we perceive the light. (See **Know the Science 1–4** for support with the analysis.)

Know the Science

1. What is the source of the light we see? ***Light is either emitted from its original source or reflected off other materials, enabling us to see the material/object.*** Certain objects, such as burning candles, emit their own light. The reason a table around the candle "lights up" is that light reflects (bounces) off its surface. The table itself is not emitting light and is therefore not a light source. Certain materials or surfaces reflect light better than others. For example, polished metal surfaces can reflect a lot of light, while dull or rough surfaces do not reflect much light. Reflection and absorption will be explored in more depth during Lesson 9.

2. Is light bright or dim? ***Light can be described as either bright or dim.*** Students may be familiar with the everyday terms *bright* and *dim*. These are subjective terms, but they get students thinking about characteristics and properties of light. Light that is very bright is more intense and carries more energy than light that is dull or dim.

3. How does a prism work? ***Light waves are refracted in a semitransparent prism.*** Transparency is a descriptive quality that means see-through. A prism works by refracting, or bending, light as light waves pass through it. Each frequency of light bends a bit differently than any other frequency. Refraction refers to changing the direction of a wave, such as a light wave. When a light source, such as a flashlight, is shined onto one side of the prism, the light will bend and appear on the other side of the prism. We will see different colors emerge because each color has a different frequency.

4. Can light pass through all objects? ***No. Glass is transparent, but not all objects are.*** Light travels through glass, so the glass is described by the property of transparency. However, light won't go through all solids. Nontransparent objects reflect light by "blocking" light from passing through them. Objects that reflect light are described as opaque.

- Light a candle with a match or candle lighter. Exercise proper lab safety precautions and adhere to your school's safety procedures at all times. Turn the lights off in the classroom so that the room is dark. Ask students what they observe.
    - » What colors do you see in the light? (*Answers will vary but will likely include yellow, orange, and possibly blue.*)
    - » Is the light bright or dim? (*dim compared, for example, to daylight*)
    - » How are we able to see this light? (*Light energy transfers to our eyes.*)
    - » Look at the table next to the candle. It is glowing. Does the table give off light? (*no*)
- Stick glow-in-the-dark stickers onto a poster board. Turn the lights off in the classroom so that the room is dark. Ask students what they notice.
    - » Is this light? How do you know? (*Yes. I know because it is visible.*)
    - » What colors do you see in the light? (*The answer depends on the type of stickers.*)
    - » Is the light bright or dim? (*dim*)
    - » Look at objects next to the stickers. Do they give off light? (*little, if any*)
- Show students an intact glow stick. Turn the lights off in the classroom so the room is dark. Break the glow stick so it activates and starts to glow. Ask students what they notice.
    - » Is this an example of light? (*yes*) How do you know? (*It is visible.*)
    - » What colors do you see in the light? (*Answer depends on variety of materials.*)
    - » Is the light bright or dim? (*dim compared to daylight*)
    - » Look at objects next to the glow stick. Do they give off light? (*no*)
- Show students a prism. Arrange the prism next to a sheet of white poster board. Turn off the lights so that the classroom is dark. Shine a flashlight onto one side of the prism, and watch as a rainbow of colors appears on the white poster board. Ask students what they see.
    - » Is this an example of light? Why or why not? (*Students should indicate that the source of light is the flashlight, not the prism.*)
    - » What colors do you see? (*The full spectrum should be visible.*)
    - » Is the light bright or dim? (*bright in a focused spot but dim compared to daylight*)
    - » How else could you describe this light? (*colored, rainbow*)
- Show students the clear piece of glass and the wooden block. Turn off the lights so that the classroom is dark. Shine a flashlight through the piece of glass. Then do the same for the wooden block. Ask students to describe the behavior of the light.
    - » What is the light doing? (*It passes through the glass but is blocked by the block.*)

» Why can the light go through the glass? (*The glass is transparent.*)

» Why doesn't the light go through the wooden block? (*The wood is not transparent. It is opaque.*)

- Turn a lamp (with a light bulb) on and off in a dark classroom. Ask students what they observe.

  » How would you describe this light? Is it bright? (*Answers will vary depending on the lamp and bulb.*)

  » What colors do you see in the light? (*Students will likely say, "white"; the bulb may produce slightly yellow or blue light.*)

4. Summarize and discuss. 5 MIN

Tell students that they just observed different sources of light, or things that emit light energy. Discuss with students the qualities of light that they noticed in the demonstrations, such as dimness, brightness, color, and behaviors of light (such as how light interacts with matter, passing through some objects unchanged, changing when passing through others, or being "blocked" by others still). Explain that light is an example of energy transfer, referencing their previous learning from CKSci Grade 4 Unit 1 *Energy Transfer and Transformation*.

SUPPORT—Return to students' questions that they posed on Find the Light (AP 8.1). Ask if anyone's questions have been answered and how or if they might refine their questions based on the new examples they have explored in this lesson.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 8.1) for sample student responses.

- Collect the completed Find the Light (AP 8.1). Scan the questions that students posed about the light sources observed in the classroom. Before starting the next lesson, choose one or two questions (such as "How does light behave?") to present to the class to kickstart Lesson 9. Use the discussion as an opportunity to reinforce main ideas about the qualities of light and to correct misconceptions. For example, some students may believe that a transparent object may be nonreflective. However, all visible objects reflect some amount of light, or we would not be able to see them. For example, windows are transparent, but we can still see them, especially if we're close up or there is bright light shining on them.

LESSON 9

Light Waves

Big Question: How does light behave?

At a Glance

Learning Objectives

- ✓ Identify sources of light.
- ✓ Describe examples that illustrate how light waves travel and interact with matter.
- ✓ Draw a model of the path of light from its source to its interactions with an object.

Lesson Activities

- reading
- observation
- discussion and writing

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Science and Engineering Practices: Developing and Using Models, Scientific Knowledge Is Based on Empirical Evidence

Developing and Using Models is important to this lesson because light waves are often represented by models. In this lesson, students read about light and its various behaviors and then develop their own simple drawing of how light behaves based on what they have learned. This will also help prepare students to investigate how light creates changes through a solar oven activity in Lesson 10.

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 162–163 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.

absorb	emit	**light source**	**reflect**
color	**light**	**light wave**	**transparency/transparent**

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

Student Reader, Chapter 3
"Light Waves"

Activity Page

AP 9.1

Activity Page
Light Behaviors (AP 9.1)

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

Materials and Equipment

Collect or prepare the following items:

- tracing paper
- flashlight
- clear glass
- water
- straw
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

The Core Lesson 45 min

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

Online Resources

How does light behave? To build on what students learned in Lesson 8, open this lesson with a brief video, "Flashlight Beam Tag," that shows light and how it originates from a source and travels in straight lines as waves that reflect off of an object for us to see. This will act both as a refresher for students' prior knowledge and to pique their interest in what they will learn in the Student Reader. (See the Online Resources for a link to a suggested video.) Ask what students can observe in the video and if they have any questions. Then use the following questions to promote discussion:

» What is an example of a light source? (*lighthouse, flashlight, sun, laser*)

» Why do we even see the light beam? (*because light energy reflects off of some material to reach our eyes*)

» How did the light travel? (*a straight path*)

» What would happen if an object gets in the way of the light? (*the light may be blocked from our sight, but the object will be lit at some place.*)

Have students keep the different sources of light in mind as they go through the remainder of the lesson. They will be asked to compare what they have learned in the video to what they will learn from their Student Reader.

2. Read and discuss: "Light Waves." 20 min

Student Reader

Ch. 3

Read together, or have students read independently, "Light Waves," Chapter 3 in the Student Reader. The selection reinforces the ideas that light is a form of energy that travels as waves and that light interacts in various ways with matter.

Preview Core Vocabulary Terms

Before students read, write these terms on the board. Encourage students to pay special attention to these terms as they read.

absorb	**light**	**light wave**	**transparency/transparent**
color	**light source**	**reflect**	

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 13

After students have read the page, ask them if they have ever seen the sunlight shine through a grouping of trees, bushes, or even clouds. Ask:

» What evidence is there that light transfers energy to the tree? (*The tree's leaves and branches are lit by light, and shadows are cast behind them.*)

» What happened when the sunlight passed between the tree's leaves and branches? (*The light continued and was not interrupted.*)

SUPPORT—The discussion of light in the text says that light waves transfer and pass through certain kinds of matter. Have students look at the picture more closely and use it to provide evidence for the statement. They should understand that the light waves cannot pass through the matter that makes up the trees but that they can pass through the matter that makes up air.

Pages 14–15

Prompt students to reflect on Lesson 8 and the various light sources that they saw examples of (flashlight, glow stick, lamp, etc.). Then prompt them about what they have learned so far about waves, such as sound and water waves. Explain that light is another form of energy that moves in waves. Refer students to the part of the page that talks about how fast light waves travel. Note that 8 minutes and 20 seconds is an average, and briefly explain that Earth's elliptical orbit varies Earth's distance from the sun, so this number can sometimes change.

Online Resources

SUPPORT—If needed and there's time, allow students to watch a video about how light and heat from the sun are formed by a chemical reaction known as fusion. (See the Online Resources for a link to a suggested video.) (See **Know the Science 1**.)

SUPPORT—To help students comprehend the relationship between the sun and Earth, use a globe to model Earth. Then use something, such as your desk, to represent the sun. Move the globe as far away from the desk as possible, and tell students that the distance between them represents the distance between Earth and the sun—93 million miles (150 million kilometers).

Know the Science

1. What is fusion? ***The process that powers the sun and other stars!*** When the nuclei of two hydrogen atoms combine, or fuse together, they form a helium atom. It takes tremendous speed and force to cause the two hydrogen nuclei to fuse. This happens because the sun is a giant mass of atoms and its gravity is always pulling those atoms together. The impact between the atoms is so great that, while they do fuse together, they also release a tremendous amount of energy. This energy is the light we see and heat we feel from the sun, which moves outward from the sun to anything in its path, including Earth and the other planets in our solar system. Light and heat from the sun is what enables us to see things and to survive in our environments.

Pages 16–17 Discuss with students the light sources depicted in the image of the campsite. Ask students to name the objects that are lit up in the image. To help them in anticipation of the Activity Page exercise, ask the following:

» What sources of light might campers use to help light up the insides of their tents? (*lamps, flashlights*)

» The image shows the moon shining down on campers. What is the actual light source for the moon? (*the sun*)

» Why are the moon and tent lit up? (*The moon is reflecting sunlight. The tents have light sources inside that are visible through their material.*)

CHALLENGE—Ask: Why is *moonlight* a misleading term? What's the actual source of the light we see from the moon? Have students supply evidence to support their answers.

See if students can come up with other examples of translucent objects that are not mentioned in the Student Reader. Examples may include tracing paper, thin pieces of plastic, ice, and light bulbs.

SUPPORT—If needed and there's time, show students a piece of tracing paper, and shine a flashlight through it. Allow students to see firsthand how translucent objects allow light, or some light, to pass through them. You may need to turn the lights off in the classroom for this demonstration.

Pages 18–19 After reading the pages, return to the Big Question, and ask: How does light behave? Have students think of the different characteristics of light, such as color (wavelength), brightness (amplitude), and its interactions with matter (absorption, reflection, etc.). These are examples of different ways that light can behave. Support students as they compare and contrast the diagrams of the two light waves on page 19, and help them connect these models to real-world experience. For example, since the top wave has higher crests and lower troughs, it has a greater amplitude. Since we know that amplitude refers to brightness, we can conclude that the top wave will be brighter than the bottom wave. Also, because they have the same wavelength, they must be the same color.

SUPPORT—If needed and there's time, review with students the different properties of waves. Draw a wave on the front board, and have the class help you label the wave. Ask:

» What is the crest of the wave? (*the highest part of a wave*)

» What is the trough of the wave? (*the lowest part of a wave*)

» What is wavelength? (*the distance from crest to crest*)

Point out to students that the crests and troughs can vary in waves depending on the amount of energy transferred into them, making the light brighter or dimmer.

Page 20 Explain that light is able to change direction and bend at the corners of barriers because light is a wave. A wave's wavelength and speed can be affected by its interactions with different kinds of matter. (See **Know the Science 2**.) Different types of matter have varying effects on light and thus can change what the light does and how we experience it.

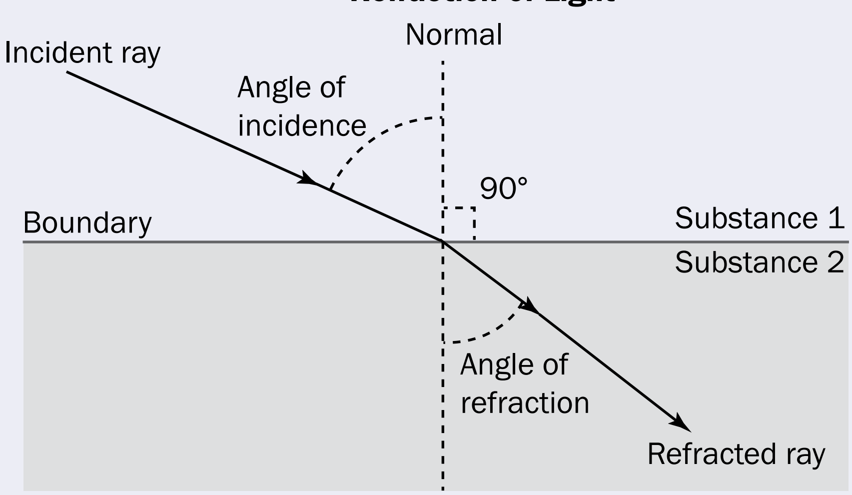
> **SUPPORT**—If needed and there's time, demonstrate for students how light can bend. Fill a clear glass with water, and place a straw into the glass. Have students observe the way that the part of the straw that is underwater appears to be broken from the part of the straw that is above water. Encourage students to share their thinking about what causes this to occur, using evidence from the text to support their explanations.

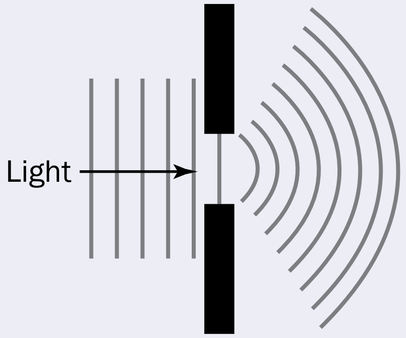
Refer to the paragraph that discusses how light waves can cause change and be converted (transformed) to other forms of energy. Refer students back to the examples in Unit 1 related to energy transfer and transformation. Energy can be **transferred** from place to place or from object to object (such as in collisions). Energy can also **transform** from one type of energy to another (such as from light to heat). Pique student interest in lessons to come by mentioning that students will learn more about this phenomenon of light causing change and transformation later in the unit, when they build and investigate solar ovens.

Know the Science

2. Why can light change direction and bend? *Refraction and diffraction!* Refraction is a phenomenon in which a wave (in this case, a light wave) changes direction due to a change in speed when the light passes from one medium to another. Diffraction occurs when light spreads out to get around obstacles. These terms are used to identify specific behaviors of light, although students are not expected to describe the differences between these two terms and the concept of reflection. The below diagrams can be used to enhance teacher comprehension, though students are not required to see these diagrams and there is no assessment for students at this level to describe the two phenomena. It can be discussed with students that engineers use the concepts of refraction and diffraction to design and build certain types of technology, such as lasers and high-powered radios, that can be used for space or air travel, as well as for information technologies.

Refraction of Light





Pages 21–22

Reiterate for students that different animals have different types of eyes (for instance, the two eyes on a fish are different in number and structure when compared to the eight eyes of a spider!) but that all of them have one thing in common: they gather light, in some special way, to see. (You might also explain that some animals are born blind even though they have eyes, such as moles or certain types of fish, at which point they depend on other senses to navigate their environments.) (See **Know the Science 3**.)

Focus student attention on the paragraph that discusses plants and how they are able to sense the direction of light. Ask students if they have ever seen a plant growing toward one side. This is because the plant is growing toward the light. (See **Know the Science 4**.)

3. Facilitate student modeling. 10 MIN

Activity Page

AP 9.1

Introduce Light Behaviors (AP 9.1). Explain to students that they will complete the Activity Page based on what they have learned so far in this lesson. Introduce the directions with students, but do not make any drawings or models, as this activity is designed to help students model the behaviors of light on their own. Explain that their models will help them prepare for the next lesson, where they will design and build a device that uses light to make changes to solve a problem.

> **SUPPORT**—If needed, help students by writing terms related to the behavior of light on the board, but do not place them in any kind of context. These can include *reflect*, *absorb*, *bending*, *changing direction*, and *radiating*. You may also help students start their models by asking volunteers to identify the kinds of light sources and/or objects that they might represent in their illustrated model.

Know the Science

3. Do all animals have the same level of vision? ***No!*** Not only do animal eyes come in various shapes, sizes, colors, and numbers, but different animals also have different levels of vision. Eagles, for instance, have the ability to shift their visual focus so quickly that they can practically zoom in on things that are far away. Eagles can also see a wider range of colors than other types of birds. Owl eyes, on the other hand, have more light sensitivity, allowing them to see better at night than during the day. Mantis shrimp have specialized eyes that give them the ability to see more colors (more than humans), allowing them to detect changes in their environment that would not be noticeable to the human eye. The extreme range of animal vision plays an important role in an animal's ability to survive in its environment.

4. How do plants detect the direction of incoming light? ***Internal chemistry!*** Plants can orient themselves in response to light, either growing toward (positive phototropism) or away from (negative phototropism) a light source. Growing toward light gives plants a chance to receive greater benefits that light provides, and growing away from certain types of light can help protect a plant from something that is recognized as harmful or dangerous. During phototropism, the plant's internal chemistry changes on a cellular level, telling the stem and leaves, for example, to enlarge in a specific direction. (See the Online Resources for a link to a suggested video.)

After time enough for students to complete their diagrams, approximately five minutes, lead a discussion about the examples that students drew on the Activity Page. Ask volunteers to share their models. Point out student drawings that are similar, and ask students to explain and identify any predictable patterns that they see. (*Light travels in straight lines, passes through some objects/types of matter but not others, etc.*) However, there can be variations in light waves, which would affect whether light bends or is reflected, its color, its brightness, etc. Use the models to illustrate these variations, noting creative ways that students represented the phenomenon of light. To help promote discussion, ask the following:

» How is what you read in the Student Reader similar to what you saw in the video at the beginning of the lesson? (*Sample answer: It shows that light travels in a straight line.*)

» How is what you read different from what you saw demonstrated in the previous lesson? (*Answers will vary.*)

You may also use the Activity Page Answer Key for AP 9.1 to help you look for and discuss key aspects of an exemplary model of light.

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Ask students to prepare new cards for *absorb* and *color* and add notes to the cards that they previously prepared for the other terms.

absorb	**light**	**light wave**	**transparency/transparent**
color	**light source**	**reflect**	

Word Work

- **absorb:** (v. to take something in and contain it) Point out that *absorb* is a term that students may have heard in day-to-day life, such as to *absorb* information like a sponge. Ask volunteers to use *absorb* in a sentence. Encourage sentences that use *absorb* in relation to light. (*The cardboard absorbs the sunlight.*) Have students write on their card a definition of *absorb* in their own words. Point out that *absorb* is the opposite of *reflect*.
- **light:** (n. a form of energy that can transfer through empty space and can make things visible) Have students write the definition of *light* in their own words. Then have them use it in a sentence.
- **light source:** (n. an object that gives off its own light) Ask students to name four sources of light. Tell them they can use examples from this lesson. Then have them draw the primary source of light for Earth. (*the sun*)

- **light wave:** (n. an energy disturbance that transfers, or radiates, light) Tell students that light waves transfer, or radiate, light energy. Then ask them to write down three other words that come to mind when they think about a light wave. (*crest, trough, amplitude*)
- **reflect:** (v. to bounce off of) Point out that *reflect* is the opposite of *absorb*. Brainstorm with students three or more examples of objects that light can reflect off of. (*mirrors, water, aluminum foil*) On their cards, have students draw a picture of light reflecting off of a surface.
- **color:** (n. an aspect of light that enables otherwise identical objects to be distinguished from each other through the sense of sight [vision]) An intuitive interpretation of color and naming colors are among the first structured learning exercises many very young children experience. However, a precise definition of what color means can be challenging to articulate. Instruct students to write a sentence about color also using the words *light* and *reflect*.
- **transparency/transparent:** (n. a property of matter that allows light to pass through it)/(adj. allowing light to pass through) Have students write examples of transparent materials on their Core Vocabulary card.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 9.1) for correct answers and sample student responses.

- Collect the completed Light Behaviors (AP 9.1) as students work on their vocabulary words. Scan the drawings that students created to model light. If models do not clearly demonstrate understanding of light, engage in further discussion, emphasizing any labels or details that are missing and why they are important to the model (light source, path of light, how it interacts with an object/example of matter). Use the Activity Page Answer Key for AP 9.1 as a guide for exemplary work at this grade.
- Choose one or two additional models to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas about how light behaves.

LESSON 10

Investigating Light and Change

Big Question: How does light cause change?

At a Glance

Learning Objective

✓ Describe examples of changes caused by the energy of light waves.

Lesson Activities (2 days)

- teacher demonstration
- student investigation
- discussion and writing

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Science and Engineering Practices: Developing and Using Models, Developing Possible Design Solutions

Developing and Using Models and **Developing Possible Design Solutions** are important to this lesson because models of light energy will help students understand that light waves cause change. In this two-day lesson, students will interpret scientific models and develop a solar oven from a given design plan to investigate how light energy can cause changes to physical objects. Students will also discuss ways that scientists and engineers use this core idea to benefit people.

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.

absorb	light	light wave
color	light source	reflect

Instructional Resources

Activity Pages

AP 10.1
AP 10.2

Activity Pages
Build a Solar Oven (AP 10.1)

Test Your Solar Oven (AP 10.2)

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

Materials and Equipment

Collect or prepare the following items:

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

For Demonstration

- 3 clear balloons
- black balloon
- magnifying glass

Day 1 (one of each per pair of students)

- scissors
- glue bottles/glue sticks
- pizza box (or similar small box)
- aluminum foil
- black construction paper
- ruler
- transparent plastic wrap

Day 2 (one of each per pair of students)

- pencils
- crayons (with paper removed)
- small amount of butter
- rock
- (optional) other objects that will change in a solar oven

Encourage students to investigate different ways to make a solar cooker. You may choose to provide them with reference materials with images or a video. (The video is listed under Step 3 later in the lesson.)

Advance Preparation

- Blow up one of the clear balloons, temporarily clamping the end, but do not tie it off.
- Partially insert the black balloon inside the clear balloon that is blown up, and partially inflate the black balloon inside the other balloon. Tie off both balloons, with the black balloon inside the clear balloon.
- Repeat these steps with the remaining two clear balloons, putting one balloon inside the other. Use the video to help. (See the Online Resources for a link to a suggested video.)

Online Resources

For Day 2, designate an outdoor or indoor area for students to test their solar ovens in direct sunlight for approximately fifteen to twenty minutes. If it is overcast or rainy on Day 2, you will need to wait for a clear day or supplement their investigation with a daylight lamp.

The Core Lesson TWO DAYS, 45 MIN EACH

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

How does light cause change? Remind students that light energy travels as waves, using previous examples and models as support. Ask students to describe the energy of waves, using their prior knowledge as evidence of their thinking. As a reminder, ask the following:

» How do water waves cause change?

» How do sound waves cause change?

Ask students to start thinking about how light energy can also cause change. Promote student thinking by asking them to consider sunlight. For example, "If people stand in direct sunlight for many hours, what happens?" (*Sunlight can cause people to become very hot and/or their skin to burn.*) Remind students that energy from the sun travels in waves, or patterns of energy transfer. Students can observe this energy when they see a beam of sunlight breaking through a cloud.

Ask students to consider a blacktop or asphalt road on a sunny day. Promote student thinking by asking whether they have seen evidence of energy in/around the asphalt when the sun was shining on it. Explain that phenomena such as bubbles and steam rising from the asphalt are examples of changes caused by the energy of light waves. Have students come up with examples of other kinds of changes that light can cause. (*Bright lights can cause temporary or permanent blindness in some organisms with eyes. Light can cause objects to heat up, resulting in an object cooking, baking, or melting. Light that is concentrated can cause some objects, such as wood or dry grass, to catch fire.*) (See **Know the Science 1** to help with analysis.)

Know the Science

1. How does light cause changes? ***Energy transfer!*** Energy from the sun is transferred to Earth, where light waves interact with matter. This interaction between light waves and matter causes a change that we can observe because of energy transformations. When light strikes objects, those objects absorb the light, which causes molecules to vibrate or rotate. When molecules vibrate or rotate, energy is produced, making heat. Photons of light can also collide with electrons, which transfers energy from the photons to the electrons. These electrons can then transfer energy to atoms and molecules. One by-product of energy transfers is heat. Therefore, light transfer makes heat. Consider the example described earlier: Sunlight strikes blacktop or asphalt. The blacktop or asphalt absorbs some of that energy, while some of the energy is reflected. In the case of both the absorption and the reflection, heat is transferred, causing the surface of the roadway to become much hotter than the surrounding area.

2. Demonstrate examples and guide discussion. 10 MIN

Take out the clear balloon with a black balloon partially inflated inside it (prepared before Day 1). Ask students to predict what will happen when you hold a magnifying glass to the balloons and focus the sunlight on the clear balloon. You can record their predictions on the front board or chart paper or have students write their questions down for reference later in the lesson. After allowing students to share their questions and ideas about possible answers, take the class outside or to a window where the sunlight is streaming in. Hold up the balloon in the sunlight. Place the magnifying glass between the sunlight and the balloon so that it focuses the light onto the balloon. Do this until the black balloon inside pops. Ask the following:

- » Was your prediction correct? (*yes, no, or partially correct*)
- » What changed, and what stayed the same? (*The black balloon got bigger, but the clear balloon did not change much.*)
- » What caused the black balloon to pop? (*The black balloon absorbs more light and heat energy than the clear balloon, so the black balloon swells faster and pops from the heat.*)
- » What do you think will happen if we do the same activity with two clear balloons? (*The inside balloon probably will not pop, because it will not absorb more heat.*)

Repeat the activity with the two clear balloons you prepared before class. Ask the following:

- » What changed, and what stayed the same? (*Results may vary, but there should be little change in the interior balloon.*)
- » What caused the change? (*energy*)
- » Was it the same thing as the black balloon example? (*no*)

3. Preview the investigation. 5 MIN

Online Resources

Introduce students to the concept of solar ovens. Tell students that, over the course of two days, there will be enough time to build their own ovens. On the first day, they will design a plan to build an oven using a given set of materials and then build it. On the second day, they will test their ovens to investigate how they work and the kinds of changes that light waves can cause.

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

Activity Page

AP 10.1

www.coreknowledge.org/cksci-online-resources

Separate students into pairs, and distribute Build a Solar Oven (AP 10.1). Review the Activity Page with students, and pass out or direct students to the materials that each pair will use to investigate light.

Explain that students will craft a solar oven from the materials provided but that the final design plan is up to them. Lead a discussion about the materials and how solar ovens work (i.e., they use light from the sun to make changes to objects or materials;

this is possible thanks to energy transfer and transformation as the light interacts with matter). Students may have questions about how to make certain parts of the oven. Help students brainstorm ways that each of the materials might be used, and assure them that you will go around the room to answer questions as they get started.

4. Facilitate the design process. 25 MIN

Give students between five and ten minutes to come up with a design plan to build their solar ovens from the materials each pair has been given. Build a Solar Oven (AP 10.1) includes a space for students to describe how their oven will be made. Before they put their plan into motion, have each pair describe their design to you for your approval. You may choose to compare their plans to the sample plan presented on the following page.

SUPPORT—If parts of the student pairs' plans appear to be too far from the goal, ask guiding questions to get them back on track rather than telling them outright what to do. If this still does not work, you may allow them to research how to make a pizza box solar oven on the internet. You may wish to give students a suggested website to use in their research.

Use Science Practices

Circulate throughout the room, providing support as necessary. Encourage students to think about and describe what they know about energy that supports their design plan. Ask questions such as the following:

- How will the aluminum foil help light make a change? (*The foil is a smooth surface, so it will bend the light and direct it to the oven.*)
- How will the black construction paper help light make a change? (*The black paper will absorb the light and increase the heat.*) (See **Know the Science 2–4**.)

Know the Science

2. How will aluminum foil help light make a change? *It directs light onto the object in the solar oven.* Smooth surfaces reflect light better than rough surfaces. Metal surfaces also tend to reflect light better than nonmetal surfaces. Aluminum foil is a smooth metal and has a high potential to reflect light. Reflecting the light onto a specific object or area can result in an energy transformation, raising the temperature of that object or in that area. This transformation, using light waves (actually the infrared wavelengths) to heat objects, can be useful to people such as when baking foods or intentionally melting objects.

3. How will the black construction paper help light make a change? *It absorbs light, helping warm or cook any object sitting on it.* Objects that are black absorb more light than objects that are different colors. The black construction paper, then, helps absorb light—in a specific area.

4. What is the relationship between heat and light? *Only certain wavelengths of light will heat matter.* What we think of as the heat of sunlight is the result of the infrared wavelengths of light interacting with matter. These are the "heat-carrying" wavelengths because they interact with common matter to increase the movements of molecules. We feel sunlight hot on our arms on a summer day because infrared light rays stimulate the matter that makes up our skin.

As students check their plans with you, be sure to draw students' attention to the engineering practices that they are engaged with: developing possible solutions to design problems. In this case, students are provided with the criteria and constraints of the problem (i.e., to build a solar oven with the given materials), but this scaffolded approach in Lesson 10 will provide students a concrete experience with the design process before they dive deeper into open-ended design problems later in this unit during Part D "People Use Waves to Transfer Information," Lessons 12–14.

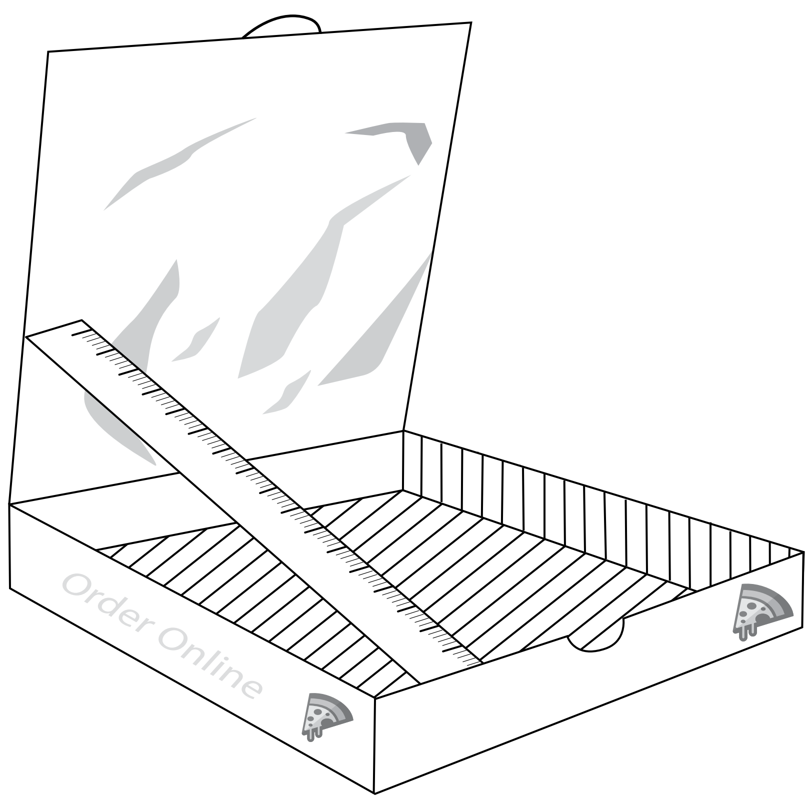
As students finish building their solar ovens, have students write their names somewhere on their ovens and turn them in. They should also complete their Activity Pages and turn them in as well. Tell students that in the next class period, they will test their models to see if they work.

Guidance for Building a Pizza Box Solar Oven

STEP 1 Use scissors to remove the folding edges of the pizza box lid, and place aluminum foil over the inside of the remaining lid. Make it as smooth as possible. Wrap the aluminum foil tightly around the edges of the lid so that it does not fall off. The shiny side of the foil should face out.

STEP 2 Line the bottom of the pizza box with black construction paper. Glue it down so that it cannot move or fall out if the box is moved.

STEP 3 Use the ruler to prop the lid of the box open. You may encourage students to use transparent wrap to keep the heat in.



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

How does light cause change? Remind students that during Day 1, they observed a demonstration with balloons in which light waves caused a change. Remind them that they also made a solar oven to investigate the kinds of changes that light waves can cause. Ask a few student pairs the following questions:

» How does a solar oven work? (*It is heated by the sun.*)

» What do you think you can do with your solar oven? (*I can use solar light and foil to direct the light waves and heat the solar oven.*)

Prompt students to think about different things they can change using their solar ovens by directing or focusing light waves. Ask them to make a list of three to five different objects that might change when placed in their oven and then predict how they think the solar ovens would affect those objects. For example, "Would the solar ovens cause changes to the object? If so, what changes would they cause and why?"

Point students to the area you have chosen, either in the classroom (such as along a window where the sun shines in) or on the school grounds, where students will test their solar ovens.

NOTE: There may be times when, due to cloudy skies or the time of year (when the sun is less direct in the sky), the solar ovens do not work as intended. If this occurs, inform students as to the reason you believe the ovens didn't work, and show them a video of one actually working.

2. Encourage student questions. 5 MIN

Before students begin testing their solar ovens, have them share any questions they may still have. These questions can be about anything they learned the day before or about the building of the ovens themselves. Engage in a short class discussion, encouraging other students to answer questions they know the answers to.

3. Support the investigation. 25 MIN

Let students know that, if necessary, they can use the first few minutes of class to complete their solar ovens if they did not get them finished during Day 1.

Activity Page

AP 10.2

Divide students into the same pairs from Day 1, and introduce the directions for Test Your Solar Oven (AP 10.2). Pass out the remaining materials (a pencil, a crayon, a small amount of butter, and a rock) to each pair. The paper should be removed from the crayon. Explain that students will now take their solar ovens and place them in the area you have chosen. Ask them to place their solar ovens in the area in such a way as to take full advantage of the sunlight. (The light should reflect off the aluminum foil and onto the black construction paper.) Have them place their objects inside the solar oven, spaced an equal distance apart. Explain that they will leave their solar ovens in the sun for approximately fifteen to twenty minutes.

While students are waiting, have them predict what will happen to each of the objects in the solar ovens. Use the following prompts:

» What will happen to the pencil? (*It may get a little warm, but it won't get hot enough to burn.*)

» What changes do you expect to see in the crayon? (*The crayon will slowly melt.*)

» What will happen to the butter? (*The butter will melt quickly.*)

» What changes do you expect to see in the rock? (*The rock will get too hot to touch, but it will not change form.*)

Have students complete the prediction part of their Day 2 Activity Page, as well as answer the question that follows.

Online Resources

When time is up, have students return to their solar ovens and complete the Activity Page. You may also choose to show students a video about harnessing the power of the sun to meet our energy needs. (See the Online Resources Guide for a link to a suggested video.)

SUPPORT—Review the Activity Page table where students will record their observations. If students are confused, model how to complete the table for them using an object other than those the students used in the actual activity.

Ask students whether their predictions were correct. If they were not, ask students what was different and why. In the end, students should observe that the pencil and the rock were warmer than they were before but that neither changed form. The crayon, however, began to melt or melted completely, depending on the heat. The butter likely melted completely.

Have students remove the objects from the solar oven. The pencil can be reused, the crayon and butter discarded properly, and the rock placed in a garden or natural area around the school.

Safety Note: The solar ovens and the objects inside them may be hot to the touch. When students pick up the ovens or remove the objects from them, make sure their hands are properly protected with gloves or other insulating materials.

4. Summarize and discuss connections. 5 MIN

Now that students have learned how light can cause change, lead them to understand how scientists and engineers use this knowledge to benefit people. Provide students with an example of one technology that makes use of light. For example, solar panels absorb light, convert it, and store the energy to be used later. The interactions of light and solar panels can generate energy that is used to heat homes and office buildings or power industries. Many streetlights along busy roads are also designed to be powered by energy from the sun. Ask students to provide examples of their own.

Help students understand that science, engineering, and technology are all closely related. Scientists study the natural phenomenon of light to learn more about how it can be harnessed to produce energy. Engineers then design and build devices that can harness the energy from light to solve problems, such as heating buildings more efficiently or operating street lights. Technology includes the products that engineers design, such as solar panels, to harness the energy of light. In these ways, science, engineering, and technology have a real-world impact on humans, including students. Have students name other examples of science, engineering, and technology working together to solve a common problem. (*Example: Scientists study friction to come up with ways to help people get from place to place faster. Engineers build devices such as maglev trains or systems to fill potholes in roads, thereby helping people to get from place to place faster.*)

Preview future learning. Tell students that, during Lessons 12–14, they will learn about and design ways to use light and sound waves to transmit information. Ask students to name types of technology that use waves to transmit information. Examples might include cell phones, televisions, or other information technologies.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 10.1 and AP 10.2) for correct answers and sample student responses.

- Collect the completed Build a Solar Oven (AP 10.1) and Test Your Solar Oven (AP 10.2). Review student responses.
    - Day 1: Students should describe how their solar oven will work and build their models based on their designs. Students should be able to tell that a solar oven works when the aluminum foil directs energy from the sun onto the inside of the box.
    - Day 2: Students should record their observations of the objects placed inside the solar oven and the reasons that explain why they observed what they did. For instance, the crayon could melt when hot enough, but a rock would not. However, a rock could still become hot from the sunlight.

LESSON 11

Invisible Energy

Big Question: What are some different kinds of light waves?

At a Glance

Learning Objective

✓ Recognize that energy waves exist beyond the spectrum of visible light.

Lesson Activities

- demonstration
- reading
- discussion and writing

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Patterns are important to this lesson because wavelengths are an example of repeating patterns. The length of a light wave determines whether people can see it as visible light. Light waves that people cannot see have shorter or longer wavelengths than visible light waves that people can see. Collectively, these are known as electromagnetic radiation. In this lesson, students will learn about these light waves of all wavelengths (the electromagnetic spectrum) and how scientists and engineers use various wavelengths to benefit people.

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.

electromagnetic	light wave	reflect
light	radiation	

Instructional Resources

Student Reader

Ch. 4

Student Reader, Chapter 4
"Invisible Energy"

Activity Page

AP 11.1

Activity Page
Invisible Energy (AP 11.1)

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

Materials and Equipment

Collect or prepare the following items:

- microwave
- food item or liquid in a cup
- internet access and the means to project images/video for whole-class viewing

For the demonstration, have a food item that is easy to prepare and not messy, or a liquid such as water in a cup, ready to use in the microwave. Do not allow students to taste, eat, or drink the item.

THE CORE LESSON 45 MIN

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

What are some different kinds of light waves? Open the lesson with a short demonstration of a microwave oven. If you do not have a microwave oven in class, bring a small one from home, or if there's time, take students to an area of the school where there is one available. Place a piece of food or a cup of liquid in the microwave oven, and turn the oven on. Ask:

» What do you think will happen to the food or liquid placed in the microwave oven? (*It will heat up. If it heats too long, it may burn or boil.*)

» How do you know? (*That's what happens at home when I use the microwave.*)

» What do you think causes the changes to the food or liquid? (*It must use some kind of waves because it is called a microwave. A few students may understand that it uses radio waves that generate heat when applied to an object.*)

Have students keep the demonstration in mind as they go through the remainder of the lesson. They will be asked to compare what they have learned in the demonstration to what they will learn from their Student Reader.

2. Read and discuss: "Invisible Energy." 20 MIN

Student Reader

Ch. 4

Read together, or have students read independently, "Invisible Energy," Chapter 4 in the Student Reader. The selection reinforces the idea that not all waves in the light spectrum can be seen by the human eye.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Pages 23–24 After students have read page 24, ask them to look at the infrared image of the person on the bicycle. Point out that the image reveals that the back wheel is warmer than the front, as is the air around the back wheel. Ask students why they think this is. (*The center of gravity is not halfway between the front and back of the bicycle, which means that there is more weight pressing on the back tire. This means that that tire has more contact with the ground, resulting in more friction force acting on it. Also, torque, a kind of twisting force that causes rotation, is acting on the back tire, helping warm the air around the bicycle.*) Have volunteers discuss reasons why they cannot see this heat in real life, only in pictures from infrared cameras. Also ask the following:

» What does wavelength have to do with whether light waves are visible or invisible? (*The human eye can only see light that is within a certain range of wavelengths.*)

» Can light of any wavelength cause a change? (*yes, because all are forms of energy*)

Page 25 Prompt students to think about how wavelength affects what can be achieved with each type of wave. Ask the following:

» Which type of waves are most often used for communicating? (*radio waves*)

SUPPORT—Most students will be unfamiliar with radio waves. Explain that radio waves have been used for many things in the past and continue to be used for radio broadcasting, satellite communication, radar, and so on. (Note that students will learn more about radio waves and radar in the support for page 26.)

Page 26 Have students continue their discussion about the benefits of electromagnetic radiation by naming other devices and technology that use invisible light energy. (See **Know the Science 1**.) Ask the following:

» Do you or members of your family own any of these devices? If so, which ones?

» How do you use them and why?

SUPPORT—As a result of the reading so far, some students may come away believing that all electromagnetic radiation is helpful. Be sure to point them to the last paragraph on the page as well as to the example on page 24 of how too much ultraviolet light can cause sunburn. Have them name other ways that electromagnetic radiation can be harmful, but be aware of any issues that students may have and keep the conversation light.

Know the Science

1. What is radar? ***Radar is a radio-based electromagnetic system that detects objects!*** The word *radar* is an acronym, or a name made up of the first letters of each word in a longer name. *Radar* stands for **RA**dio **D**etecting **A**nd **R**anging. Note that the capitalized and boldfaced letters, when added together, form the word *radar*. Radar devices have a transmitter and a receiver. The transmitter sends out electromagnetic radiation, which may be radio waves or microwaves. These waves bounce off objects and return to the receiver. The receiver can then tell the operator of the radar system how large the object is, how far away it is, how fast it is moving, and in which direction it is moving. Radar is used for locating many things, including aircraft, ships, interstellar objects, and landmarks.

3. Encourage discussion. 15 MIN

Activity Page

AP 11.1

Introduce Invisible Energy (AP 11.1). Explain to students that they will complete the Activity Page based on what they have learned so far in the lesson. Allow them to consult their Student Reader if they struggle to complete the activity. Encourage students to compare the different types of electromagnetic radiation and to discuss their pros and cons.

Online Resources

If possible, project the image of the electromagnetic spectrum onto the board or chart paper.

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

> **SUPPORT**—Remind students of the microwave oven demonstration from the beginning of the lesson, and ask them what kind of electromagnetic radiation it used. (*microwaves*) Have them again describe what happened to the food or liquid and why, and have them compare their new answers with the answers they gave at the beginning of the lesson.

Lead a discussion about the examples students described in their tables. Ask volunteers to share their examples. Use additional guiding questions to help students link details in this discussion back to the Activity Page and the reading selection.

» What are some of the ways that waves can be helpful? (*Waves can supply heat, light, and radio signals.*)

» What are some of the ways that waves can be harmful? (*Waves that are too powerful can cause problems such as too much heat and radiation burns.*)

4. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 11.1) for correct answers and sample student responses.

- Collect the completed Invisible Energy (AP 11.1). Scan the tables that students completed. If students misidentified waves and what they are used for, engage in further discussion, emphasizing the correct information for what they got wrong.

PART D

People Use Waves to Transfer Information

Overview

Lesson	Big Question	Advance Preparation
12. Codes and Signals	What is a code?	Read Chapter 5 in the Student Reader.
13. Investigating Transfer of Information (3 days)	How can signals transfer information?	Gather materials for hands-on activity. (See Materials and Equipment, page 13.)
14. Using Signals	How are waves used to send signals?	Read Chapter 6 in the Student Reader.

Part D: What's the Story?

Patterns of sound and light waves can transfer information. This section builds on what students have already learned about sound waves and light waves to focus on how information can be sent by these waves of energy.

In Lesson 12, we start by focusing on wave patterns. Students read about light and sound transmitted over distance, as well as the physical symbols that are used to represent messages. The goal of this lesson is to emphasize patterns and describe what a code is.

In Lesson 13, students spend three days investigating how information is transferred through signals. They learn that people can cause waves to occur in patterns and then use these waves to communicate information. The goal of this lesson is for students to develop a code based on patterns that are tested and communicated and then transfer it over a distance using a signal.

In Lesson 14, students apply their knowledge of codes and signals to real-life uses of these communication techniques. They will look at different types of signals used in the everyday world, such as radio, binary codes, and fiber optics.

LESSON 12

Codes and Signals

Big Question: What is a code?

At a Glance

Learning Objective

✓ Describe an example of transforming a pattern into another form, still communicating the same information.

Lesson Activities

- demonstration
- reading
- discussion

NGSS References

Disciplinary Core Idea PS4.C: Information Technologies and Instrumentation

Crosscutting Concept: Patterns

A **pattern** is a regular or repeated way in which something occurs. Patterns are the basis of how most information is transferred today, often by light waves, sound waves, or radio waves. Broadcast stations, cell phones, and GPS devices transfer data, sound, and images using codes, which are patterns of symbols understood by the sender and the receiver. In this lesson, students will explore patterns, codes, and signals used for communication. They will understand the role of sound waves and light waves in some kinds of communications.

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 162–163 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.

code	**pattern**	**symbol**
gesture	**signal**	

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. 5

Student Reader, Chapter 5
"Codes and Signals"

Activity Page

AP 12.1

Activity Page
Decoding (AP 12.1)

Materials and Equipment

Collect or prepare the following items:

- flashlight
- smoke alarm
- index cards for student vocabulary deck (4 per student)

THE CORE LESSON 45 MIN

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

Activity Page

AP 12.1

What is a code? Open the lesson by presenting students with a series of symbols and asking them what each symbol represents. The symbols should be visual in nature and something most students can identify, such as a stop sign shape or other kinds of street signs (choose those without words, but do not use any that appear on the Activity Page), common emoji, the peace sign, or any other symbols you choose. Ask students to identify what each symbol represents.

Distribute Decoding (AP 12.1). Decode each of the symbols together. Then make a list of other common symbols. Then give students a minute to identify the type of wave used to communicate each type of code listed in the table.

Introduce the idea of a signal by testing the smoke alarm so that it makes a sound. Discuss how a smoke alarm uses a code and a pattern. Be sure students understand that signals act over a distance. Some signals can act over longer distances than others, depending on the type of wave and the medium (wires, air, or other) being used.

2. Read and discuss: "Codes and Signals." 15 MIN

Student Reader

Ch. 5

Read together, or have students read independently, "Codes and Signals," Chapter 5 in the Student Reader. The selection reinforces the idea that people can communicate by transferring a pattern into another form.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read.

code **pattern** **signal** **symbol**

Discuss the difference between gestures, symbols, patterns, codes, and signals. Refer to the words on the board or chart paper, and have students describe what each word means. Ask them to include examples of each.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 27 After students have read the page, have them each think of one gesture they can use to communicate a positive message, such as a smile, a thumbs-up, a head nod, or a high five. Then have them think of one gesture they can use to communicate a negative message. (Remind them that some negative gestures are not appropriate for the classroom and should be avoided.) If time allows, have each student or selected students perform the gesture and discuss what it communicates.

Pages 28–29 After reading the pages, discuss the advantages of using symbols and codes for communication. Discuss how students can communicate with babies who can't yet talk or with people who speak a different language.

Pages 30–31 Make a class list of different signals that students have encountered and what they communicate; for example, railroad crossing, fire alarm, alarm clock, low battery alert.

- Relate the sound and light signals to the previous lessons in which students learned about sound waves and light waves.

  SUPPORT—To reinforce the advantage of using gestures, symbols, signals, and codes to communicate with babies who can't talk yet or with people who do not speak the same language, have students play a brief version of Password in pairs. Whisper to one student an animal name (giraffe, wolf, cat, or whale, for example). Have that student use gestures, signals, or symbols to communicate the name of the animal.

Page 32 Discuss students' experiences with walkie-talkies, phones, and cell phones.

- Discuss how these devices translate one energy pattern into another to communicate.
- Explain that radio waves, like other types of waves, transfer energy from place to place. (See **Know the Science**.)

3. Encourage discussion. 10 MIN

- Review the different types of signals that students have discussed. Categorize them by energy type.
    - sound signals
    - light signals
    - motion signals
- With students, identify the pattern that each signal uses to communicate.
- With students, identify the type of energy and wave that each signal employs to communicate.
- Identify how each signal transforms a pattern of one form of energy to another to communicate.

SUPPORT—Remind students of the different types of waves they have studied in this unit, including light, sound, and water waves. Review the concept that waves transfer energy from one place to another. Have students identify the types of wave energy that are being transferred in an alarm clock (electrical energy to sound energy). Have them identify the pattern that is communicated. (*a ringing alarm*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students write each term in the upper left corner of an index card and underline it (one term per card).

symbol **code** **pattern** **signal**

Know the Science

How do baby sound monitors work? ***They transfer energy from one place to another.*** A baby monitor has a transmitter that receives sound waves a baby makes when it cries. The transmitter transforms the sound waves to radio waves. A receiver picks up the radio waves and transforms them back to sound so the parent can hear the baby cry.

Word Work

- **symbol:** (n. a visual object or mark that stands for something else) Remind students that they interact with a set of symbols every day, the alphabet. The alphabet is a series of characters that represent sounds that make up words. Have students recall additional symbols and describe what they stand for. (*For example, students might identify numerals that represent quantities or the colors red and green as standing for "stop" and "go."*)
- **code:** (n. a pattern of symbols that can be used to communicate a message) Extend the example of the alphabet here. Letters are symbols that represent sounds. Combinations of letters are words and sentences, which are codes. In the present technological era, students are likely already familiar with the use of *code* to mean computer programming language.
- **pattern:** (n. a regular or repeated way in which something occurs) Have students write a sentence or two explaining how patterns relate to symbols and codes. (*What makes a sender and receiver both understand a message is that they both recognize the pattern of symbols that make up a code.*)
- **signal:** (n. a symbol sent over a distance) Have students brainstorm other words in the *signal* word family, such as *sign, signature,* and *signing*. Discuss the related meaning in each word: a gesture, symbol, or action used to communicate a message.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 12.1) for correct answers and sample student responses.

- Collect the completed Decoding (AP 12.1). Scan the responses to see if students understand that codes are patterns that translate one pattern into another form.

LESSON 13

Investigating Transfer of Information

Big Question: How can signals transfer information?

At a Glance

Learning Objectives

✓ Describe an example of transforming a pattern into another form, still communicating the same information.

✓ Make a presentation showing how information can be transferred with patterns of light and sound.

✓ Analyze the merits of different solutions that use light or sound to transfer information.

Lesson Activities (3 days)

- student investigation
- student observation
- student presentation
- writing, discussion

NGSS References

Disciplinary Core Idea PS4.C: Information Technologies and Instrumentation

Disciplinary Core Idea ETS1.C: Optimizing the Design Solution

Crosscutting Concept: Patterns

Science and Engineering Practices: Constructing Explanations and Designing Solutions

Patterns are important to this three-day lesson because students will create codes as a way of understanding signals that use patterns to transmit information, and these signals may be encoded.

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 162–163 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.

code	**information**	**transfer**
digital	pattern	

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 Page

AP 13.1

Activity Page
Sending Coded Messages
(AP 13.1)

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

Materials and Equipment

Collect or prepare the following items:

- penlights
- flashlights
- hand mirrors
- colored fabric
- colored paper
- colored films
- plain paper
- grid paper
- string
- cardboard tubes
- pencils
- scissors
- tape
- rubber bands
- paper clips

Make the materials available to each pair of students, but allow students to select the materials they wish to use.

THE CORE LESSON THREE DAYS, 45 MIN EACH

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

How can signals transfer information? Tell students that they will conduct a hands-on activity for the next three days in which they will work in pairs to develop their own codes using patterns and that they will transfer these codes to a partner using signals.

Day 1: Students will develop their codes with their partner. They will then use light waves or sound waves in patterns to transfer their codes.

Day 2: Students will swap codes with another team and test the other team's method.

Day 3: Students will meet back up as a whole class for a discussion and analysis.

Prompt students to think about the things that make up a good code as they go through this lesson. Remind them that they learned about certain types of codes in the previous lesson.

Preview Core Vocabulary

Before students proceed, write these terms on the board or chart paper. Encourage students to think about these terms as they complete the activity. Students will do Word Work for these Core Vocabulary terms in Lesson 14.

digital **information** **transfer**

2. Preview the investigation. 5 MIN

Place students into pairs. Assign one student to be the Message Sender and the other student to be the Message Receiver.

Show students the materials that are available for them to use. Tell students that they may use as many materials as needed to make their signals work to communicate their codes in patterns.

Activity Page

AP 13.1

Distribute the Sending Coded Messages (AP 13.1), and review the various parts so that students understand what they must do for Days 1 and 2.

SUPPORT—Model for students how to fill the pages out if necessary.

Discuss criteria and constraints so that students understand their differences and why each is important in designing solutions. (See **Know the Science.**)

3. Facilitate the investigation. 30 MIN

Circulate throughout the room as students develop their codes with their partners. Remind students of the following:

- They are not allowed to use written letters or spoken words.
- They must use light or nonverbal sound (such as tapping) to transfer their codes over a distance.
- They must distinguish between sound, sound waves, light, and light waves.
- They must make instructions and a key to use for transfer of the signals and for decoding the messages. Remind students that the instructions and key must be easily understood because other teams will use them when testing their method.

Know the Science

What are criteria and constraints? ***Criteria and constraints refer to design concepts that are mostly used in engineering.*** Criteria are the needs or wants of a design. In this investigation, the criteria are the materials and some of the rules available. Constraints are the limitations of a design. In this investigation, the constraints include not being allowed to use verbal sounds or letters of the alphabet. Engineers use criteria and constraints when coming up with different solutions to problems as well as when testing those solutions.

- Codes are based on patterns.
- The signals used to transmit the codes must be sent over a distance. This distance can be from a few feet to the length of the classroom.

If the room becomes too noisy with students sending their signals over a distance with nonverbal sounds, such as banging or tapping, place teams in different parts of the room, or try to control the volume of the signaling.

TEACHER CHOICE: Assign each team a signal to develop using light or nonverbal sounds rather than letting students pick. This may help ensure that there is a good balance of both types of signals for variation.

4. Summarize and discuss. 5 MIN

Tell students to put away their materials and Activity Pages. Remind them that they will be using the Activity Pages again during the next class session, when it is time to test their new signaling methods.

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

How can signals transfer information? Tell students that they will have the same partners they had in the previous class session and that they will now test their code, signal, and information transfer to see if they work.

2. Support the investigation. 5 MIN

Activity Page

AP 13.1

Place students in the same pairs, and have them retrieve the materials needed for their coded signals. Tell students to take out their Sending Coded Messages (AP 13.1). Review the section for Day 2 so that students are reminded of what they will need to do. Remind them that the reason they have used a code is that signals transfer information in code, even though the receiver of the information usually only sees the decoded version of the message.

If necessary, allow students to finish working on the first section from Day 1 (if they have not yet completed it).

3. Coach student observations. 30 MIN

Circulate throughout the room, and give the Message Sender in each team a secret message to write down on the Activity Pages. Tell the Message Sender that this message should not be shared with his or her partner, the Message Receiver. Make sure to use a different message for each team, and keep the messages short and simple.

TEACHER CHOICE: You can also give the Message Senders the freedom to come up with their own messages to send. If so, guide students to keep them simple:

- Come up with a short sentence.
- Do not include any words that are hard to spell.

Once the Message Sender has encoded the message, he or she will send the code to the Message Receiver via a signal using patterns of light waves or sound waves. The receiver will then decode the message.

Give students time to record their results on the Activity Pages.

After students have tested their own code methods, have them trade materials, instructions, and keys with another team. Now, each team must test another team's coding method to see how it works. (Ideally, encourage teams that worked on light-based codes to trade with teams that worked on sound-based codes and vice versa.)

- Give the Message Sender on each team a new message to send. (Or have the Message Sender come up with the message using the guidelines given earlier.)
- Remind the Message Sender not to give away the message to the Message Receiver.
- Make sure students use the instructions, materials, and keys for decoding the message.

4. Summarize and discuss. 5 MIN

Tell students to give the instructions, materials, and keys back to the original team and put away their materials and Activity Pages. Explain that in the next class session, students will discuss the effectiveness of all the code methods and argue which one was best and why.

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

Activity Page

AP 13.1

How can signals transfer information? Tell students that today they will discuss the different types of signals they used to send their messages during the two previous class sessions.

Have students take out their Sending Coded Messages (AP 13.1) to refer to during the whole-class discussion.

2. Encourage student questions. 5 MIN

Lead a discussion about the different ways that students used to send their signals. Use this opportunity to allow students to ask questions about the different ways messages can be sent. Use specific examples to help answer questions.

3. Showcase and discuss solutions. 30 MIN

Each team had to come up with a way to send a signal over a distance. Showcase three or four different examples that students came up with, and discuss them as a whole group. Ask students the following questions to prompt discussion:

» What do you think makes a coded system "good"? (*It should be complete enough to solve a problem or to make something usable.*)

» How can we measure or tell whether a signal works or doesn't work? (*If a code works, the receiver will be able to decode the message.*)

» Why is it important to follow the criteria and constraints? (*The criteria and constraints help make sure that the code can be used for the use that is intended.*)

After you have showcased the different signaling methods, have students consider and discuss the following:

» How are these signaling methods similar? (*They communicate a message.*)

» How are these signaling methods different? (*Possible answer: Some methods use light, some use color, and some use sound.*)

» Which signaling method do you think is best? Why? (*Students should explain their rationales for stated preferences.*)

» How do you think the other signaling methods could be improved? (*Students may point out ways to make the messages or instructions more clear.*)

4. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 13.1) for correct answers and sample student responses.

- Collect the completed Sending Coded Messages (AP 13.1). Scan the questions that students posed regarding making, transmitting, receiving, and decoding coded messages. Choose one or two questions to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas about transmitting information and to correct misconceptions. Misconceptions may include the idea that there is no difference between codes, signals, and patterns. Reinforce to students that signals are the ways information is transmitted, codes are how the signals transmit the information, and patterns are what the signals use for the codes. If necessary, explain to students that they will learn more about these differences in the next lesson, which asks, "How are waves used to send signals?"

LESSON 14

Using Signals

Big Question: How are waves used to send signals?

At a Glance

Learning Objectives

- ✓ Describe an example of how people use waves to send information.
- ✓ Analyze the merits of different solutions that use light or sound to transfer information.

Lesson Activities

- demonstration
- reading
- discussion and writing

NGSS References

Disciplinary Core Idea PS4.A: Wave Properties

Crosscutting Concept: Patterns

Patterns are important to this lesson because the signals discussed rely on waves (analog) or digits (digital) to transmit information, whether through electrical flow, radio waves, or other methods. In this lesson, students will learn more about how information is converted into signal patterns. The signals are then sent from one device to another, where they are transformed to a form that allows the person getting the information to understand it.

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 162–163 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.

analog	**digital**	pattern
code	**information**	**transfer**

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. 6

Student Reader, Chapter 6
"Using Signals"

Activity Page

AP 14.1

Activity Page
Develop Models of Signals (AP 14.1)

Materials and Equipment

Collect or prepare the following items:

- coded message
- code key

Prepare a short coded message for students. It can be something as simple as "The sky is blue." Prepare a code key to go along with it. This should be used to represent the concept that information can be sent using information that is coded as signals.

- index cards for student vocabulary deck (4 per student)

The Core Lesson 45 min

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

How are waves used to send signals? Open the lesson with a short exploration of how students think cell phones send a text message from one place to another. Ask the following:

» What will happen if I call someone? (*The voice message is turned into a digital signal and then turned back into a voice message for the message receiver to be able to hear.*)

» What will happen if I send a text message? (*The text message is turned into a digital signal and then is converted back to a visual display.*)

Break students into small groups, and have them brainstorm how they think a text message moves from one phone to another phone. Students can then diagram a text message moving from one phone to another phone. Engage students in a brief discussion. Ask the following:

» How do you think cell phones and other devices send and receive information? (*radio waves*)

» How might these be similar to using a code? (*Both forms of messages use coding and decoding.*)

Understand that students may not be able to answer these questions correctly. Explain that by the end of the class session, they will revisit these questions.

2. Read and discuss: "Using Signals."

15 MIN

Student Reader

Ch. 6

Read together, or have students read independently, "Using Signals," Chapter 6 in the Student Reader. The selection helps students understand that much of the video and audio they hear on television, radio, the internet, and cell phones comes from waves, almost always radio waves.

Prepare Core Vocabulary Cards

Write the following terms on the board or chart paper, and instruct students to complete Core Vocabulary cards for these terms as they read.

analog **digital** **information** **transfer**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts:

Page 33 Based on what they have learned, have students trace the program they last saw on television to its source. Allow them to do this on a blank sheet of paper, and encourage them to use arrows to show the direction in which the signal is moving. Answer any questions they have, and then look over their models.

Pages 34–35 Have students provide additional examples of analog signals being sent as radio waves. Then have them do the same with digital signals being transmitted. If they struggle with this, prompt them to name things in their homes that show video or provide audio. Compare a phonograph record to a CD or online music. Have them state which ones they believe are analog and which they believe are digital.

SUPPORT—Remind students that forms of video and audio that enter their homes as radio waves are then transformed to electrical signals that move through wires before they can be seen or heard. Specific examples of this may be televisions and radios.

Pages 36–37 Have students name three ways that cell phones can transmit information (*audio, video, text*). Ask them which ones they or their family members use most often and why.

Pages 38–39 Point out that when people use the camera on their cell phones, they sometimes get a message stating, "Camera would like to know your location" (or something similar). (See **Know the Science 1**.) Ask the following:

» What is happening when you receive this message? (*The phone is using GPS to record where the picture is being taken.*)

Ask students to think of other devices besides cell phones that may be equipped with GPS. (See **Know the Science 2**.)

Page 40 Have students think of devices in their homes that receive and show information, such as televisions, radios, and cell phones. Ask them which ones have wires and what they think those wires are used for. Then break down those with wires into which ones probably use the wires for electrical impulses and which ones probably use the fiber optic wires to transmit light. For example, cable channels that are high quality likely receive their images through fiber optic cables.

3. Encourage discussion. 10 MIN

Activity Page

AP 14.1

Introduce Develop Models of Signals (AP 14.1). Explain to students that they will complete the Activity Page based on what they have learned in the lesson. Allow them to consult their Student Reader if they struggle to complete the activity. Encourage students to compare the different types of signals and how they are sent.

SUPPORT—Have students use arrows to show the direction that the signals/waves are moving to get from where they originate to where they end up (in the cell phone, television, or GPS device).

Discuss how different types of devices use different types of signals. Distribute the coded message you prepared in advance for students and provide them with the code key. Instruct them to now decipher their messages.

Know the Science

1. Does GPS use trilateration or triangulation to locate a place or object? *Trilateration!* Trilateration is a geometric process in which a location is pinpointed accurately. GPS has twenty-four satellites in space and many stations on Earth. By receiving and transmitting a signal from any three satellites, GPS determines the absolute location of a place or object by determining the intersection point between the three satellites. Triangulation is a process that surveyors use to determine the location of a point by forming triangles between its known parts. Because GPS does not use angles to determine locations, it does not use triangulation.

2. Is GPS used only for cell phones? *No!* Although GPS is commonly used in cell phones, it can be used in any number of devices. Often, newer models of automobiles have a GPS device built into them, which enables them to travel long distances without their drivers getting lost. Drones can be guided by GPS systems. Sometimes, scientists use GPS devices. For example, paleontologists frequently search for fossils during the summer months, when the ground is less hard than it is during the winter months. If they find a fossil at the end of the hunting season, they may want to return to it the next year. Before GPS, it was often difficult to find the exact location of the fossil. Now, the location can be recorded in a GPS device and returned to the next year.

4. Teach Core Vocabulary. 5 MIN

Word Work

- **transfer:** (v. to move from one place to another) Students learned a great deal about energy transfer in the Grade 4 unit *Energy Transfer and Transformation*. Emphasize that it is precisely the behavior of energy transfer that makes energy waves useful for communicating across a distance. Have students write a short sentence using the words *transfer* and *communicate.* (*Sample answer: I can communicate by using the sound of my voice to transfer a message to people who can hear me.*)
- **information:** (n. types of data such as pictures, sounds, and messages) Point out that human beings collect, record, store, and share vast quantities of information. Ask students to share how they think the world would be different if people had not figured out ways to share information over distances. (*Possible answer: We would not know much about what was going on in other places.*)

The contrast between analog and digital signals is very abstract for students at this level. The important takeaway is for them to note that digital codes (simple, binary patterns—off/on or 1/0) enable all computer technology.

- **analog:** (adj. describing signals sent as continuous waves) Provide students with the definition of *analog*, and emphasize that the use of analog wave signals to send broadcast messages is getting less and less common.
- **digital:** (adj. describing signals sent as separate bits and not continuous) Provide students with the definition of *digital*, and emphasize that the use of digital electronic signals in communications is now the norm.

5. Check for understanding. 5 MIN

Activity Page

Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 14.1) for correct answers and sample student responses.

- Collect the completed Develop Models of Signals (AP 14.1). Scan the models that students drew. If students misidentified how waves and patterns contribute to the different types of signals, engage in further discussion, emphasizing the correct information for what they got wrong.

UNIT REVIEW

Waves and Information Transfer Game

Big Question: What have I learned about waves?

At a Glance

Learning Objective

✓ Fluently discuss waves, how they transfer energy, and how that is useful.

Lesson Activities

- discussion
- vocabulary game

NGSS References

4-PS4-1: Develop a model to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.

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

www.coreknowledge.org/cksci-online-resources

The Big Idea

Energy is transferred in waves. Students are familiar with mechanical waves in water waves and sound. They have learned that waves have properties by which they are measured and described and that those properties can be modeled in various ways.

Students also experience electromagnetic waves every day as they observe light and utilize devices that operate using radio and microwaves. Because energy waves occur in repeating patterns, they are useful for transferring information via coded signals.

Core Vocabulary

Language of Instruction: During instruction, remind students of their prior exposure to the following terms.

absorb	**frequency**	**pitch**	**trough**
amplitude	**information**	**reflect**	**vibrate**
analog	**intensity**	**signal**	**vibration**
code	**light**	**sound wave**	**volume**
color	**light source**	**symbol**	**wave**
crest	**light wave**	**transfer**	**wave height**
digital	**pattern**	**transparency/transparent**	**wavelength**

Core Vocabulary Deck: Students should refer to their full set of Core Vocabulary cards during the review discussion.

Instructional Resources

Activity Pages

AP UR.1
AP UR.2

Activity Pages
Race the Board (AP UR.1)

Vocabulary Crossword Puzzle (AP UR.2)

Make copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- front board
- front board markers (or chalk)
- question and answer cards/sheets
- timer (or phone)

Advance Preparation

Write your own questions and answers for the game on your own cards or sheet. You might want to prepare approximately twenty-five to thirty questions so that you can keep the game moving quickly from one question to the next. Have the questions ready to read when you play the game with the class, and make sure students cannot see or have access to the answers. Students will not get to see the questions in advance. Questions should be a variety of vocabulary-based questions and concepts-based questions from information covered in the unit. Additionally, some questions should require diagrams or models of waves to be drawn or labeled.

Shuffle the questions into a random order so that you do not have too many similar questions back to back.

THE CORE LESSON 45 MIN

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

What have I learned about waves? Review with students what they learned throughout this unit:

- how waves move
- characteristics of water waves
- parts of a wave
- how sound travels and interacts with matter
- characteristics of sound waves
- how light behaves
- how light travels and interacts with matter to cause changes
- how waves are used to transfer information

2. Preview the activity. 5 MIN

Activity Page

AP UR.1

Tell students that you will play a game as a class using the Core Vocabulary cards they made throughout the unit. Have students take out their Core Vocabulary cards. Explain that they will also have to recall concepts, including diagrams of waves, that they learned in the unit. Place students in two or three large groups, and explain that each group will perform as a team. Distribute Race the Board (AP UR.1) to students. Review the game rules with students as they follow along with their Activity Pages.

Make sure the front board is clean and markers (or chalk) are available for students to use.

3. Facilitate the review. 30 MIN

Assign each team a number, and write the team numbers on the front board. This is where you will keep track of the game points.

Give students an opportunity to ask any last-minute questions about the game rules.

Decide which team will go first.

To play, the team will send one student up to the board to compete against the other team. Students are ready with their markers or chalk to write the answers on the board. Read the question, and use your timer or phone to give students thirty seconds to answer. Since this is a race, you must pay attention to which student answers the question first and then check his or her work to see if the answer is correct. If the answer is not correct, then the student who answered first does not get a point. If the student who comes in last is the only one to answer the question correctly, that student wins the point for his or her team. If all students get the answer wrong, give the class one more chance to answer it correctly. If no team answers correctly, nobody gets the point, and the next students come up to the board for the next question.

As you use each question, discard the card for that question so that you do not accidentally ask the same question twice.

Assign points to the appropriate teams by marking the front board. The team with the most points at the end of the game wins.

4. Support further review. 5 MIN

Activity Page

AP UR.2

After the game, distribute Vocabulary Crossword Puzzle (AP UR.2). Tell students that they will take their crossword puzzles home to complete them independently. Students may use their Core Vocabulary cards to help them solve the puzzle's clues. Review with students how to complete the crossword puzzle by drawing their attention to the word bank, the clues, and the puzzle itself. Make sure students understand how to fill in a crossword puzzle according to the numbers of the clues and using only the words from the word bank.

UNIT 1

Teacher Resources

Activity Pages

Name ______________________________ Date ________________

Activity Page 1.1 (Page 1 of 3) Use with Lesson 1.

Making and Using a Wave Tank

Materials (1 per group):

- plastic bin about 5 to 7 inches deep
- black marker
- ruler
- cardboard or plastic panels, about 3 x 4 inches or based on the size of the bin
- a small object that floats

A wave tank is a way to study energy waves as they pass through water.

Using the materials above, you will turn a plastic bin into a wave tank.

Add a grid to help you measure any waves you create.

1. Use the ruler and black marker to measure and mark each inch from the bottom of the container up. The inches should be labeled beginning with 1 at the bottom and the highest number at the top. See the grid below for an example.

2. Then measure and mark each inch from the left side of the bin to the right, beginning with 1. See the grid below for an example.

5						
4						
3						
2						
1	2	3	4	5	6	7

3. Fill the bin with water up to about 2 or 3 inches. Place the bin on a hard, flat surface.

4. Place the object in the water near the center of the bin.

5. **Predict.** What will happen to the object when you move your panel in the water?

6. Place the panel in the water flat against one end of the bin. Holding the panel's bottom in one place against the bottom of the bin, tilt the top of panel forward and back. Then do it again two more times, each time increasing the strength you use to create the wave.

What happened to the object each time? What happened with the water?

Measure and record the results in the table below.

Movement of panel	Results (What happened to the . . . ?)
Gently	Object: ______ ______ ______ Water: ______ ______ ______
Harder	Object: ______ ______ ______ Water: ______ ______ ______
Hardest	Object: ______ ______ ______ Water: ______ ______ ______

7. Was your prediction correct? Use the evidence you collected from your grid measurements to explain your answer.

____

____

8. What happened to the water when you transferred more energy to it? Explain your answer.

____

____

____

9. How is what you saw in the water tank like what you saw with the rope?

____

____

____

____

Name ______________________________ Date ____________________

Activity Page 2.1 (Page 1 of 2) Use with Lesson 2.

Wave Model

Energy can move from place to place in the form of waves. When energy moves, for example, from left to right through water, any one part of the water moves up and down as energy transfers through it.

Draw a model of a wave moving through water from left to right. Label each part, and add arrows to help illustrate any changes that occur. Then answer the questions that follow. You may add boats, wildlife, people swimming, or other objects to your model to show the size of the waves. Your waves can be big or small.

What is a wave?

____

____

What is a crest?

____

What is a trough?

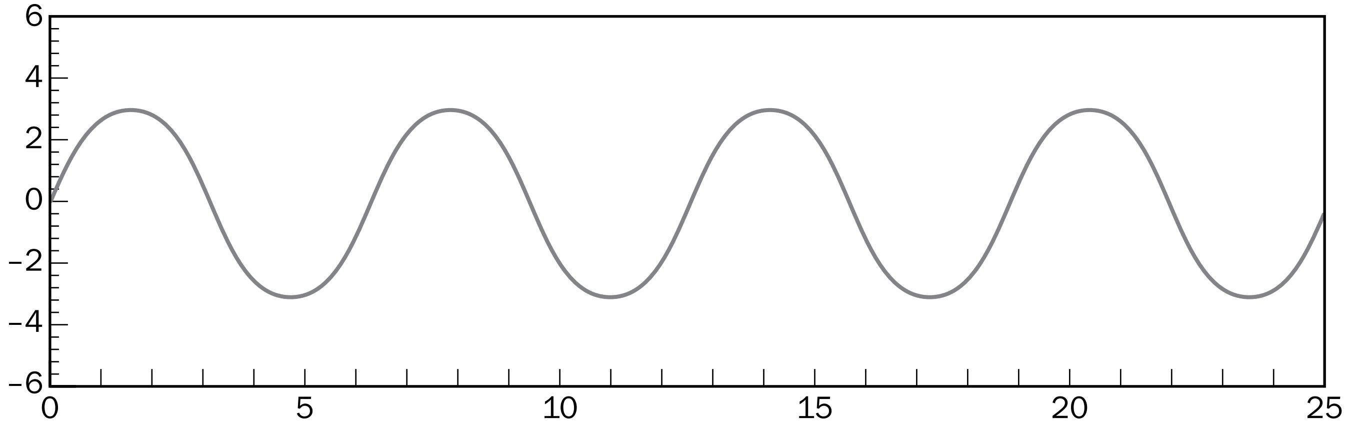
____

What is a wavelength?

____

____

Compare this wave to the model you have drawn.



Which wave shows more energy passing through the water? Support your answer with evidence using the terms you have learned in this lesson.

Name ______________________________ Date ________________

Activity Page 3.1 Use with Lesson 3.

Modeling a Water Wave (Day 1)

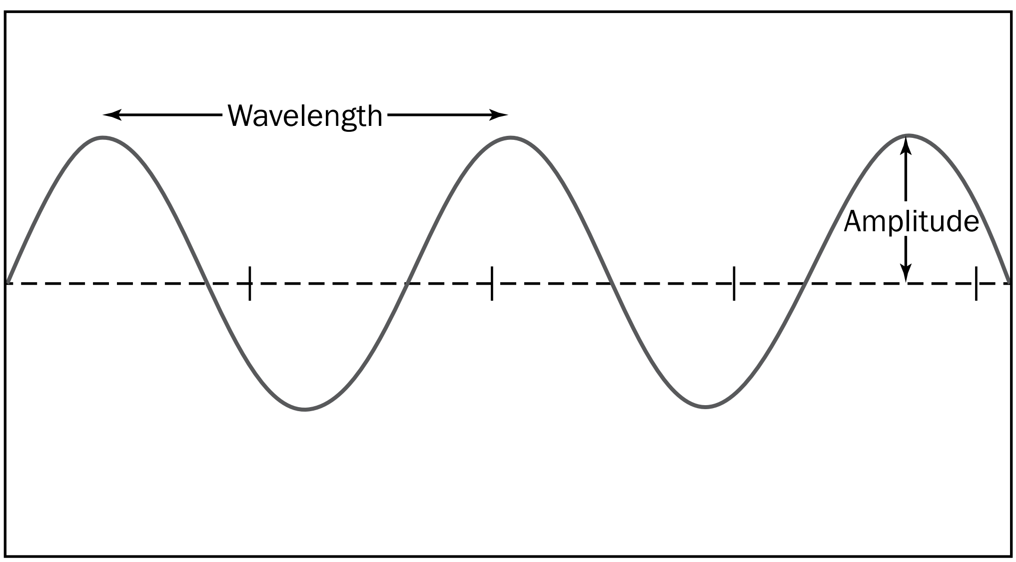
In this activity, you will make a physical model to represent three water waves. Your model should be able to compare the amplitudes and frequencies of the two waves.

<u>Circle</u> the materials you will use to make your wave model.

poster board	construction paper	markers
scissors	glue	shoebox
colored pencils	yarn	

Use the image below to help you construct your wave model.

Wave



Distance →

– – = Water line when no energy is moving through it

On the lines below, describe how your model will show amplitude and frequency.

____

____

____

____

____

Name ______________________________ Date ____________________

Activity Page 3.2 (Page 1 of 2) Use with Lesson 3.

Testing a Wave Model

Model how the amount of energy affects a wave. Use the spring toy with different amounts of energy transferred into it, and record your observations.

STEP 1: Place the spring toy on the floor. With someone holding the other end, lightly move the other end of the spring from right to left once.

STEP 2: Use the stopwatch to measure how fast the wave moves through the model. Count how many wave crests pass through a certain point over a 5-second period. Then divide by 5.

STEP 3: Use a ruler to measure the height of the crests.

STEP 4: Measure the wavelength.

STEP 5: Record the results in the table below.

STEP 6: Repeat for each amount of energy.

Amount of Initial Energy	Frequency	Amplitude
Small amount		
Medium amount		
Large amount		

1. How did the frequency of the wave change as more input energy was transferred to the wave model?

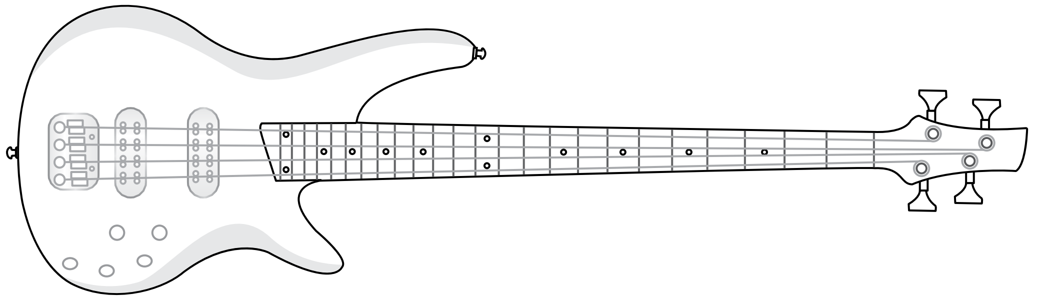
2. How did the amplitude of the wave change as more input energy was transferred to the wave model?

3. If an object were placed at the end point of each of the three waves, how would that object be affected differently by each wave?

Name ________________________________ Date ____________________

Activity Page 4.1 Use with Lesson 4.

Making a Shoebox Guitar



Materials (per person):

shoebox with lid

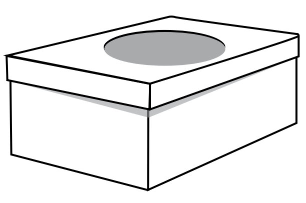
4 to 6 rubber bands

unsharpened pencil

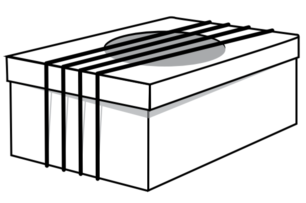
pair of scissors

A shoebox guitar is a way to study sound waves as they pass through an object. Using the materials, turn a shoebox into a guitar.

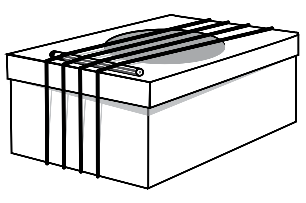
1. Trace a circle in the shoebox lid, and then cut the circle out, making a hole. Place the lid back on the box.



2. Stretch between 4 and 6 rubber bands around the box. Make sure they are over the hole in the lid. These should not be too flexible or too tight.



3. Place an unsharpened pencil under the rubber bands.



Congratulations! You have made your own shoebox guitar.

Name ______________________________ Date ____________________

Activity Page 4.2 Use with Lesson 4.

Investigating Sound Waves with a Shoebox Guitar

Materials (per student):

1 shoebox guitar

Investigate sound and different kinds of vibrations with your shoebox guitar.

1. Identify two or three ways you can make different kinds of sound with your guitar.

____

____

2. Describe two or three characteristics of the different kinds of sound you can make with your guitar. Pluck one of the rubber bands on the guitar. What do you hear? Why?

____

____

3. Pluck one string, then another and another, very quickly. Was the sound the same, or did it change? Explain your answer.

____

____

____

4. How do you think both shoebox guitars and real guitars make sound? Explain your answer.

____

____

____

Name ______________________________ Date ________________

Activity Page 5.1 Use with Lesson 5.

Sound Observations

<u>Compare</u> how sound is different when it travels through air, liquids, and solids. Write *loud, louder, loudest* and *clear, clearer, clearest* to describe each sound in each of the different states of matter.

Sound	Air	Liquid	Solid
pencil tap			
cell phone tone			
dolphin in and out of water			

<u>Write</u> a conclusion about how sound waves change when they travel through different types of matter.

____

____

Name ______________________________ Date ________________

Activity Page 6.1 Use with Lesson 6.

What Does It Sound Like?

Sounds exist all around you! Listen to your teacher's demonstrations, and describe the examples of sounds.

Complete the table to describe each sound. In the Description columns, list ideas/qualities that describe each example. The first example has been done for you.

Example of Sound ***What is the source of the sound?***	**Source of Vibration**	***How would you describe the sound?***	**Describe Using Volume and Pitch**
a fire alarm	alarm	very loud, shrill	high volume, high pitch

Write two questions you have about the sound examples.

1. ______________________________

____

2. ______________________________

____

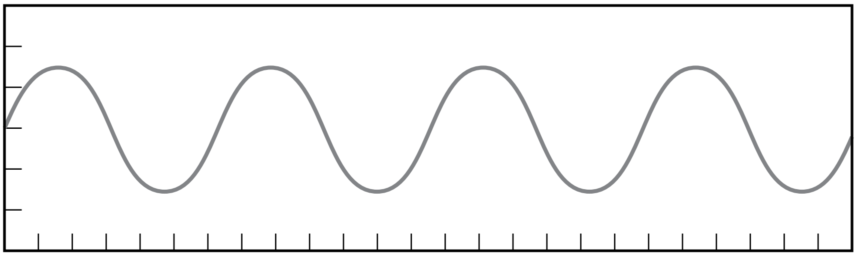
Name ______________________________ Date ____________________

Activity Page 6.2 Use with Lesson 6.

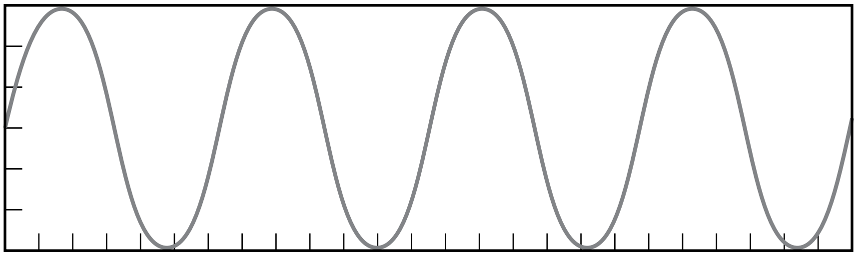
Lesson 6 Check

<u>Compare</u> the pair of diagrams below. <u>Draw</u> a line to match the sound to the model of the sound wave that it would make.

a whisper

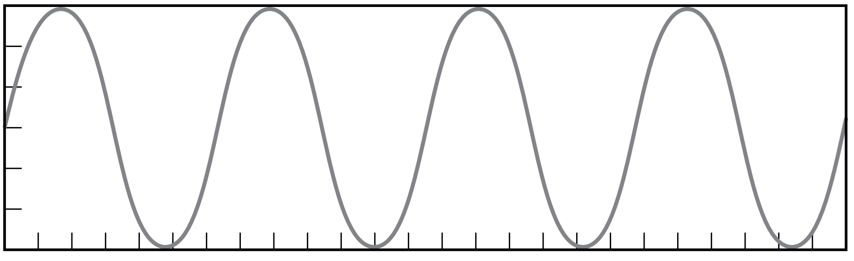


a train blowing its horn

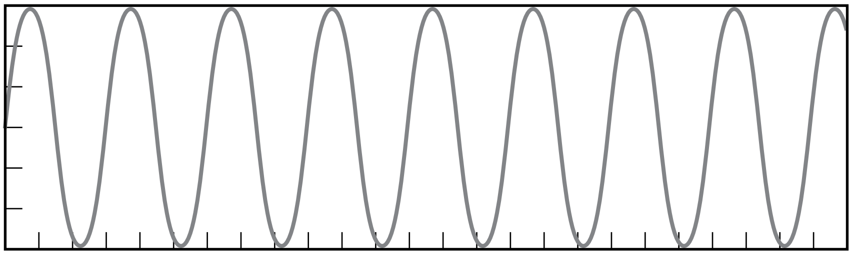


<u>Compare</u> the pair of diagrams. <u>Draw</u> a line to match the sound to the model of the sound wave that it would make.

a mouse squeaking



sound from a tuba

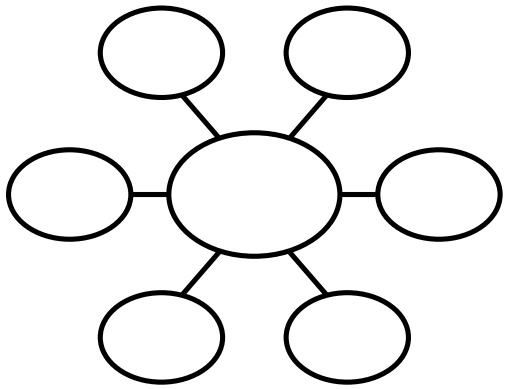


Name ________________________________ Date ____________________

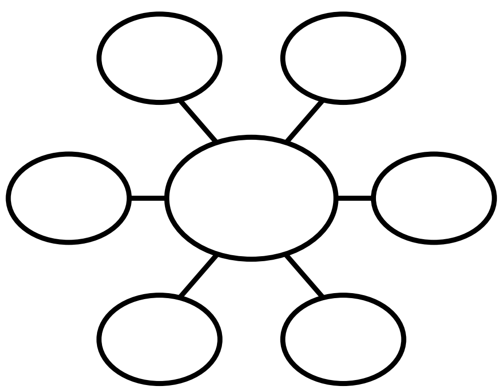
Sound Words

To remember what a word means, think of a synonym, example, picture, definition, or phrase that is related to it.

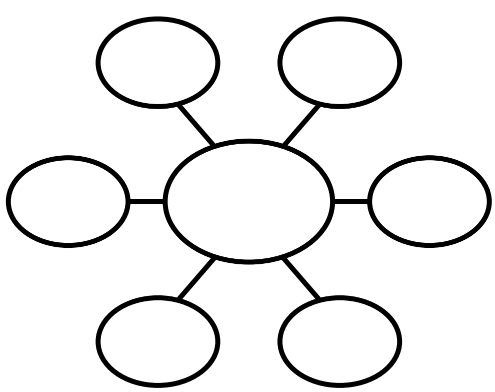
Write *amplitude* in the center circle of the word web. Then, in each spoke, write a word or phrase that helps you remember what *amplitude* means.



Write *frequency* in the center circle of the word web. Then, in each spoke, write a word or phrase that helps you remember what *frequency* means.



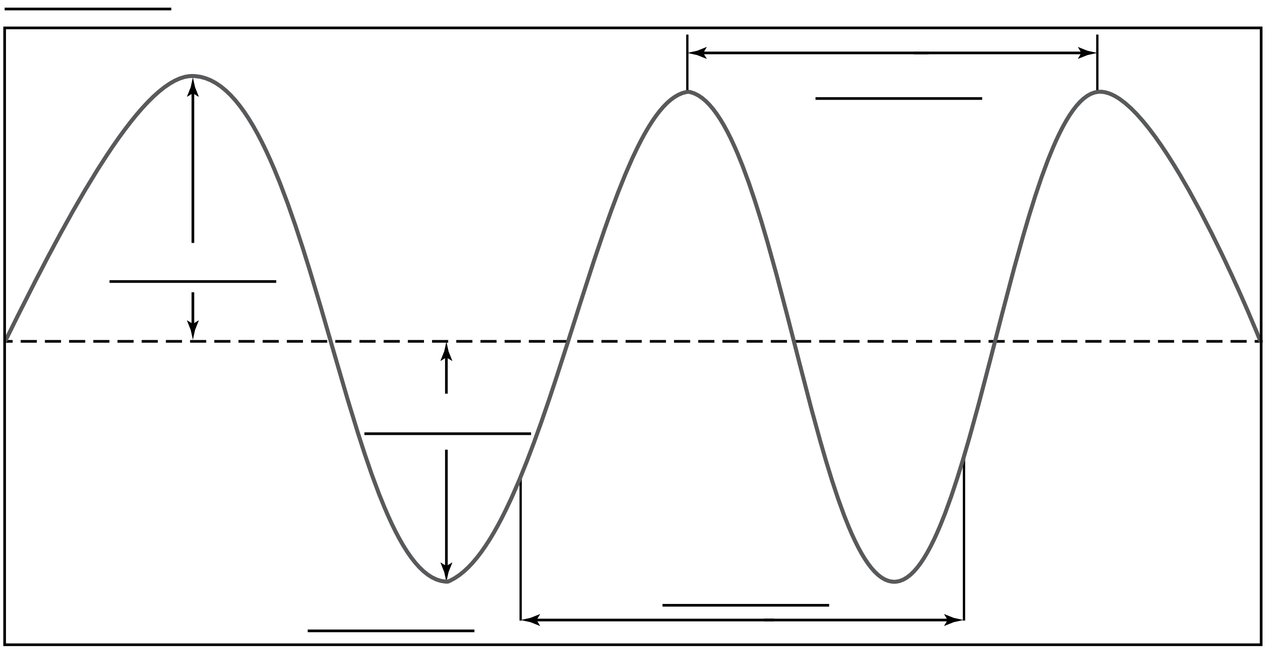
Write *wavelength* in the center circle of the word web. Then, in each spoke, write a word or phrase that helps you remember what *wavelength* means.



Write the names of the properties of the wave. Use the words from the word box.

crest	**trough**	**amplitude**	**wavelength**

Wave Properties



Match each word to its definition.

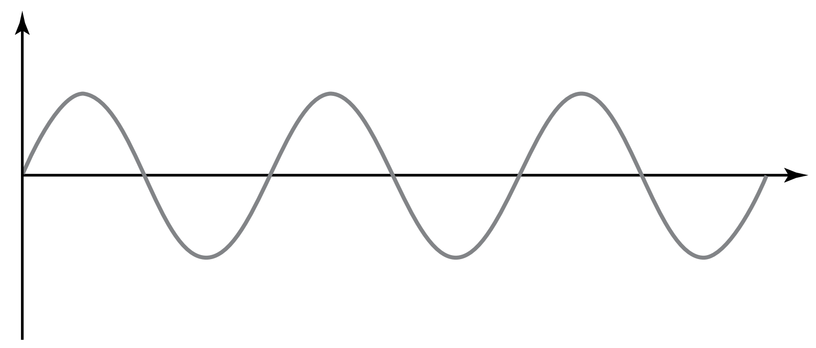
pitch	the number of peaks in a sound wave over time
sound wave	how high or low a sound is, shown by longer or shorter wavelengths
vibration	how loud or quiet a sound is, shown by amplitude in a sound wave
volume/intensity	back-and-forth or side-to-side motions
frequency	an invisible wave that carries energy from a source of a vibration

Name ______________________________ Date ____________________

Activity Page 7.2 (Page 1 of 2) Use with Lesson 7.

Modeling Sound Waves

In this activity, you will draw a model of different types of sound waves.



Draw a sound wave on the graph below that has greater volume than the one above.

Label each part of one of the waves. Include these parts in your labels: crest, trough, and wavelength.

Label the amplitude.

What causes a wave to have greater intensity?

____

____

Describe the sound you have drawn. Compare it to the sound above.

____

____

Draw a wave showing higher frequency than the sound wave at the top of the previous page.

Label each part of one of the waves. Include these parts in your labels: crest, trough, and wavelength.

Label the amplitude.

Describe the sound you have drawn. Compare it to the sounds on the previous page.

List three examples of sources of high-pitched sounds.

What causes a wave to have shorter or longer wavelengths?

How does the frequency of the wave affect the sound?

Name ______________________________ Date ____________________

Activity Page 7.3 (Page 1 of 2) Use with Lesson 7.

Testing Sound Waves

All sounds you hear are the result of sound waves, which are caused by vibrations. These vibrations occur when energy transfers to and changes an object making it begin to move, back and forth.

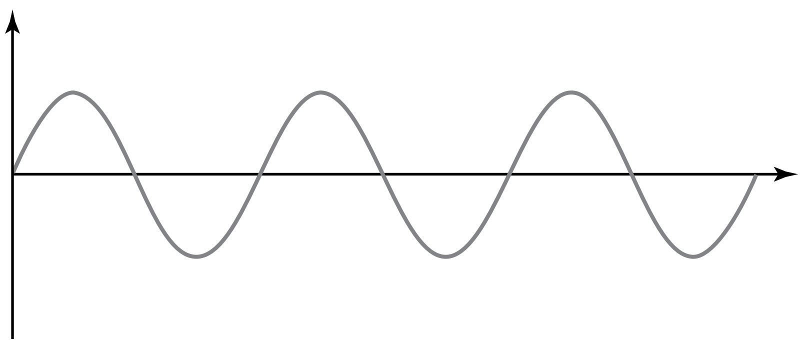
STEP 1: Look closely at one of the strings on your shoebox guitar.

STEP 2: Pluck the string gently.

What happened to the string? Describe the motion of the string with supporting details.

____

____



STEP 3: Now, pluck the string with much more force.

STEP 4: Imagine that the wave diagram above represents the sound of your first pluck. Now draw a wave that represents your second pluck in comparison with that one. These sound waves should show what you think the amplitude and frequency look like for the two sounds you made.

STEP 5: Answer the following questions about your model.

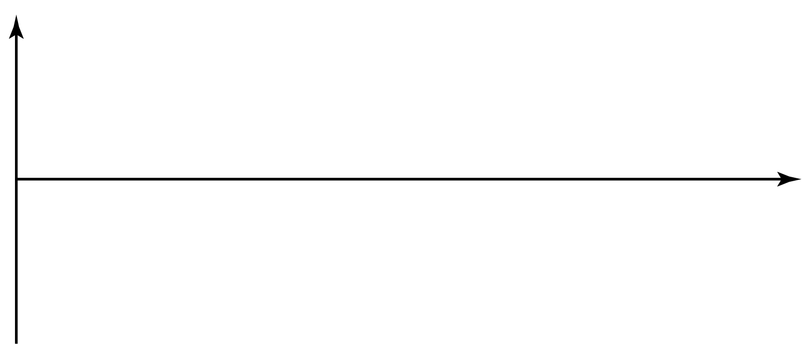
How is your model like the wave model on the previous page? Explain your answer.

How is your model different? Explain your answer.

STEP 6: Play your guitar. Make different sounds with it. Make a sound with high pitch and then a sound with low pitch.

Describe how you were able to create different pitches using your shoebox guitar.

What kind of wavelengths do you think the different kinds of sound have?



Name ______________________________ Date ______________

Activity Page 8.1 Use with Lesson 8.

Find the Light

Light is all around you! It comes from natural sources and from things that have been designed by people. Explore the space you are in. Look for sources of light.

Find four examples of things that emit light. Complete the table to describe your choices.

Source of Light	How can you describe the light?

Write two questions that you have about your examples of things that make light.

1. ______________________________

____

2. ______________________________

____

Name ______________________________ Date ____________________

Activity Page 9.1 Use with Lesson 9.

Light Behaviors

Light travels as light waves. These waves are different depending on the light source, the wavelength, and the amplitude, which each change the way light behaves.

Draw a model of light behaving in some way when it interacts with matter. Label the light source and the type of object interacting with light. Then answer the questions that follow. You may add more than one object to your model to show how light behaves and interacts with matter.

What is a light wave?

____

What was the light source in your drawing?

____

How did your light interact with matter?

____

____

CHALLENGE: Describe what you think would happen if a glass of water were placed between the source of light and the object(s) in your drawing.

Name ______________________________ Date ____________________

Activity Page 10.1 Use with Lesson 10.

Build a Solar Oven (Day 1)

Ovens use heat to make a change, such as cooking food to make it more edible or changing other things by adding heat. Light from the sun can also cause changes to objects, including food.

Use the following objects to build a solar oven:

scissors	glue	pizza box
aluminum foil	black construction paper	ruler

How will you use these materials to make a solar oven?

STEP 1: Describe your design on the lines below.

____

____

____

____

____

____

STEP 2: Show your design plan to your teacher. When your plan is approved, you may move to the next step.

STEP 3: Build your solar oven.

STEP 4: Predict what you will do with your solar oven.

____

____

____

____

____

Name ______________________________ Date ________________

Activity Page 10.2 Use with Lesson 10.

Test Your Solar Oven (Day 2)

Light travels in waves and transfers energy. It can cause changes to objects.

Complete the table below by placing each object in your solar oven and placing the oven in direct sunlight.

Describe what happens to each object in your solar oven.

Object	Predict what will happen to each object.	What happened to the object?	Why?
pencil			
butter			
crayon			
rock			

How does your solar oven work?

Describe how light is used in your oven to cause a change.

____

____

Name ______________________________ Date ______________

Activity Page 11.1 Use with Lesson 11.

Invisible Energy

Engineers use waves to do many things that are helpful in our everyday lives.

<u>Place</u> each wave in order of wavelength from shortest to longest: X-rays, radio waves, microwaves, gamma rays.

____

____

____

____

<u>Complete</u> the table by describing each wave and explaining how it is used. Then <u>answer</u> the question that follows.

Name of Wave	What Wave Is Used For	How Wave Can Be Harmful

Have you ever used any of these waves? If so, how?

____

____

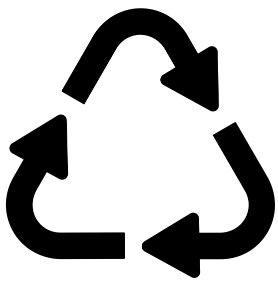
____

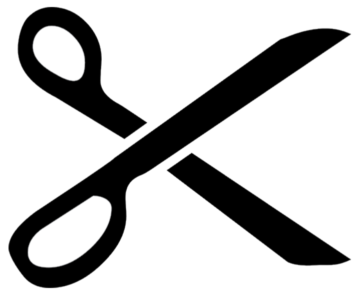
Name ____________________ Date ____________________

Activity Page 12.1 Use with Lesson 12.

Decoding

<u>Write</u> the meaning of each symbol.





<u>Complete</u> the table by writing "sound waves," "light waves," or "radio waves" to tell how each signal is sent.

Signaling Device	Sound Waves, Light Waves, or Radio Waves?
Morse code key	
lighthouse	
traffic signal	
two-way radio	
cell phone	

Name ________________________________ Date ____________________

Activity Page 13.1 (Page 1 of 3) Use with Lesson 13.

Sending Coded Messages

Shhh . . . In this activity you will create your own code for sending information over a distance using a signal! Let's get started!

DAY 1

STEP 1: Circle your role on the team.

I am the *Message Sender / Message Receiver.*

STEP 2: With your partner, develop a new code that you will use to send a message.

Criteria:

- Use either light, nonverbal sounds (such as tapping), or both
- Send the coded message over a distance
- Use any materials you want

Constraints:

- No written letters
- No spoken words

Write the key that can be used for your code on the lines below. If you need more space, attach an extra sheet of paper.

____

____

____

Describe how your code works. Write the instructions on the lines below.

____

____

What is the method of transmission for your code?

____

____

Does your code meet all the criteria and constraints?

____

DAY 2

STEP 1: If you are the Message Sender, write the coded message on the line below.

What kind of waves will you use to send your signal?

STEP 2: If you are the Message Sender, send the coded message to your partner. If you are the Message Receiver, try to decode the message that is being sent to you. You can use your key.

What was the correct message received?

Did the signaling method work? Why or why not?

STEP 3: Now trade with another team. Give them your instructions, materials, and code key, and you will get their instructions, materials, and code key.

STEP 4: With your partner, study the instructions, materials, and code key of the other group's code method.

STEP 5: If you are the Message Sender, write the new coded message on the line below.

STEP 6: If you are the Message Sender, send the coded message to your partner.

STEP 7: If you are the Message Receiver, decode the message that is being sent to you on the lines below.

Answer the following questions about your investigation.

What signaling method did you use?

Did it use light waves or sound waves?

Was the correct message received?

What worked well about this signaling method?

What would you do to improve the signaling method?

Does their code meet all the criteria and constraints? Explain your answer.

What questions do you still have about sending, transmitting, receiving, and decoding coded messages?

Name ______________________________ Date ____________________

Activity Page 14.1 Use with Lesson 14.

Develop Models of Signals

Engineers use waves and signals to communicate images, words, and ideas.

Draw a model of each of the following. In your model, show how waves or signals are used to help the technology work.

cell phone

fiber optic cable

GPS

Name ______________________________ Date ____________________

Activity Page UR.1 Use with Unit Review.

Race the Board

Game Rules

In this game, you will work with your team to answer the most questions and score the most points.

- One student from each team will approach the board and have his or her markers ready.
- The teacher will read a question.
- The students from each team will race to write the correct answer on the board (or draw a correct model/diagram on the board).
- Students will get thirty seconds to answer the question, and they will be timed.
- The team that gets the answer correct first wins a point.
- If no student answers the question correctly, then the teacher opens up the question to the rest of the class, and students can race to raise their hands and answer it first.
- After each question, a new student from the team approaches the board and has a chance to answer. All students will get at least one chance to answer a question at the board.
- Students can bring their Core Vocabulary cards with them to the board and use them to search for the answers.
- The team with the most points at the end wins.

You can use the scorecard below to keep track of your team's points:

My Team's Points

Name ______________________________ Date ____________________

Activity Page UR.2 (Page 1 of 2) Use with Unit Review.

Vocabulary Crossword Puzzle

Use the words in the word bank to complete the crossword puzzle. Review the cards in your Core Vocabulary deck before you begin.

absorb	color	crest	pitch	light	light source*	light wave*	reflect
sound wave	trough	vibrate	vibration	volume	wave	wavelength	

*Spaces between words are not included in the puzzle.

Across

1. the quality of sound that is described as "high" or "low"

5. to take it in and contain it

7. a disturbance that transfers energy through matter or through space

9. the lowest part of a wave

10. the motion of an object or material that is vibrating

11. objects that convert some other kind of energy into light energy

13. to bounce off of

14. to move back and forth quickly

Down

2. an aspect of light that enables otherwise identical objects to be distinguished from each other through the sense of sight (vision)

3. the way light energy transfers, or radiates

4. a form of energy that can transfer through empty space

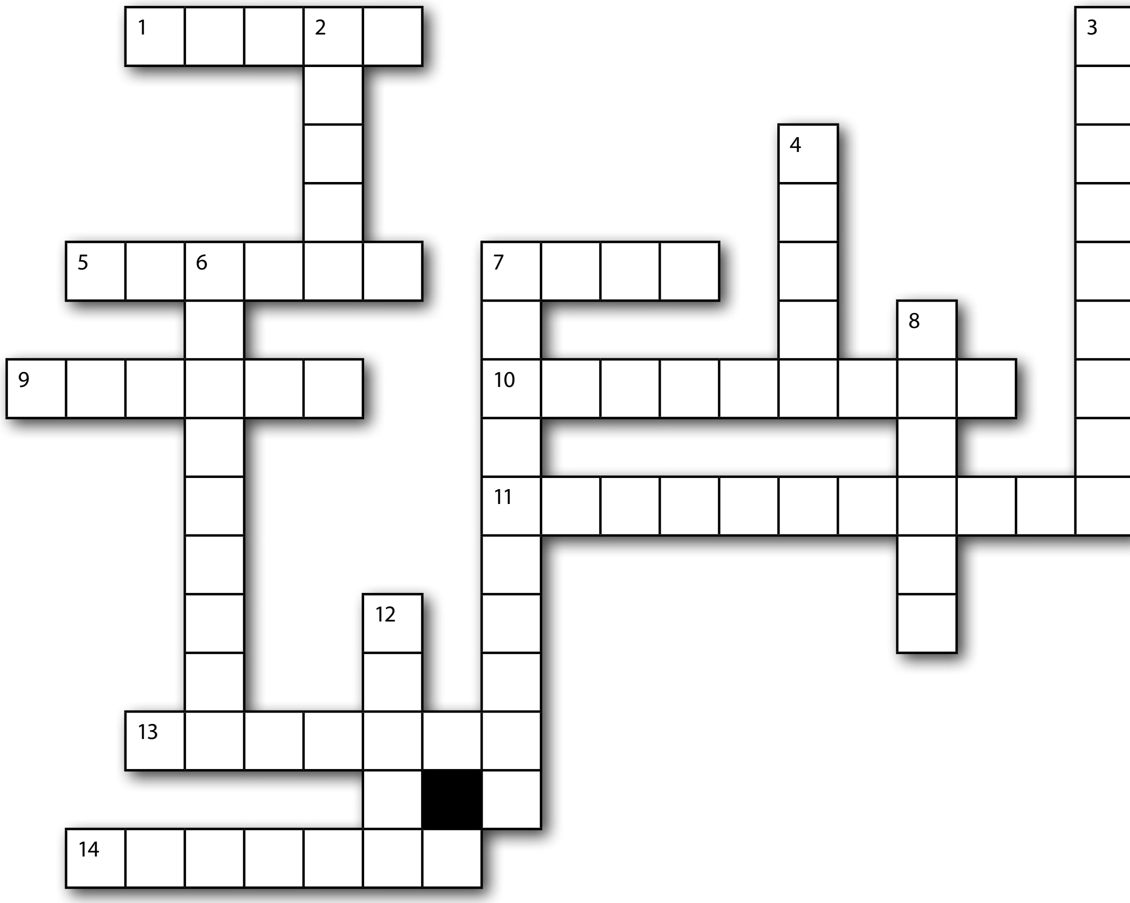
6. a transfer of energy through material as it is disturbed by vibrations

7. the distance from one crest to the next crest of a wave

8. the loudness or intensity of sound

12. the highest part of a wave

Vocabulary Crossword Puzzle



Name ______________________________ Date ____________________

Unit Assessment: Investigating Waves

Answer the items below to show what you have learned.

1. Which sentence describes possible effects of a wave transferring energy into water? Circle the letter for each correct answer.

a) Objects move up and down in the water.

b) The water becomes still.

c) Waves form in the water.

d) Objects move in the direction of the wave.

2. A hurricane forms in the Atlantic Ocean. Winds in the hurricane travel at 75 miles per hour. These strong winds move against the ocean waters.

What is the relationship between the wind and the water waves that form as a result? Use evidence and examples you have learned to support your explanation.

____

____

____

____

____

3. Draw a model of a wave. Label the crest, the trough, and the wavelength. Add labels to show the relationships between frequency and wavelength and between amplitude and the amount of energy the wave has.

Does the wave contain high or low energy? ______________________________________

Describe how the wave transfers energy. ______________________________________

____

4. Describe three ways you can use vibrations to make sound.

Way 1 ______________________________

____

Way 2 ______________________________

____

Way 3 ______________________________

____

How does sound travel? Use Core Vocabulary to explain your answer.

____

____

5. In each box, draw a model to show how sound waves travel through solids, liquids, and gases. Label each drawing as **Solid**, **Liquid**, or **Gas**.

6. Which sentence describes a way that energy from sound waves can cause a change? Circle the letter for each correct answer.

a) Glass is shattered by an opera singer's voice.

b) A woman gets burned by the midday sun.

c) High winds cause large ocean waves to form.

d) A loud concert causes a man's ears to ring.

e) A warm oven turns dough into bread.

f) The phone vibrates when it rings.

7. Draw a model of a sound wave. Label the crest, the trough, the amplitude, and the wavelength. Identify whether the wave's frequency is high or low. Write a sentence describing how you know this.

Frequency: ______________________________

Describe how you know about the wave's properties: ______________________________

____

____

____

8. A light source is an object from which light waves originate.

Write "yes" or "no" after each object to describe whether it is a light source or not.

a) the sun ______________________________

b) a cell phone ______________________________

c) a mirror ______________________________

d) a window ______________________________

e) a lampshade ______________________________

f) the moon ______________________________

9. Which of the following can light waves pass through? Using vocabulary words from the unit, explain whether light waves can travel through each and why.

empty space ______________________________

____

solids ______________________________

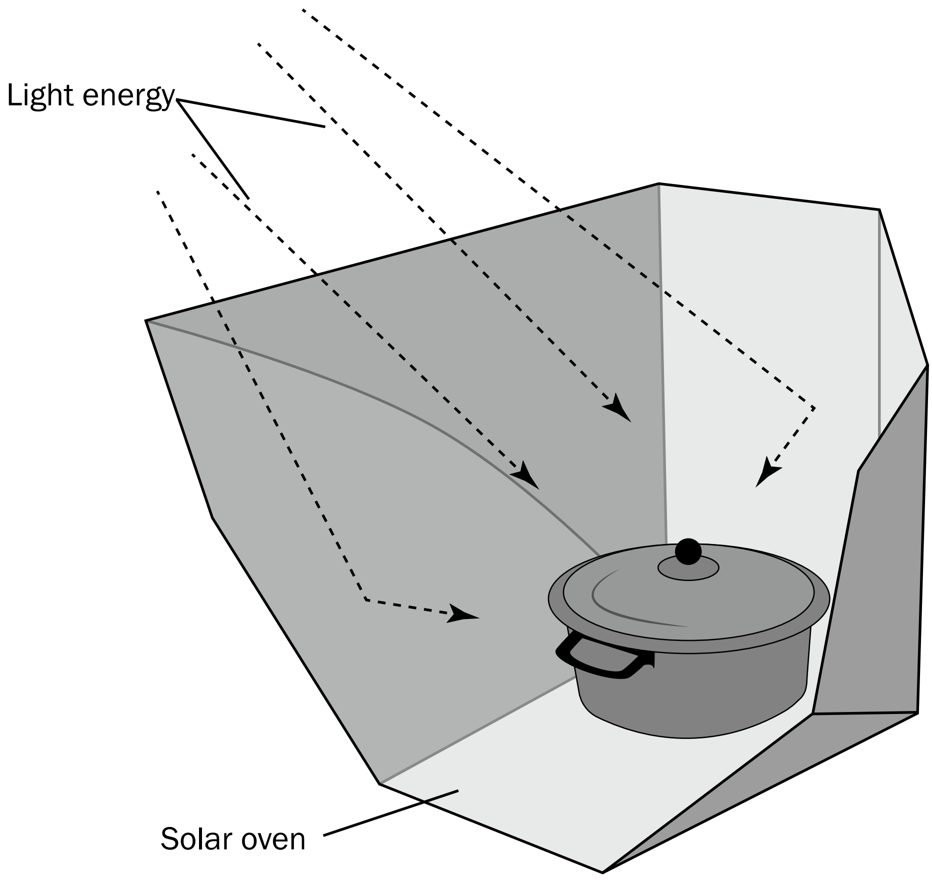
____

liquids ______________________________

____

gases ______________________________

____



10. Manuel has made a solar oven. Inside it, he has placed a pot containing potatoes, a few other vegetables, and water.

What kind of energy does the solar oven use, and where does it come from?

____

____

____

11. What change does Manuel hope to cause by placing the pot in a solar oven?

____

____

____

12. Some light cannot be seen by human eyes. Using evidence from the unit, explain why some light is invisible to human eyes.

____

____

____

____

____

13. Provide three examples of a pattern being transformed from one form to another to communicate information. Then answer the question that follows.

Example 1: ____

Example 2: ____

Example 3: ____

Why might engineers transform patterns from one form to another?

____

____

____

14. You need to communicate a simple message to another student, but you have to do it in code. Make a code and a code key you could use to communicate with the other student. You may use sound or light to communicate your code. Write your message below, and then describe the code and code key you will use.

Message: ____________________

Describe your code: ____________________

____

____

Code key: ____________________

____

____

15. Compare the ways that people use light and sound to transfer information. Which is better? Present your arguments below. Be sure to list criteria and constraints for each.

Light: ____________________

____

____

____

Sound: ____________________

____

____

____

Activity Pages Answer Key: *Investigating Waves*

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 of the Activity Pages of this unit.

AP 1.1 Making and Using a Wave Tank (pages 116–118)

5. Accept all plausible predictions.
6. Student results should show that the more force used to make waves, the larger the waves in the wave tank and the more movement the object will have up and down.
7. Student answers should be supported with the evidence from their wave tank.
8. Students should note that the water moved more when more energy was added.
9. Both types of waves grew larger with more energy and got smaller as the energy moved through it.

AP 2.1 Wave Model (pages 119–120)

- Accept all plausible student drawings of a wave.
- Accept all definitions that identify the basic concepts of the term to be defined.
- Student responses should be supported with evidence from their investigation.

AP 3.1 Modeling a Water Wave (Day 1) (page 121)

Students should indicate what materials they will use, a description of their model, and a brief explanation of how energy will be inputted into the model.

AP 3.2 Testing a Wave Model (pages 122–123)

1. Students should note that the frequency increases as energy is added to the spring toy.
2. Students should note that the amplitude increases as energy is added to the spring toy.
3. Students should discuss the different effects of the waves using the concept of energy causing change.

AP 4.2 Investigating Sound Waves with a Shoebox Guitar (page 125)

1. Students should list methods such as plucking a string and tapping a string.
2. Students should reference characteristics using vocabulary from the unit, such as *intensity*, *pitch*, and *vibration*.
3. The strings should make similar sounds if they are using identical rubber bands with the pencil at a right angle to the strings. If the guitar uses different rubber bands and/or has the pencil at an angle that is not 90° to the rubber bands, the sounds should be different.
4. Students should note that both guitars have strings that create sound waves that move through the guitar and through the air.

AP 5.1 Sound Observations (page 126)

- Accept plausible student observations.
- Students should note that sound waves change speed as they move through different types of matter and that this changes how the sound is heard.

AP 6.1 What Does It Sound Like? (page 127)

- Accept all student responses that describe the sounds.
- Accept all student questions about the sounds. If time allows, have a whole-class or small-group discussion to attempt to answer the questions students pose.

AP 6.2 Lesson 6 Check (page 128)

- The line from the whisper should go to the graph with the smaller amplitude. The line from the train should go to the graph with the larger amplitude.
- The line from the mouse squeaking should go to the graph with the shorter wavelength. The line from the tuba should go to the graph with the longer wavelength.

AP 7.1 Sound Words (pages 129–130)

- Accept all student responses used in the word webs.
- The crest will be the highest point of a wave. The trough will be the lowest point of a wave. The amplitude will be the distance from the axis to the crest or trough. The wavelength will be the distance from one crest or one trough to the next.
- frequency, pitch, volume/intensity, vibration, sound wave

AP 7.2 Modeling Sound Waves (pages 131–132)

- Page 1: Student graphs should show a wave that has higher crests and lower troughs than the printed graph.
- Student labels should be correct.
- Students should note that a wave would have greater intensity if more energy were in the wave.
- Accept all student descriptions of the model sound wave. Comparisons should note the similarities and differences between the two graphs.
- Page 2: Student drawings should show more peaks on the graph and should be labeled correctly.
- The sound described should have a higher pitch.
- Accept all student examples of higher-pitched sounds.
- Sound wavelengths will change as the frequency changes. Higher frequencies will have shorter wavelengths, and lower frequencies will have longer wavelengths.
- When the frequency increases, the pitch goes up, and when the frequency decreases, the pitch goes down.

AP 7.3 Testing Sound Waves (pages 133–134)

Step 2: Student descriptions should note the repeated motion of the string.

Step 4: Student graphs should show larger amplitude and same frequency.

Step 5: Students should note the differences in the two graphs, such as a larger amplitude, and the similarities, such as the same pitch and frequency.

Step 6: Accept all student descriptions. Students should note the similarities and differences in the wavelengths of the different sounds.

AP 8.1 Find the Light (page 135)

- Accept all student sources and descriptions of light.
- Accept all student questions about the light.
- If time allows, have a whole-class or small-group discussion to attempt to answer the questions students pose.

AP 9.1 Light Behaviors (page 136)

- Accept all student drawings of light interacting with matter. Correct any misconceptions students may have in their models.
- A light wave is the way light energy transfers.
- Students should identify the light source and interaction of light with the matter.
- Challenge: The location of the objects appears shifted when viewed through the water in the glass.

AP 10.1 Build a Solar Oven (Day 1) (page 137)

Step 1: Student designs utilize the materials from the list.

Step 4: Accept all plausible predictions that reference an investigation of light.

AP 10.2 Test Your Solar Oven (Day 2) (page 138)

Students make predictions for all objects and include observations of what happened to each object as well as an explanation of the cause (light) of what happened to the material.

AP 11.1 Invisible Energy (page 139)

- radio waves, microwaves, X-rays, gamma rays
- Radio waves: used to communicate; can cause burns if exposed to high doses
- Microwaves: used for cooking and radar; can damage cells in living things
- X-rays: used for medical purposes; can damage cells in living things
- Gamma rays: used for medical purposes; can cause cancer and gene damage

AP 11.1, continued
(page 139)

- Students may have used radio waves to listen to the radio, microwaves to heat up food, and both X-rays and gamma rays when they see a doctor.

AP 12.1 Decoding
(page 140)

- recycling symbol, use scissors symbol, poison symbol, wheelchair accessible symbol, diaper changing station symbol, no smoking symbol
- Morse code key: sound waves; lighthouse: light waves; traffic signal: light waves; two-way radio: radio waves; cell phone: radio waves

AP 13.1 Sending Coded Messages
(pages 141–143)

Day 1: Student writes key code and includes a description of how the code works and instructions for its use.

Student identifies method of transmission and whether the code meets the criteria and constraints.

Day 2: Student includes code and method of wave to send code.

Students note how well the code worked and the reasons why.

AP 14.1 Develop Models of Signals
(page 144)

Students draw a model of each method of using a signal. The following should be part of their models:

Cell phone: cell phone, tower, tower, cell phone

Fiber optic cable: computer or television, cable box, fiber optic cable, cable lines to another location

GPS: GPS transmitter, three satellites showing a signal going from each to the transmitter

AP UR.2 Vocabulary Crossword Puzzle
(pages 146–147)

ACROSS:

1. pitch

5. absorb

7. wave

9. trough

10. vibration

11. light source

13. reflect

14. vibrate

DOWN:

2. color

3. light wave

4. light

6. sound wave

7. wavelength

8. volume

12. crest

Unit Assessment: Teacher Evaluation Guide

Teacher Directions: The Unit Assessment is designed as a fifty-point test. Through this assessment, students demonstrate their overall learning of the unit's Learning Objectives. CKSci Unit Assessments typically range from ten to fifteen questions in the upper elementary grades, which can be answered in a single classroom session or administered in two sittings. Items with simpler answers that assess knowledge but not the deeper understandings of the content, such as multiple choice or short answers, are weighted differently and are worth fewer points. Assessment items that require more complex thinking and a deeper understanding of the content, such as writing explanations or identifying multiple relationships, are worth more points. Items that require synthesis of content and other student knowledge are weighted with more points as well. Some test items encourage students to use their Core Vocabulary decks as a reference source for terminology and concepts related to the test item.

Expected Answers and Model Responses

1. a, c (2 points)

2. Student response notes that stronger winds transfer more energy into the waters of the Atlantic Ocean. As more energy is transferred into those waters, the water waves grow bigger and carry more of that energy. (3 points)

3. (5 points)

Above Average	Student response includes labels and/or clear descriptions of each part of the wave.
Average	Student response includes a mostly accurate drawing with labels.
Adequate	Student response includes a drawing.
Inadequate	Student response includes an inaccurate or no drawing.

4. Accept all plausible student descriptions of ways to use vibrations to make sounds. These can include strumming on a guitar or other stringed instruments, tapping on an object, whispering into a tin can walkie-talkie, or some other action to cause vibrations that result in sound. Response to the second part of the question should include Core Vocabulary words such as *sound waves*, *vibration*, *wave*, and *wavelength* and should indicate that sound travels in waves through particles in matter. (3 points)

5. (5 points)

Above Average	Student response accurately shows particles in solids close together, particles in liquids farther apart, and particles in gases farthest apart. Drawing should indicate that sound waves travel fastest through solids, less fast through liquids, and most slowly through gases. Labels are accurate.
Average	Student response shows particles in solids close together, particles in liquids farther apart, and particles in gases farthest apart. Drawing should indicate that sound waves travel fastest through solids, less fast through liquids, and most slowly through gases. Labels are mostly accurate.
Adequate	Student response includes drawings that contain some inaccuracies. Labels may be only partly accurate.
Inadequate	Student response includes inaccurate or no drawings. Labels are missing or inaccurate.

6. a, d, f (2 points)

7. (5 points)

Above Average	Student response includes labels and/or clear descriptions of each part of the wave. Student identifies whether the frequency is high or low based on the wavelength and uses evidence from the lesson to describe how he or she knows this.
Average	Student response includes an accurate drawing with labels. Student identifies whether the frequency is high or low based on the wavelength and describes how he or she knows this in basic terms.
Adequate	Student response includes a drawing. Student identifies whether the frequency is high or low but does not explain how he or she knows this.
Inadequate	Student response includes an inaccurate or no drawing. Student misidentifies whether the frequency is high or low. Student does not describe or inaccurately describes how he or she knows this.

8. yes, yes, no, no, no, no (3 points)

9. Student response should note that light waves can travel through empty space. Light waves don't need particles of matter to travel through, unlike sound waves. They can travel through some solids, liquids, and gases, depending on how transparent they are. The more opaque they are, the less light waves can travel through them. In these cases, the atoms absorb some of the photons so that the light cannot pass through them. (3 points)

10. Student response should indicate light energy from the sun. (2 points)

11. Student response should indicate that certain wavelengths of light energy heat up the contents of the pot, which changes by cooking the contents in the same way that people cook food in pots on stoves or in regular electric ovens. (3 points)

12. Student response should indicate that some light waves have shorter or longer wavelengths than other light waves. Most wavelengths of light cannot be detected, or seen, by human eyes. (3 points)

13. Student examples should accurately reflect ways that scientists and/or engineers transmit information from one form to another—such as light over distance; physical symbols such as flags, dots/dashes; sound (telegraph)—to communicate information. Student may indicate that this is to help transmit information quickly across long distances or to larger numbers of people. (3 points)

14. Accept all plausible student descriptions of codes and code keys. Codes and code keys should be simple enough that other students could decipher them with relative ease. (5 points)

15. Accept all plausible student arguments. Student response should include criteria and constraints for each means of transmitting information and then logically argue which is better based on those criteria and constraints. (3 points)

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

absorb, v. to take something in and contain it (18)

amplitude, n. the height or distance from the crest to either the mid-point or the trough of a wave

analog, adj. describing signals sent as continuous waves (34)

C

code, n. a pattern of symbols that can be used to communicate a message (29)

color, n. an aspect of light that enables otherwise identical objects to be distinguished from each other through the sense of sight (vision) (18)

crest, n. the highest part of a wave (3)

D

digital, adj. describing signals sent as separate bits and not continuous (35)

disturbance, n. an interruption of stillness

E

electromagnetism, n. the interaction of electric fields on matter

emit, v. to give off

F

frequency, n. the number of times a wave peaks over a period of time (7)

G

gesture, n. a movement of a part of the body to communicate an idea or emotion

I

information, n. types of data such as pictures, sounds, and messages (33)

intensity, n. the measurable strength or power of a vibration (7)

L

light, n. a form of energy that can transfer through empty space and can and make things visible (13)

light source, n. an object that gives off its own light (14)

light wave, n. an energy disturbance that transfers, or radiates, light (15)

M

medium, n. the matter through which sound passes

P

pattern, n. a regular or repeated way in which something occurs (29)

pitch, n. the quality of sound that is described as high or low and is related to a wave's frequency (7)

R

radiation, n. the emission of energy as electromagnetic waves

reflect, v. to bounce off of (16)

S

signal, n. a symbol sent over a distance (30)

sound wave, n. a transfer of energy through a material as it is disturbed by vibrations (5)

source, n. the origin of something

symbol n. a visual object or mark that stands for something else (28)

T

transfer, v. to move from one place to another (33)

transparency, n. a property of matter that allows light to pass through it (16)

trough /trof/, n. the lowest part of a wave (3)

V

vary, v. to differ

vibrate, v. to move back and forth quickly **(5)**

vibration, n. the motion of an object or material that is vibrating **(5)**

volume, n. the way humans perceive loudness from the intensity of a sound wave **(7)**

W

wave, n. a disturbance that transfers energy through matter or through space **(1)**

wave height, n. the vertical distance from the top of the crest to the bottom of the trough of a wave **(3)**

wave speed, n. the pace at which wave crests in series pass a point of reference; frequency

wavelength, n. the distance from one crest to the next crest of a wave **(3)**

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 are durable, 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 for 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 plan 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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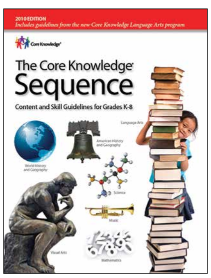

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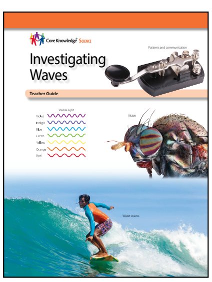
The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including earth and space, physical, and the life sciences, the *Core Knowledge Sequence* 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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