Core Knowledge® SCIENCE

Astronomy: Space Systems

Solar system

Teacher Guide

Space exploration

Patterns in the night sky

Eclipses

Astronomy: Space Systems

Teacher Guide

Core Knowledge®

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Astronomy: Space Systems

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Teacher Guide

Core Knowledge Science™ 5

UNIT 5

Introduction

About this Unit

The Big Idea

This unit focuses on the scientific concept that Earth is one object in a system of objects in space and that observations of objects in space reveal predictable patterns of motion.

Students will learn that humans have long wondered about our place in the universe. Much of what we know about the universe comes from various kinds of exploratory tools, such as telescopes and space probes, as well as human spaceflight. Growing scientific evidence has allowed us to comprehend that we are part of a large solar system, which lies within an even larger galaxy that is but one of many millions of galaxies in the universe. The sun is the closest of all stars to Earth. The sun appears to be the brightest star, but that is only because it is the closest from our perspective on our planet's surface. Other stars farther away have a greater absolute brightness than the sun.

Students also relate the shape and motion of Earth, as well as the force of gravity, to our understanding of our solar system. Earth rotates on its axis, which takes one day. Earth also orbits the sun, which takes one year. These movements can be discerned from evidence such as the transition from day to night, the changing location of shadows during the day, and the slow shifting of the stars in the sky during the year. The planets of our solar system orbit the sun due to the sun's gravitational force. From our perspective on the surface, Earth's gravitational force, which pulls toward the planet's center, is perceived as pulling "down."

Note to Teachers and Curriculum Planners

This unit introduces Grade 5 students to real-world examples and fundamental concepts that will be explored in greater depth in later grades. Students will learn about the system of planets that orbit our sun. The following are preliminary considerations for planning and instruction relative to this unit:

- This unit introduces gravity as a pull "downward" toward the center of Earth. It engages students to think about the shape of the Earth and that "down" is a description depending on one's location across our planet. Mathematical representations of gravity are not introduced in this unit.
- Regarding the brightness of stars, this unit's assessment opportunities do not include measurement of the sizes of stars and only require students to consider the relative distances that cause apparent brightness. Classification of stars is not considered a Grade 5 expectation.
- Students investigate patterns of day/night, shadow movement, and seasonal changes; however, students are not expected to explain the causes of the seasons at this grade level.

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 from 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**
Astronomy (Grade 3) • The universe: an extent almost beyond imagining • Galaxies • Our solar system: sun, planets, other objects • Planetary motion: orbit and rotation • Gravity, gravitational pull • Exploration of space **Astronomy (Grade 6)** • How gravity keeps the planets in orbit • Stars • The Milky Way is our galaxy.	**Introduction to Astronomy** • How we know about our solar system and universe: ◦ Earth-based observations ◦ Space probes and space-based telescopes (such as the Hubble Space Telescope) ◦ Human space flights (such as *Apollo 11*, the first landing on the moon) ◦ Computer-assisted observations **Gravity** • Earth's gravitation is perceived as pulling "down." • Gravity of the sun pulls on all objects in our solar system, causing predictable orbits of the planets.
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?*

This unit, *Astronomy: Space Systems*, has been informed by the following Grade 5 Performance Expectations for the NGSS topic *Space Systems: Stars and the Solar System*. Students who demonstrate understanding can

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.

5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Online Resources

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

www.coreknowledge.org/cksci-online-resources

*NEXT GENERATION SCIENCE STANDARDS (NGSS) is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and their endorsement is not implied.

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:

PS2.A: Forces and Motion

Grades K–2

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

Grade 3

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

PS2.C: Stability and Instability in Physical Systems

Grades K–2

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

PS3.A: Definitions of Energy

Grade 4

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

PS3.B: Conservation of Energy and Energy Transfer

Grades K–2
- Sunlight warms Earth's surface.

Grade 4
- Light also transfers energy from place to place.

PS3.C: Relationship Between Energy and Forces

Grades K–2
- A bigger push or pull makes things go faster. Faster speeds during a collision can cause a bigger change in shape of the colliding objects.

ESS2.D: Weather and Climate

Grades K–2
- Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

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. Introduction to Astronomy — Lessons 1–3

- Distinguish between the terms *universe*, *galaxy*, and *solar system*.
- Identify our solar system as part of the Milky Way galaxy.
- List the planets in our solar system in order of increasing distance from the sun.
- Describe three ways we know about our universe and solar system.
- Identify at least three objects that can be found in our solar system.

B. Evidence of Earth's Movement — Lessons 4–8

- Organize and present data about changes associated with Earth's rotation and orbit.
  - Describe patterns in the data that help explain Earth's movement.
- Distinguish between Earth's rotation and its orbit.
- Explain how it can simultaneously be day at one location on Earth and night at another location.
- Predict the differences in shadows seen at two different places on Earth.

- Describe observable patterns in the phases of the moon.
- Identify the relative positions of the sun, the moon, and Earth during a lunar eclipse and a solar eclipse.

C. Stars — Lessons 9–12

- Organize and use data to demonstrate that apparent brightness of the sun and stars is due mainly to their distance from Earth.
- Organize and use data that explains why some stars and constellations are only visible in certain seasons.
- Identify the sun as the closest star to Earth.
- Describe an example of a constellation.
- Describe how constellations are named.
- Describe why some stars appear brighter than others.

D. Gravity — Lessons 13–14

- Provide evidence that Earth's gravitational force pulls objects "down" toward the center of Earth.
- Describe the shape of Earth.
- Identify the direction of Earth's gravity at two or more locations on Earth's surface.
- Explain the relationship between the sun's gravity and the orbits of the planets around the sun.
- Explain the relationship between the moon's gravity and tides on Earth.

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

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

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

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

Using the Teacher Guide

Pacing

The *Astronomy: Space Systems* unit is one of five units in the Grade 5 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 eighteen days teaching the *Astronomy: Space Systems* unit so that you have time to teach the other units in the Grade 5 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. Introduction to Astronomy	**1.** Exploring Space (two class sessions)	How do people know what is in space?
	2. The Solar System	What is the solar system?
	3. The Vastness of Space	What is the universe, and what are galaxies?
B. Evidence of Earth's Movement (5-ESS1-2)	**4.** Modeling Earth's Revolution and Rotation	How can I model the ways that Earth moves in space?
	5. Earth's Movement	How does Earth move in space?
	6. Modeling the Sun-Earth-Moon Relationship	How can I model the relationship among the sun, Earth, and the moon?
	7. The Moon from Earth	What are moon phases and eclipses?
	8. Changing Star Patterns	How do star patterns provide evidence of Earth's movement?
C. Stars (5-ESS1-2)	**9.** Brightness and Distance	What is apparent brightness?
	10. Brightness of Stars	Why do some stars appear brighter than others?
	11. Constellations	What are constellations?
	12. Diagramming Seasonal Constellations	Why does the night sky change throughout the seasons?
D. Gravity (5-PS2-1)	**13.** Gravity	What is gravity?
	14. Using Evidence About Gravity (two class sessions)	How can I use evidence to support an argument that Earth is a sphere?
Unit Review and Assessment	Unit Review: Women and Studying Space	How have people learned about space systems?
	Unit Assessment	What have I learned about space systems?

Activity Pages and Unit Assessment

Activity Pages

AP 1.1
AP 1.2
AP 2.1
AP 3.1
AP 4.1
AP 5.1
AP 6.1
AP 7.1
AP 8.1
AP 9.1
AP 10.1
AP 11.1
AP 12.1
AP 13.1
AP 13.2
AP 14.1
AP 14.2
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 113–150. 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—Exploring Space (AP 1.1)

Lesson 1—Space Collage (AP 1.2)

Lesson 2—Objects in the Solar System (AP 2.1)

Lesson 3—The Universe (AP 3.1)

Lesson 4—The Movement of Earth (AP 4.1)

Lesson 5—Patterns and Evidence of Movement (AP 5.1)

Lesson 6—Shadows (AP 6.1)

Lesson 7—Phases (AP 7.1)

Lesson 8—Moving Stars (AP 8.1)

Lesson 9—Star Light, Star Bright (AP 9.1)

Lesson 10—Comparing Stars (AP 10.1)

Lesson 11—Patterns in the Constellations (AP 11.1)

Lesson 12—Constellations (AP 12.1)

Lesson 13—Diagramming the Direction of Earth's Gravitational Pull (AP 13.1)

Lesson 13—Lesson 13 Check (AP 13.2)

Lesson 14—Earth's Shape Evaluation Guide (AP 14.1)

Lesson 14—Identifying Evidence of Earth's Shape (AP 14.2)

Unit Review—Space Systems Big Questions (AP UR.1)

Unit Review—Vocabulary Review (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 151–152.

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 140–145) to monitor progress during each lesson and to measure understanding at the conclusion of the unit. Many lessons provide tips to help you support students who need further explanations or clarifications.

Effective and Safe Classroom Activities

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

These resources, included at the back of the Teacher Guide on pages 153–157, consist of the following:

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

Online Resources

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

www.coreknowledge.org/cksci-online-resources

Materials and Equipment

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

Part A: Introduction to Astronomy

Lesson 1

- poster board
- construction paper of various colors
- scissors (1 per group)
- glue
- drawing utensils
- access to the school's library during class time when no other classes will be there
- 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 (2 per student)

Lesson 3

- index cards for student vocabulary deck (2 per student)

Part B: Evidence of Earth's Movement

Lesson 4

- heat lamps or flashlights (1 per pair of students)
- balls (1 per pair of students)
- ruler or stick
- sunny place to put the ruler in the ground where it will not be disturbed and can be checked a few times throughout the day
- index cards for student vocabulary deck (1 per student)

Lesson 5

- printed photo of a Ferris wheel
- globe
- heat lamp or flashlight
- internet access and the means to project images/video for whole-class viewing

Lesson 6

- flashlights (1 per group of students)
- larger balls (1 per group of students)
- smaller balls (1 per group of students)
- space for students to be able to move freely to demonstrate revolution and rotation
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

Lesson 7

- flashlights (1 per group of students)
- larger balls (1 per group of students)
- smaller balls (1 per group of students)
- space for students to be able to move freely to demonstrate revolution and rotation
- handheld mirror
- glue sticks
- scissors
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

Lesson 8

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

Part C: Stars

Lesson 9

- flashlights (2 identical per group of students)
- new batteries
- meterstick
- colored painter's tape
- large area that can be darkened, such as a gym or auditorium
- photo of the night sky

Lesson 9, continued

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

Lesson 10

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

Lesson 11

- stapler
- scissors
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

Lesson 12

- soccer ball (or any ball of similar size)
- clay
- bright sticker
- table lamp (no shade)
- roll paper (5 feet per group)
- painter's tape or sticky tack to temporarily hang roll paper sheets
- wall space for students to hang their constellations

Part D: Gravity

Lesson 13

- tennis ball
- string (about 12 feet long)
- tape

Lesson 13, continued

- scissors
- books (for weights)
- globe
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

Lesson 14

- clear plastic cup or bottle
- gravel
- teaspoon
- water
- tennis ball
- permanent marker
- rubber band that fits tightly over the tennis ball
- globe or large ball
- modeling clay
- flat toothpick
- small sticky note
- scissors
- solid shapes (cube, cylinder, cone, sphere)
- flashlight or lamp
- internet access and the means to project or print images for whole-class viewing

Unit Review

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

Sample Pacing Guide

The sample Pacing Guide suggests use of the unit's resources across an eighteen-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
Exploring Space DAY 1 TG Lesson 1 AP 1.1	*Exploring Space* DAY 2 TG Lesson 1 AP 1.2	*The Solar System* TG Lesson 2 SR Chapter 1 AP 2.1	*The Vastness of Space* TG Lesson 3 SR Chapter 2 AP 3.1	*Modeling Earth's Revolution and Rotation* TG Lesson 4 AP 4.1

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
Earth's Movement TG Lesson 5 SR Chapter 3 AP 5.1	*Modeling the Sun-Earth-Moon Relationship* TG Lesson 6 AP 6.1	*The Moon from Earth* TG Lesson 7 SR Chapter 4 AP 7.1	*Changing Star Patterns* TG Lesson 8 AP 8.1	*Brightness and Distance* TG Lesson 9 AP 9.1

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
Brightness of Stars TG Lesson 10 SR Chapter 5 AP 10.1	*Constellations* TG Lesson 11 SR Chapter 6 AP 11.1	*Diagramming Seasonal Constellations* TG Lesson 12 AP 12.1	*Gravity* TG Lesson 13 SR Chapter 7 AP 13.1, 13.2	*Using Evidence About Gravity* DAY 1 TG Lesson 14 AP 14.1, 14.2

Week 4

Day 16	Day 17	Day 18		
Using Evidence About Gravity DAY 2 TG Lesson 14 AP 14.1, 14.2	*Women and Studying Space* TG Unit Review SR Chapter 8 AP UR.1, UR.2	Unit Assessment AP Unit Assessment		

Pacing Guide

Eighteen days have been allocated to the *Astronomy: Space Systems* unit to complete all Grade 5 science units in the *Core Knowledge Curriculum Series*™. If you cannot complete the unit in eighteen 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

Introduction to Astronomy

Overview

Lesson	Big Question	Advance Preparation
1. Exploring Space (2 days)	How do people know what is in space?	Gather materials for hands-on investigation. (See Materials and Equipment, page 12.)
2. The Solar System	What is the solar system?	Read Student Reader, Chapter 1.
3. The Vastness of Space	What is the universe, and what are galaxies?	Read Student Reader, Chapter 2.

Part A: What's the Story?

A basic understanding of the universe is a prerequisite for understanding why shadows appear, why there is day and night, why different stars appear in different parts of the sky at different times of the year, and why the sun is brighter than other stars in the sky. This section teaches students about the objects that appear in the sky, the solar system, the galaxy, and the universe as a whole to help them understand the concepts described above.

In Lesson 1, we introduce students to the universe by having them research objects in space as well as one technology that has helped us understand that object better. The goal is to introduce basic concepts about space that students can build on over the next two lessons before learning about Earth's relationship to other planets and stars in the universe.

In Lesson 2, students learn the definition of a solar system as well as about each planet in our solar system. They also learn to distinguish between rocky planets, gas giants, and dwarf planets, among other objects in our solar system.

In Lesson 3, students learn to distinguish the terms *galaxy*, *universe*, and *solar system*. They also learn about individual technologies that have been used to learn more about what is in space. In addition, they learn about specific accomplishments people have made in relation to space, such as circling Earth in a spacecraft and landing on the moon. Finally, students come to an understanding that space exploration is not standing still and that scientists are always working on new ways to get humans into space or to another planet.

So, to repeat, students are introduced to the concept of a vast universe with many parts, including solar systems and galaxies, and many objects, including stars, planets, dwarf planets, asteroids, meteors, comets, and dust. They also learn about the technologies that have enabled us to learn more about space. All of this is in preparation of Parts B and C in this unit, where students will consider deeper concepts related to Earth's position in the solar system, the Milky Way galaxy, and the universe.

This set of lessons lays the foundation for meeting the learning objectives in Parts B, C, and D of this unit.

LESSON 1

Exploring Space

Big Question: How do people know what is in space?

At a Glance

Learning Objective

✓ Describe three ways we know about our solar system and universe.

Lesson Activities (2 days)

- student investigation
- discussion and research
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

Note that the first three lessons in this unit introduce students to the universe and some of what it contains, along with the technology that humans use to see the various objects in space. The lessons do not address a specific NGSS Performance Expectation.

Analyzing and Interpreting Data is important to students' study of Earth and the solar system as they research how humans know what is in space. They also analyze and interpret data from various technological advancements to better understand that space is large and contains many objects, including dwarf planets, planets, and stars, as well as solar systems and galaxies, among other things.

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 purple 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 151–152 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.

galaxy	star	**universe**
solar system	sun	

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 purple above. (**Note:** Lesson 1 is introductory in nature. These terms and others will be taught with additional context in subsequent lessons.)

Instructional Resources

Activity Pages

AP 1.1
AP 1.2

Activity Pages
Exploring Space (AP 1.1)

Space Collage (AP 1.2)

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

Materials and Equipment

Collect or prepare the following items:

- poster board
- construction paper of various colors
- scissors (1 per group)
- glue
- drawing utensils
- access to the school's library during class time when no other classes will be there
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

It may be best to conduct the entire Day 1 class session in the library. Taking students to the library during the activity portion of the session may cause a loss of time, which will be needed for students to conduct their research. If the library is used, be sure to have access to equipment that can play videos from the internet.

The Core Lesson — Two days, 45 min each

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

How do people know what is in space? By Grade 5, most students will have some conception of space and the universe, whether through movies, television series, books, comic books, or other media. In this lesson, they will learn more about what humans actually know about space and how they came to know it, including what objects exist in space. They also will be introduced to some basic terms related to space, which they will explore further in the next two lessons.

Begin the discussion by engaging students in a discussion about what they already know about space. Ask the following:

- What is outer space? (*the universe beyond Earth's atmosphere*)
- What are some of the things that exist in space? (*planets, stars, galaxies, moons, comets*)

NOTE—Some students might state answers for which there is no current evidence. For example, they may name aliens as things that exist in space based on their viewing of science fiction movies or television shows. Be sensitive when replying to such answers, but be sure to remind students that answers must be based on facts and evidence.

2. Encourage student questions. — 5 min

Online Resources

Show students a video about the universe. Have students listen and look for key words or phrases and what they mean, including *solar system, galaxy/galaxies*, and *universe.* Invite them to take notes. If they do not understand something, encourage them to ask questions.

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

www.coreknowledge.org/cksci-online-resources

Play the video again, this time pausing at any moment they need to take in and synthesize information. (See **Know the Science** on the following page.) Explain that students will learn more about different aspects of space throughout this lesson and in the two lessons that follow.

Preview Core Vocabulary Terms

Before students begin their research, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they work through this lesson. Support students with guidance if they struggle with the terms. Students will complete vocabulary deck cards and Word Work for these terms in later lessons.

galaxy **solar system** **universe**

3. Preview the investigation. 5 MIN

Activity Page

AP 1.1

Distribute Exploring Space (AP 1.1), and review the directions with students. Separate students into groups, and assign them one technological advancement from the first page and one space object from the second to investigate. Explain that they will use the library's resources to find out how their technological advancement has helped scientists learn more about space, as well as what scientists know about the object they have been assigned.

Explain that once they have researched space objects and technology, they will take their construction materials and, on Day 2, make a collage showing what they have learned about space.

4. Facilitate the investigation. 20 MIN

Online Resources

Once students have been assigned or allowed to choose a technological advancement, you may want them to watch a short video about that technology.

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

www.coreknowledge.org/cksci-online-resources

As students work on Exploring Space (AP 1.1), circulate around the room to ensure that students are correctly completing the data tables. The data tables will help students organize the information so that they can better put it together with other student information on the second day. Encourage students to think about how the technological advancement they have been assigned has been used to learn more about the space object they have been assigned. Remind students, however, that their technological advancement has likely been helpful in learning about the space objects that other groups have been assigned as well.

Know the Science

Why do astronomers classify objects in space into systems such as galaxies and solar systems?
Describing interactions helps scientists to understand how the universe works. When scientists refer to *space*, they are usually referring to the universe as a whole. The universe is all existing matter in space, including stars, planets, dwarf planets, and dust, as well as all the empty space between these things. It is so vast that astronomers organize it into smaller units. One unit is a solar system, a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris. The sun is the center of our solar system, and Earth is one of eight planets that exist within that system. A larger unit is a galaxy. A galaxy is a collection of dust, gas, stars, and their solar systems. The universe, then, is made up of many galaxies, and each galaxy is made up of many solar systems. Scientists have named many galaxies and solar systems, some of which are shown in the video. By doing so, they can keep track of where places are in the universe. For example, they know that the Milky Way galaxy and a nearby neighboring galaxy, Andromeda, are moving toward each other and will collide in about four billion years.

SUPPORT—Some students may struggle with researching their technological advancement or space object. If it is easier for each group, have some in the group research the advancement and others research the space object. Then have students come together at the end of the research period to share what they know. It is important not do the research for students who are struggling but to help show how the research is done. By Grade 5, most students should understand the basics of library and online research, but they may still need an occasional refresher or help with a difficult subject.

5. Encourage discussion. 5 MIN

Once students have had time to complete their data tables, bring the class back together for a whole-class discussion to briefly summarize what students discovered. Students should be able to explain their observations and support them with evidence from the data. Remind students that on Day 2 of the activity, they will work together to show how the space objects they researched are part of the universe.

6. Check for understanding. 5 MIN

Activity Page

AP 1.1
Answer Key

Formative Assessment Opportunity

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

Collect the completed Exploring Space (AP 1.1). Scan the data tables that students completed, and check for accuracy. Be sure to return them to students before the start of the next day so that students will have them to complete their collage.

If students still have questions or are confused about anything they have learned, now is the time to engage them in a brief discussion. Allow volunteers to take a stab at answering the questions, and provide constructive feedback to affirm correct answers.

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

How do people know what is in space? Remind students that on the first day of the lesson, they researched one technological advancement and one object in space to learn more about how we know what is in space. Ask the following:

- How do scientists organize space from the largest system to the smallest? (*the universe, galaxies, solar systems*)
- What are some of the technological advancements that have helped us learn more about space? (*telescopes, space probes, rovers, a space station, lunar landing, etc.*)

2. Encourage student questions. 5 MIN

Activity Page

AP 1.2

Distribute Space Collage (AP 1.2), and review the directions. Have students name some of the objects in space that they have learned about so far. Then have students discuss how the objects might be related to each other. For example, planets revolve around a star; moons revolve around planets. Ask students to keep this in mind as they plan their collage.

> **CHALLENGE**—Discuss proportions and scale. Students should consider that the universe has many galaxies and that a single galaxy has many suns or stars. A solar system may have more than one star and many planets.

Encourage students to ask each other questions.

Then decide as a class what the class collage will show. Will it be the universe with lots of galaxies, a galaxy, or a solar system?

3. Facilitate the activity. 25 MIN

Separate students into the same groups they were in on Day 1. Pass out colored construction paper to each group, as well as scissors and drawing utensils, and have students draw and cut out the objects they researched. For example, one group may have researched moons. If so, that group should draw and cut out moons. When each group has drawn and cut out an adequate number of objects, have students come together to make a collage on the poster board.

> **SUPPORT**—Be sure that students understand they don't necessarily have to have an accurate number of cutouts for some aspects of the collage. For example, if a group researched moons and the collage is covering the solar system, students do not have to make one moon for every moon that exists in the solar system. Students do, however, have to show that they understand what moons are.

4. Encourage discussion. 5 MIN

Each group should have a designated member to discuss the space object it researched. As each group places its cutouts on the collage, the designated member should tell the rest of the class what the group learned. Once the collage is completed, have each group discuss its technological advancement. Encourage other students to ask questions of the group, and guide the class discussion.

5. Check for understanding. 5 MIN

Activity Page

AP 1.2
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect the completed Space Collage (AP 1.2). Look over the models that students drew. If any students misunderstood what they were supposed to illustrate, go over the model with them, and have them redo it as a take-home assignment.

If students still have questions or are confused about anything they have learned, now is the time to engage them in a brief discussion. Allow volunteers to take a stab at answering the questions, and provide constructive feedback to affirm correct answers.

LESSON 2

The Solar System

Big Question: What is the solar system?

At a Glance

Learning Objectives

- ✓ List the planets in our solar system in order of increasing distance from the sun.
- ✓ Identify and describe at least three different types of objects that can be found in our solar system.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

The first three lessons in this unit introduce students to the universe and some of what it contains, along with the technology that humans use to see the various objects in the space. Note that this section does not cover a specific NGSS Performance Expectation.

Patterns are important to students' study of Earth and the solar system as they learn that solar systems all have one thing in common: at their core is a star or stars, around which revolve various bodies such as planets, dwarf planets, asteroids, and other objects. They also learn about other patterns, such as how planets are spheroid and moons are satellites that revolve around other objects in space.

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 purple 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 151–152 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.

ellipse/elliptical	planet	**solar system**	terrestrial
orbit	revolve/revolution	system	

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 purple above.

Instructional Resources

Student Reader

Ch. 1

Activity Page

AP 2.1

Student Reader, Chapter 1
"The Solar System"

Activity Page
Objects in the Solar System (AP 2.1)

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

Materials and Equipment

Collect or prepare the following:

- 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

What is the solar system? Display a video of Venus transiting the sun. Point out that, by comparison, Venus appears to be a tiny speck in front of the enormous sun. Size is just one difference between these two objects that are part of the same system.

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

Activity Page

AP 2.1

Introduce the directions for Objects in the Solar System (AP 2.1). Let students know that they will be describing the various characteristics of the planets as they read Student Reader Chapter 1. Before going over the directions, ask students to recall what they saw in the video in the previous lesson and what they learned about the solar system. Ask the following:

- What is the solar system? (*a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris*)
- What are some components of a solar system? (*one to three stars, planets, moons, asteroids, comets, meteors, etc.*)

SUPPORT—Explain that students will learn more about our solar system and what can be found there in the reading. Encourage students to take notes as they read or to complete the activity during the reading. Some students may not be able to answer these questions based on what they learned in Lesson 1, but others will. Be aware of this, and tell students who cannot answer the questions that they will learn more about the answers in this lesson.

2. Encourage student questions. 5 MIN

Lead a discussion about the planets.

- Ask students to name as many planets in our solar system as possible. If they have trouble thinking of one, have them think about the planet they live on. (*Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune*)
- Ask what sets Earth, the planet we are on, apart from the others they know about. (*Some will say that it contains life while the others do not.*)

Encourage students to ask questions about the planets or anything else in the solar system. Write these questions down on the board or chart paper, and ask students to regularly consult them throughout the reading. They may be answered as the reading progresses.

Draw students' attention back to the Big Question, and introduce Chapter 1 of the Student Reader.

3. Read and discuss: "The Solar System." 20 MIN

Student Reader

Ch. 1

Prepare to read together, or have students read independently, "The Solar System," Chapter 1 in the Student Reader. This chapter reinforces the definition of the solar system as a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris.

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.

orbit **solar system**

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 reading page 1, ask students if they have ever gone outside to look at the sky at night.

- Have them describe what they saw. (*stars, the moon, shooting star, northern lights*)
- Based on the definition of *solar system* on the page, ask students which parts of what they saw might be part of our solar system. (*Students will likely point out that the moon is part of our solar system, and some may be able to name a few planets.*)

Make sure students understand, however, that the overwhelming majority of the objects they see in the night sky, including all the stars, are not part of our solar system. These exist outside the solar system. Tell students that in this lesson, they will learn only about the parts that are in our solar system.

SUPPORT—For extra support, point out that everything in our solar system revolves around the sun or revolves around an object that revolves around the sun. Remind students that not everything they see in the night sky revolves around the sun, which is our solar system's only star. (See **Know the Science 1** for further support with this analysis.)

Page 2

Note that the picture of Mercury was taken by a craft sent into space by NASA, which stands for the National Aeronautics and Space Administration. Explain that NASA and other space agencies in other countries around the world often work together to design craft that will travel into space, take images of foreign objects, and measure aspects of them. Tell students that they will learn more about spacecrafts in the next lesson.

Have students compare and contrast Mercury and Venus. Ask the following:

- How are the planets similar? (*Both are rocky; both are hotter than Earth.*)
- How are they different? (*One is very small; one is much larger.*)
- How does each planet's distance from the sun affect its revolution around the sun? (*Because Mercury is closer, its revolution distance is shorter.*)

Know the Science

1. Are there other solar systems? *Yes!* Stars lie at the center of solar systems. Some, perhaps most, of the time, there is only one star at the center of a solar system. However, scientists have observed solar systems that have up to three stars. In each solar system, everything that is not a star revolves around its star or stars. Scientists have discovered at least 2,500 other stars in our galaxy that have planets orbiting them. And there are likely many more that have yet to be discovered. Scientists estimate that there are 200 billion stars in our galaxy. Any planet that orbits any of these stars is known as an exoplanet, or a planet outside our solar system.

NOTE—While Mercury is mostly very hot, new studies suggest that the parts of it facing away from the sun actually have water ice. The ice exists mainly at the planet's north pole. Some of that ice is in shadowed areas, and some of it exists in large craters.

CHALLENGE—Ask students to research independently to find out what might have happened to the gases that were near the sun when our system formed.

Page 3

This page presents a good opportunity to remind students of what makes something alive. (*It takes in nutrients, it expels waste, it grows, it can reproduce, and so on.*)

- » Ask students to name some of the things on Earth that support life. (*its mix of gases, water, the right temperature*)
- » Also ask how Earth's moon sets it apart from the other planets. (*Earth is the only planet to have only one moon.*)
- » Ask students how Mars differs from Earth. (*It's much colder, has far less water, and does not support life.*)

Have students describe what Mars may have been like if it supported life in the past. (*Students' answers should show that they understand it might once have been more like Earth is today.*)

Pages 4–5

Before they read the page, remind students that the first four planets they have read about so far are all rocky planets. If they are confused by this, explain that the solid surface of Earth itself is made up of rock. Everywhere students look, under everything, is a layer of rock. This is true under the ocean, and it's true on land, too. Rock is not only in places where it can be seen. It lies under all the soil and surface material. Most of Earth is made up of rock.

- » Ask students to think back on past learning. What is the inside of Earth like? (*Parts of it are hard rock, but deeper beneath the surface, the greater pressures transform it into molten rock.*)
- » Have students read pages 4 and 5. Then ask students to describe how the planets described on these pages differ from the planets they have already read about. (*Jupiter, Saturn, Uranus, and Neptune are gas giants. They are far larger than the rocky planets, and they are mostly made of gases.*)

Ask students to connect what they read about Mars and deduce what evidence scientists use to consider whether life is or might have at one time been possible in these places. Point out that while Jupiter and Saturn differ radically from Mars and Earth, they both have terrestrial moons. Jupiter's moon Europa has evidence of salt water.

Ask students to relate the positions of Uranus and Neptune in relation to the sun to their icy characteristics.

SUPPORT—Scientists pronounce the planet name *Uranus* as /yer*en*us/.

Page 6 After reading the page, have students describe some of the other things that are in the solar system. (*dwarf planets, rocky or metallic bodies such as asteroids and meteors, and comets made of ice and dust*) (See **Know the Science 2** for further support with this analysis.)

4. Encourage discussion. 5 MIN

To help students understand some of the main ideas in the lesson, have them consider a space heater, wood stove, fireplace, or oven. Ask students where they are hottest when standing near one of these objects. Students should understand that the closer they stand to the object, the hotter they are and that the farther they stand from the object, the cooler they are. Relate this to the position of the planets in relation to the sun.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary terms (displayed 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):

orbit **solar system**

Word Work

- **orbit** (n. the oval-shaped path an object follows as it revolves around another object in space; v. to revolve around another object) Have students identify space objects that orbit around other space objects. (*the moon around Earth, Earth around the sun, Mars around the sun*) Explain that an orbit has an elliptical or oval shape.

  Compare the terms *orbit* and *revolve*. (*Both mean to move in a path around an object and are often used interchangeably. Although* orbit *is used in everyday language, it is more specific than* revolve *in a discussion of a space object's path. To revolve is to travel around and around. To orbit is to follow an elliptical path.*)

Know the Science

2. How are dwarf planets different from planets? Pluto was once considered a planet, but it is now officially classified as a dwarf planet. The criteria that scientists use to determine whether an object in space is a planet are threefold: 1) It has an orbit around the sun. 2) Its gravity is strong enough that it is spherical in shape. 3) It is large enough that it has cleared its orbit of other objects. The issue for dwarf planets such as Pluto is that they do not clear their orbital paths of other objects because they are too small. Pluto is one of five known dwarf planets in our solar system, though astronomers believe there may be up to two hundred.

- **solar system** (n. a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris) Clarify for students that when we refer to "the" solar system, we typically mean "our" solar system. But guide a comparison about what all solar systems must have and how they may differ. Ask students what all solar systems must have. (*a star at the center*) Then, ask students how solar systems might also differ. (*They have different objects that orbit the star.*)

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

6. Check for understanding. 5 MIN

Activity Page

AP 2.1
Answer Key

Formative Assessment Opportunity

See the Objects in the Solar System (AP 2.1) Answer Key for correct answers and sample student responses.

As students finish the Core Vocabulary task, collect their completed Objects in the Solar System (AP 2.1). Scan the descriptions that students made.

Discuss the answers with students to reinforce main ideas and correct misconceptions. For example, some students may believe that the term *solar system* and the word *universe* can be used interchangeably, which is not the case. If students do not understand the difference between a planet and an exoplanet, go back over **Know the Science 1** to address the issue.

LESSON 3

The Vastness of Space

Big Question: What is the universe, and what are galaxies?

At a Glance

Learning Objectives

- ✓ Distinguish between the terms *universe, galaxy,* and *solar system.*
- ✓ Identify our solar system as part of the Milky Way galaxy.

Lesson Activities

- reading
- discussion
- vocabulary instruction

NGSS References

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

The purpose of the first three lessons in this unit is to introduce students to the universe and some of what it contains, along with the technology that humans use to see the various objects in space. Note that this section does not cover a specific NGSS Performance Expectation.

Analyzing and Interpreting Data is important to students' study of the universe and its many galaxies as they learn about the various technologies that have enabled scientists to study space. Students understand that various technologies capture images and information about the universe and its galaxies, sometimes from a fixed point on Earth and sometimes from space, and transmit that information back to scientists, who then analyze it and interpret the data to arrive at conclusions about what lies in space and how it relates to other objects in space, including Earth.

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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crew/crewed/uncrewed	rover	system
galaxy	satellite	telescope
probe	space station	**universe**

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 purple above.

Instructional Resources

Student Reader

Ch. 2

Activity Page

AP 3.1

Student Reader, Chapter 2
"The Vastness of Space"

Activity Page
The Universe (AP 3.1)

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

Materials and Equipment

Collect or prepare the following:

- index cards for student vocabulary deck (2 per student)

The Core Lesson 45 min

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

Activity Page

AP 3.1

What is the universe, and what are galaxies?

Distribute The Universe (AP 3.1), and go over the directions. Explain that as students read through "The Vastness of Space," Student Reader Chapter 2, they should look for technologies that have helped us understand each object in space better.

To prepare students, remind them of what they learned in the previous lesson by asking the following:

» What is a solar system? (*a system of objects in space that include at least one star, planets, their moons, asteroids, comets, and other space debris*)

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 throughout the lesson.

galaxy **universe**

Have student volunteers tell what they think a galaxy and a universe are based on what they have learned so far. Ask them to pay close attention to the reading, because they will learn the definitions of both in Chapter 2. They will also see how these differ from a solar system.

SUPPORT—Encourage students to take notes as they read or to complete the Activity Page during the reading rather than waiting until the end of their reading of the chapter.

2. Encourage student questions. 5 MIN

Lead a discussion with students about space. Note that students have already learned much about space, including what solar systems, stars, planets, moons, and other objects are.

- » Ask students to name something else in space that they have not learned about so far in this unit. (*Students may name black holes or galaxies.*)
- » How do we know about what is in space? Call on volunteers to name any technology they know about that helps us understand space better. (*Students may name land- and space-based telescopes, satellites, or space stations.*)
- » Ask each student to write down one question he or she has about space. Then have students check for an answer to their questions as they read. (*For example, do I see planets or stars in the night sky?*)

3. Read and discuss: "The Vastness of Space." 15 MIN

Student Reader

Ch. 2

Prepare to read together, or have students read independently, "The Vastness of Space," Chapter 2 in the Student Reader. This chapter reinforces the definitions of *galaxy* and *universe*, making it clear that solar systems are part of a galaxy and that galaxies are part of the universe. The Student Reader also explains various technologies that scientists use to study space.

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 7

Confirm that students understand the meaning of *vast* in the title and text. (*extremely, almost unthinkably large*) Call attention to the description of a system within a larger system in the first paragraph, and guide discussion with the following questions:

- Ask students again to define the word *galaxy*. At this point, they should be able to answer the question correctly. (*a collection of dust, gas, stars, and their solar systems*)
- Then ask them how this differs from the definition of *solar system*. (*A solar system is part of a galaxy.*)
- Ask which is more encompassing, a solar system or a galaxy. (*galaxy*)

Remind students of the question you asked earlier about what technologies exist that help us know about what is in space. Note that on this page, one technology is named (*Voyager 1* and *Voyager 2* spacecrafts). Have each student look over The Universe (AP 3.1) and write the technology next to any object it may have helped scientists learn more about.

Page 8

Have students look at the bottom image on the page. Then ask the following:

- Why might the Milky Way galaxy be named the way it is? (*To ancient peoples, it looked like a milky road in the sky.*)

Explain that many people cannot see the Milky Way in the night sky because of light pollution. (See **Know the Science** for further support with this analysis.)

Page 9

After reading the page, ask the following:

- What is the universe? At this point, students should be able to answer the question correctly. (*all existing matter and energy in space*)
- How is the universe different from a solar system and a galaxy? (*There are many solar systems in a galaxy. There are many galaxies in the universe.*)
- What do you see in the image on the page? (*Most will say that they see stars. Point out that these are not all stars. Many of them are galaxies, with the light of all the stars in those galaxies combined. Others are the light of more than one galaxy combined.*)

Write the following words on the board or chart paper: *universe, galaxy, solar system*. Have students place them in the correct order from smallest to largest (*solar system, galaxy, universe*).

Know the Science

Why can't people in some places of the world see the Milky Way in the sky? *Light pollution.* In many places, including cities, suburbs, most small towns, and along major highways and interstates, there are many lights that automatically come on when darkness falls. Because of this, night is much brighter than it was before the invention of the light bulb. When the sky is brightened by lights, the stars become harder to see. This is known as light pollution. Find a picture of Earth at night taken from space. Explain that the bright patches are areas where there are many lights shining simultaneously. In these areas, it is harder to see the stars in the sky. Tell students that before the invention of the light bulb and modern lighting systems, people could see the stars much more plainly and that some of the stars they saw looked like a milky path in the sky.

Pages 10–11

Ask students what all of the technologies on pages 10 and 11 have in common. (*They all investigate space objects, and none of them carry people.*) Remind students that the Voyager probes mentioned on the first page of the chapter are two specific examples. Preview the terms *crewed* and *uncrewed*. Explain that a crewed spacecraft is a craft that carries people into space. An uncrewed spacecraft is one that goes into space without people.

> **SUPPORT**—Point out that another term for crewed is *manned* and another term for uncrewed is *unmanned*. Clarify that regardless of whether or not spacecraft carry people, all are launched from Earth aboard rockets.

Next, direct students to return to The Universe (AP 3.1). Write the following words on the board or chart paper: *rover, probe, satellite, telescope*. Have students see how much of the activity they can complete based on the information contained in this spread. Explain to students that some of these technologies can be used to describe objects not necessarily covered by the Student Reader. For example, satellites and telescopes can record information about stars.

Pages 12–13

After reading the pages, ask the following:

- What did Alan Shepard do? (*He was the first American to travel into space.*)
- What did John Glenn do? (*He was the first American to completely orbit Earth.*)
- What did Buzz Aldrin and Neil Armstrong do? (*They were the first humans to walk on the moon.*)

Online Resources

Discuss with students how sending people into space might help scientists in ways that sending only machines might not. For example, machines can capture technical details, which they can transmit back to scientists on Earth. However, people can relate information based on their own knowledge and learning and transmit a broader spectrum of ideas.

For detailed background and support about all of NASA's previous, current, and future missions, see the Online Resources Guide. NASA also livestreams day-to-day activities aboard the International Space Station. Also share with students that the ISS is frequently visible to the unaided eye in the night sky. The schedule of viewing opportunities by location is also available online.

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

www.coreknowledge.org/cksci-online-resources

Page 14

After students have read the page, discuss some of the challenges of sending people to Mars:

- Have students brainstorm other challenges. (*For example, Mars is very far away. It does not have an atmosphere that supports life as we know it. There is no food on Mars. It would take technology we do not currently have to fly a person or people to Mars.*)
- Explain that scientists across the world are working together to solve these many problems. Have students name the spacecraft that scientists hope will one day be able to take humans to Mars. (*Orion*)

4. Encourage discussion. 5 MIN

Have students return to the questions they wrote down at the beginning of the lesson. Ask them if the Student Reader answered their questions. Have volunteers whose questions were answered by the Student Reader share their questions and answers. Then, have volunteers whose questions were not answered by the Student Reader relate their questions to the class. Have other student volunteers answer the questions. Guide the discussion, and gently correct any incorrect answers to avoid misunderstandings.

5. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Have students prepare Core Vocabulary cards for the following terms:

galaxy **universe**

Word Work

- **galaxy:** (n. a collection of stars, their solar systems, dust, and gas) Point out that *galaxy* is a noun. Have students write the definition of *galaxy*, along with one example from the Student Reader. Then write a sentence on the board or chart paper. *There are many galaxies in the universe.* Have students write their own sentence using the word *galaxy*.
- **universe** (n. all of the existing matter and energy in space) Have students write down the definition of the word *universe*. Then ask students if they have ever used a word that had a form of the word *universe* in it. (*universal, university*) Direct students to use these related words in sentences based on what they know of them.

  Engage in a short discussion about the following example words. (Universe *and* university *are nouns;* universal *is an adjective. All words have the prefix* uni- *meaning* one *and the root word* vers *meaning* turn. *The universe is "turned into one."*)

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

6. Check for understanding. 5 MIN

Activity Page

AP 3.1
Answer Key

Formative Assessment Opportunity

See The Universe (AP 3.1) Answer Key for correct answers and sample student responses.

As students finish the Core Vocabulary task, collect the completed The Universe (AP 3.1). Scan the technologies that students wrote down for each object. Remember that some technologies listed in the Student Reader may apply to more objects than were described.

Discuss the answers with students to reinforce main ideas and correct misconceptions. For example, some students may believe that rovers have landed in places where they have not, such as planets other than Mars or on the sun, or that probes have flown to distant galaxies when, in fact, these things have not happened.

PART B

Evidence of Earth's Movement

Overview

Lesson	Big Question	Advance Preparation
4. Modeling Earth's Revolution and Rotation	How can I model the ways that Earth moves in space?	Gather materials for hands-on investigation. (See Materials and Equipment, page 12.)
5. Earth's Movement	How does Earth move in space?	Read Student Reader, Chapter 3.
6. Modeling the Sun-Earth-Moon Relationship	How can I model the relationship among the sun, Earth, and the moon?	Gather materials for hands-on investigation. (See Materials and Equipment, page 12.)
7. The Moon from Earth	What are moon phases and eclipses?	Read Student Reader, Chapter 4.
8. Changing Star Patterns	How do star patterns provide evidence of Earth's movement?	Gather materials for an activity. (See Materials and Equipment, page 12.)

Part B: What's the Story?

Understanding how Earth moves, its rotation, its orbital revolution around the sun, and its relationship to the sun and to its moon explains the natural phenomena of day and night, moon phases, eclipses, seasons, and the night sky.

In Lesson 4, students model Earth's rotation and revolution to understand the phenomenon of night and day and as a foundation for understanding seasonal changes. They relate Earth's movement to a 24-hour day and a 365-day year.

In Lesson 5, students develop an understanding of how Earth moves on its axis and identify day and night, seasons, changes in the night sky, and shadows as evidence of Earth's movements.

In Lesson 6, patterns of moon phases and lunar and solar eclipses are explored as students model different positions of Earth, the sun, and the moon that result in the different natural phenomena.

In Lesson 7, students read about shadows and the evidence of position changes of the sun, Earth, and the moon that result in eclipses and different views of moon phases. The lesson emphasizes the predictions of the patterns of these phenomena.

In Lesson 8, students consider how Earth's rotation and revolution affect their view of the night sky. Students recognize that the patterns of movement can lead to predictions of what bodies are visible.

So, to repeat, **students develop understanding of Earth's movement in its solar system, which results in and explains everyday phenomena**. The 24-hour day and 365-day year are based on Earth's movements. Because of Earth's pattern of movements, people can predict what time the sun will rise and set, seasonal changes, phases of the moon, lunar and solar eclipses, and what bodies will be visible in the night sky.

This set of lessons address the NGSS Performance Expectation 5-ESS1-2.

LESSON 4

Modeling Earth's Revolution and Rotation

Big Question: How can I model the ways that Earth moves in space?

At a Glance

Learning Objectives

- ✓ Describe and model the movement of Earth in space.
- ✓ Distinguish between Earth's rotation and its orbit.
- ✓ Use a model to identify patterns of night and day on Earth.

Lesson Activities

- hands-on activity
- observation
- writing
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

By looking for and identifying **Patterns**, students obtain information about the parts of a system and how they work together. Scientists can use tools to **Analyze and Interpret Data** in order to look for and identify patterns. They can use patterns to make predictions.

In this lesson, students will examine and describe patterns in the movement of Earth in space. Students will model these movements in several ways and learn more about the effects of Earth's patterns of movement in upcoming lessons.

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 purple 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 151–152 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.

axis **orbit** revolve/revolution rotate/rotation

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 purple above.

Instructional Resources

Activity Page

AP 4.1

Activity Page
The Movement of Earth
(AP 4.1)

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

Materials and Equipment

Collect or prepare the following items:

- heat lamps or flashlights (1 per pair of students)
- balls (1 per pair of students)
- ruler or stick
- sunny place to put the ruler in the ground where it will not be disturbed and can be checked a few times throughout the day
- index cards for student vocabulary deck (1 per student)

The Core Lesson 45 min

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

How can I model the ways that Earth moves in space? Do a simple sketch on the board or chart paper showing a tree casting a shadow, displayed twice—once with the shadow angling to the left and once with the shadow angling to the right. Emphasize that the picture shows the same tree, and ask students to describe how the shadow can be different in the two depictions and why. (*The tree is shown at two different times of day, when the sun is at different places in the sky, therefore casting shadows in different directions.*) Begin by explaining that Earth is in constant motion. Ask the following:

» What evidence do you have that Earth is moving? (*shadows changing, stars changing, moon changing, day turning into night*)

» How can we make models to show how Earth moves? (*act it out, use clay or foam models, make a computer animation, or draw a diagram with labels*)

» Why is modeling important? (*It helps scientists to look at something in more detail to determine patterns, gather data, or make predictions.*)

» What are the shortcomings of a model? (*They do not always react or work exactly the way that real-life objects do.*)

SUPPORT—Help students think about the Earth and its place in the universe. Earth is a planet that is part of the solar system. The planets move around the sun. Some planets, such as Earth, have moons that revolve around them. Finally, the planets and even the sun rotate on an axis. All planets rotate and revolve at a different rate of speed. If necessary, you may wish to show an animation or video to help students differentiate between rotation and revolution.

2. Teach Core Vocabulary. 10 MIN

Prepare and Revisit Core Vocabulary Cards

Write each of the following Core Vocabulary words on the board or chart paper, or display them in an area where students can see them throughout the lesson.

axis **orbit**

Have students take out the Vocabulary Card they made for *orbit*. Distribute one index card to each student. Instruct students to write *axis* in the upper left corner and underline it.

Word Work

Invite all students to stand up near their chairs. Ask students to spin around 360 degrees in one place. Explain that this is rotation. Explain that the Earth rotates once each day.

- **axis:** (n. an imaginary line through the center of an object that is a fixed point of reference) Explain that the point at which something rotates is the axis. Ask students to point to their axis. They should point to the top of their head. Explain that it is an imaginary line and can change, depending on the way that they rotate. Give students a chance to write the definition of *axis* on the card.

Emphasize the difference between rotation around an axis and revolution around a separate object. Refer students to their card for *orbit*, and then instruct students to move in a circle around their chairs. Explain that they just completed one revolution around their chairs and that the entire path of the revolution is an orbit. Explain that Earth and the other planets all revolve around the sun and that Earth also rotates as it revolves.

Probe for understanding by asking the following questions:

- In the model that you just acted out, if you represent Earth, what did your chair represent? (*the sun*)
- If your chair represents Earth, what could you represent? (*the moon*)
- How many times does Earth rotate in one year? (*365 times*)
- How many times does Earth revolve in one year? (*only once*)

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

SUPPORT—You may wish to call on students to come to an area of the classroom where everyone can see to model the movements for the class before having all students try it. You may also use action figures or dolls to model the movements if there is not room or for students unable to physically get up and move around the room.

3. Preview the activity. 10 MIN

Activity Page

AP 4.1

Have students make a model to prepare as the first part of the activity. Divide the class into partners. Distribute one copy of The Movement of Earth (AP 4.1) to each pair. Also distribute a lamp or flashlight and a globe or ball to each pair. Explain that students will complete the first part of the activity and then examine shadows.

Begin by having students model rotation and revolution using the ball and the light. Next, have students draw a diagram to explain rotation and revolution in the spaces on The Movement of Earth (AP 4.1).

Now, have students place a sticky note or a mark on the globe and hold it in front of the light. Ask the following:

- What time of day could it be where the mark is located? (*daytime*)

Instruct students to rotate the ball halfway. Ask the following:

- What time of day could it be where the mark is located? (*nighttime*)
- How does rotation affect the amount of sunlight a place receives? (*As Earth rotates, each place on Earth will have daytime and nighttime.*)
- What do opposite sides of the ball experience? (*opposite "times of day"*)

Give students time to complete diagrams on the Activity Page of what causes night and day. Encourage students to include labels and descriptions to explain their model. (See **Know the Science** on the following page for support.)

SUPPORT—This activity can be modeled by the teacher for the class if needed. Students may find it easier to examine and rotate the ball if the light is placed on a surface such as a desk.

4. Facilitate the activity. 15 MIN

Give a ruler or stick to each pair of students. Have students place the stick in the ground in a sunny area where it will not be disturbed throughout the day. Have students draw the stick and record the time of day on the chart. Take students out to check on the stick one or two more times throughout the day to quickly sketch and describe what they see. Ask the following:

- How did the shadow change throughout the day? (*It got shorter or longer.*)
- What causes the shadow of the stick to change? (*the rotation of Earth*)
- On a planet that takes longer to rotate, would the shadow of the stick be affected? (*Yes, it would take longer to change.*)

5. Check for understanding. 5 MIN

Activity Page

AP 4.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect The Movement of Earth (AP 4.1), and check to see that students understand the difference between revolution and rotation. Address any misconceptions or incomplete responses before moving on to the next lesson.

Know the Science

Why do we only see one side of the moon? The moon rotates on its axis once every twenty-seven days. It also takes the same amount of time to orbit Earth. This is why we only see one side of the moon. There is no "dark side of the moon." What we mean when we use that phrase is that there is one side of the moon that we never see directly from Earth. All parts of the moon have night and day; no part is always dark.

LESSON 5

Earth's Movement

Big Question: How does Earth move in space?

At a Glance

Learning Objectives

- ✓ Describe the movement of Earth on its axis and around the sun.
- ✓ Provide evidence to support explanations of Earth's movement.

Lesson Activities

- reading
- discussion
- writing evidence
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

Scientists **Analyze Data** to provide evidence to describe **Patterns** of movement of Earth in space. By identifying patterns students can obtain information about the parts of a system and how they work together. Students can use patterns to make predictions.

In this lesson, students will read to find out more about how Earth moves on its axis and around the sun and will be able to provide evidence to describe how we know about these movements.

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 purple below. During instruction, expose students repeatedly to this term, which is not intended for use in isolated drill or memorization.

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axis	ellipse/elliptical	sphere/spherical
constellation	rotate	

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 purple above.

Instructional Resources

Student Reader

Ch. 3

Activity Page

AP 5.1

Student Reader, Chapter 3
"Earth's Movement"

Activity Page
Patterns and Evidence of Movement (AP 5.1)

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

Materials and Equipment

Collect or prepare the following items:

- printed photo of a Ferris wheel
- globe
- heat lamp or flashlight
- 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

How does Earth move in space? To build on what students learned in Lesson 4 and to activate background knowledge, open this lesson by asking students to stand up and show how Earth moves in one day. Then, ask students to show how Earth moves in one year. (See **Know the Science 1** for further support with this discussion.)

Ask the following:

- What is the difference between rotation and revolution? (*One moves only around an axis, and one moves all the way around another object.*)
- What revolves around the Earth? (*the moon*)
- What revolves around the sun? (*planets, Earth, comets*)
- What is an orbit? (*the path a body traces during one revolution*)

Explain to students that in this lesson, they will learn about the movement of Earth. They will provide evidence to explain how we know about the patterns in the movements of Earth.

2. Read and discuss: "Earth's Movement." 20 min

Student Reader

Ch. 3

Prepare to read together, or have students read independently, "Earth's Movement," Chapter 3 in the Student Reader. The selection describes the way that Earth moves in relation to the moon and sun and explains the evidence that supports each pattern of movement.

Preview Core Vocabulary Term

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

Know the Science

1. How have theories about Earth's place in space changed over time? At one time, people believed that Earth was the center of the universe and that the planets, sun, and moon revolved around it. But in examining the evidence in light of studying patterns and improving technology, scientists realized that evidence did not support this idea, and theories changed. Ideas about how objects move and their locations in space relative to one another have changed over time. When new technology is developed, such as more powerful telescopes, for example, this can cause theories about the way systems work to change.

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 15

After students have read the page, explain that scientists know how Earth moves by analyzing patterns, by observing the sun, stars, moon, and shadows. Explain that technology also helps scientists discover more about patterns in the movement of Earth in space. Ask the following:

- Why don't we feel Earth moving? (*because the planet is so large*)
- What evidence is there to support the idea that Earth is moving? (*the rising and setting sun, the length of shadows, changing seasons*)
- What happens to the sun when it sets? (*The sun does not move; it is still in the same place but shining on a different part of Earth.*)

CHALLENGE—Why would the sunrise and sunset daily times be different in two example cites, such as Baltimore, Maryland, and Fort Wayne, Indiana? (*Because Earth is rotating, the sun rises earlier in Maryland and sets later in Indiana.*)

Page 16

After reading the page, refer students back to the photo of a merry-go-round on page 15. Ask the following:

- Where is the axis of this ride? (*in the center*)

Ask students to imagine riding on a merry-go-round. Explain that when you are on the ride, you are moving, but it does not always feel that way because what you are looking at is changing as you go around and around, while nothing on the merry-go-round itself is changing. Ask the following:

- How do you know that the ride has rotated? (*because you see the same things again that you saw where the motion started*)

For additional context, ask for a show of hands for students who have ridden a Ferris wheel. Ask the following:

- Where is the axis on this type of ride? (*in the center*)

Invite students to describe the experience of riding on a Ferris wheel. Explain that when you are on the ride, you rotate in a vertical plane, in contrast to a merry-go-round's horizontal plane, but still around an axis. If needed, display an image of a Ferris wheel to enhance student understanding.

- How do you know that this ride has made a rotation? (*You exit the ride in the same place where you boarded it.*)

By this logic, seeing the same pattern in the sky indicates that Earth is in a position that it was before. Repeating visible patterns indicate cycles of repeating motion.

Page 17

After reading this page, make connections between the activity that students completed in Lesson 4, Examining Shadows, AP 4.1 page 2 of 2 and what students have observed and discussed about shadows in relation to the content on the page. Ask the following:

» What causes shadows to change? (*the angle of light that results from Earth's changing position relative to the sun*)

(See **Know the Science 2** for further support with this discussion.)

SUPPORT—If further demonstrations are necessary, set up a heat lamp, and use the globe to show students how one side of Earth is having daytime while the opposite side is having nighttime. Show students how the axis of Earth is tilted. Move the globe around the heat lamp to show how the light hits the globe at different angles as it is at different points in the path around the sun. Point out how the Southern Hemisphere experiences summer while the Northern Hemisphere is experiencing winter.

Page 18

After reading this page, ask the following:

» Describe the evidence that supports that Earth revolves around the sun. (*seasons, different star patterns visible at different times of year*)

SUPPORT—Have students stand up and act out the difference between rotation and revolution if needed to support understanding of how Earth moves in space.

Guide students to look at the globe and identify parts of the world that experience opposite seasons from where they live. Have students tell what season that location would be experiencing.

For added support, show a video of the movement of the night sky.

Online Resources

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

www.coreknowledge.org/cksci-online-resources

Then ask students to partner up and develop an explanation for how the constellations appear to change as Earth rotates compared to how they change when it revolves. Call on partners to explain their answer to the class. Address any misconceptions as students offer their explanations.

Know the Science

2. Why is Earth's axis tilted, and what are the effects of the tilt? Scientists theorize that early in the formation of Earth, it was impacted by a large object, such as an asteroid, and a piece of the still-forming planet was pulled off to form the moon. They think that this impact caused Earth to remain tilted on its axis. The direction of the tilt is essentially constant. This slight tilt in the axis of Earth causes part of it to be slightly more tilted toward the sun as the other part is slightly tilted away from the sun during certain times of year.

Remember to use the word *sphere* when discussing Earth. It is not *round*, which indicates two dimensions or a flat Earth. It is a *sphere*, a word that indicates three dimensions.

3. Facilitate the activity. 10 MIN

Activity Page

AP 5.1

Distribute Patterns and Evidence of Movement (AP 5.1) to each student. Explain that students will complete the activity based on what they have learned so far in this lesson and in the previous lesson. Go over the directions with students.

> **SUPPORT**—If needed, help students look back through the chapter and provide pages for them to find the evidence for each of the patterns of movement. This Activity Page can also be completed as a jigsaw activity by dividing students into groups of four and assigning each partner a pattern of movement to find evidence for. Then students come together with their group to share and explain what they wrote on the table for their assigned pattern.

Circulate throughout the room as students complete the Activity Page, and provide support for students as they record the evidence for each pattern of movement. Encourage students to look back at the Student Reader pages to find the evidence. (See **Know the Standards** for support.)

Lead a discussion about the evidence that students recorded on the table on their Activity Page.

4. Teach Core Vocabulary. 5 MIN

Revisit Core Vocabulary Card

Direct student attention to the Core Vocabulary word **axis** (displayed earlier in the lesson). Ask students to add any new information that they have learned about the term to their Core Vocabulary card.

Word Work

- **axis:** (n. an imaginary line through the center of an object that is a fixed point of reference) List forms of *rotate*. (*rotates, rotating, rotation, rotated*) Have students say and then write a sentence on their *axis* cards with the word *rotate* or *rotation*. (*In one day, Earth will rotate on its axis one time. Day and night are evidence of Earth's rotation.*)

Know the Standards

How do scientists know about patterns? *Scientists keep accurate records!* Keeping accurate records is important. This way scientists can look for patterns. They can then make predictions in patterns. For example, you may notice that during certain times of the year, the sun seems to rise earlier each morning. Scientists can analyze the data and make predictions. Understanding patterns is especially important to farmers. By understanding patterns, they can predict the best times to plant, water, and harvest their crops.

Compare with students Earth's axis to the vertical and horizonal axis in a graph. (*Both are fixed reference lines. Earth's axis is one line. A graph has a vertical and horizontal axis that identify a single data point by measurements of two variables.*)

5. Check for understanding. 5 MIN

Activity Page

AP 5.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect the completed Patterns and Evidence of Movement (AP 5.1). Scan the table that students completed. If any contain inaccurate information, engage in further discussion, emphasizing any missing or incorrect information and clearing up any misconceptions that students may have about patterns of movement.

LESSON 6

Modeling the Sun-Earth-Moon Relationship

Big Question: How can I model the relationship among the sun, Earth, and the moon?

At a Glance

Learning Objectives

- ✓ Describe and model the movement of Earth in space in relation to the sun and the moon.
- ✓ Distinguish between a lunar and solar eclipse.

Lesson Activities

- student activity
- observe and model
- drawing
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

By looking for and identifying **Patterns**, students obtain information about the parts of a system and how they work together. Scientists can use tools to **Analyze and Interpret Data** in order to look for and identify patterns. They can use patterns to make predictions.

In this lesson, students will examine and describe patterns of movement between the sun, Earth, and the moon. Students will model, create diagrams of, and describe these movements.

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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lunar eclipse shadow **solar eclipse**

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 purple above.

Instructional Resources

Activity Page

AP 6.1

Activity Page
Shadows (AP 6.1)

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

Materials and Equipment

Collect or prepare the following items:

- flashlights (1 per group of students)
- larger balls (1 per group of students)
- smaller balls (1 per group of students)
- space for students to be able to move freely to demonstrate revolution and rotation
- 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

How can I model the relationship among the sun, Earth, and the moon? Begin by asking students to describe their shadow. Ask the following:

» What is needed to make a shadow? (*Something coming in between light and a surface casts a shadow.*)

» How does your shadow change throughout the day? (*It grows shorter and longer.*)

» Is there any time during a sunny day that you cannot see your shadow at all? (*when the light is from straight overhead*)

Online Resources

SUPPORT—Help students think about patterns of shadows that affect Earth as it rotates on its axis. Explain that the position of the sun, Earth, and the moon often results in shadows being cast on one object by another and that there are different names for these patterns of shadows. If necessary, you may wish to show an animation or video to help students understand how shadows are made and how shadows change throughout the day. Refer back to the previous lesson where students observed the shadow cast by the stick during certain times of day. 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

Preview Core Vocabulary Terms

Write each of the following Core Vocabulary terms on the board or chart paper, or display them in an area where students can see them throughout the lesson.

lunar eclipse **solar eclipse**

Distribute two index cards to each student. Instruct students to write each of the terms in the upper left corner of a card (one term per card) and underline it. Explain that students will be returning to the cards at the end of the lesson to write a definition for each term in their own words.

2. Facilitate the activity. 20 MIN

Group students in threes for this activity. Distribute a flashlight and a large and small ball to each group of students.

If space is constrained, have groups take turns demonstrating the revolution and rotation of Earth and the moon. Clear an area so students can move freely in an orbit around the flashlight. Begin by dimming the lights in the classroom. Then follow these steps:

1. Give one student in each group (the sun) the flashlight to shine upward.
2. Have one student (Earth) hold the large ball and move slowly in an orbit around the flashlight.
3. At your direction, tell Earth to rotate as he or she revolves around the flashlight.
4. Next give a third student (the moon) in each group the small ball.
5. Have the moon revolve around Earth as it revolves around the sun.
6. At your direction, tell the moon to very slowly rotate as it revolves around Earth and Earth revolves and rotates around the sun.
7. Ask each group to model a solar eclipse in which the moon comes between Earth and the sun, and show how the moon's shadow falls on Earth.

8. Ask each group to model a lunar eclipse, in which Earth comes between the moon and the sun, and show how Earth's shadow falls on the moon.

(See **Know the Science** for support.)

3. Demonstrate examples and guide discussion. 10 MIN

Activity Page

AP 6.1

Distribute one copy of Shadows (AP 6.1) to each student. Write the word *eclipse* on the board or chart paper. Ask the following:

- Has anyone ever seen a lunar or solar eclipse? (*Answers will vary.*)
- What does *eclipse* mean? (*when one object blocks another from view*)
- What is the difference between a total eclipse and a partial eclipse? (*In one, the moon or sun is completely covered, and in the other, only part of it is covered.*)

Explain that an eclipse occurs when the shadow of one object in space is cast on another object. Place the small ball in between the large ball and the flashlight. Explain that this represents a solar eclipse because the shadow of the moon falls on Earth. Explain that a solar eclipse can happen two or three times a year but that a total solar eclipse is very rare at any given location. There will only be twelve total solar eclipses in the next hundred years in different locations in North America. Ask the following:

- How does the sun appear during a solar eclipse? (*The moon moves across the sun and blocks it out.*)
- What time of day must a solar eclipse happen? (*during daylight hours*)
- What can you expect to happen during a solar eclipse? (*It gets dark during the day, you can see stars, and night animals may wake up.*)

Have students draw a model to show the position of Earth, the moon, and the sun during a solar eclipse in the space on the Activity Page.

Know the Science

What is the difference between a partial and total eclipse? During a total solar eclipse, the moon completely blocks the sun as seen from Earth so that sunlight does not reach Earth. However, you can only see a total solar eclipse before the bodies move out of alignment from a very narrow path on Earth. If you are not in this path, you will only see a partial solar eclipse. In a partial solar eclipse, the moon only partially covers the sun because the three bodies are not perfectly aligned. Total solar eclipses occur about once a year in different parts of the world. But only ten may occur on the same continent in one hundred years.

Why isn't there an eclipse during every full moon and new moon? Somewhere here you should point out that eclipses only occur when the sun, Earth, and the moon are in the same planes both vertically and horizontally.

Now, explain that a lunar eclipse happens when Earth's shadow falls on the moon. Challenge students to model the positions of the sun, Earth, and the moon during a lunar eclipse. Circulate throughout the classroom, and check each group to see that they have modeled it correctly. Ask the following:

» What causes the shadow during a lunar eclipse? (*Earth blocks the sun's light from striking the moon.*)

Have students complete Shadows (AP 6.1).

Online Resources

SUPPORT—Encourage students to look up the information for when the next solar and lunar eclipses will occur in your area. You may wish to show students a video of a solar and lunar eclipse to help them to better understand what occurs during an eclipse. 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

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed earlier in the lesson). Have students write the definition of each of the Core Vocabulary words on the front of each index card in their own words.

lunar eclipse **solar eclipse**

Word Work

- **lunar eclipse:** (n. an event during which the moon passes directly behind Earth and into its shadow) On the back side of the card, have students make a quick sketch to explain the position of the sun, Earth, and the moon during a lunar eclipse.
- **solar eclipse:** (n. an event during which the moon's shadow blocks all or some of the sun's light from reaching Earth) On the back side of the card, have students make a quick sketch to explain the position of the sun, Earth, and the moon during a solar eclipse.

To confirm understanding, ask the following:

» How are a lunar and solar eclipse alike? (*They both involve the sun, Earth, and the moon. They both occur when one object blocks light from the sun.*)

» How are a lunar and solar eclipse different? (*In a lunar eclipse, Earth comes between the moon and the sun. In a solar eclipse, the moon comes between Earth and the sun. A solar eclipse happens during the day and causes the sky to darken. A lunar eclipse happens at night.*)

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

5. Check for understanding. 5 MIN

Activity Page

AP 6.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Shadows (AP 6.1), and check to see that students have correctly modeled each pattern of shadows. Check that students' answers are correct and that students understand the position of the sun, Earth, and the moon during each type of eclipse. Address any misconceptions or incomplete responses before moving on to the next lesson.

LESSON 7

The Moon from Earth

Big Question: What are moon phases and eclipses?

At a Glance

Learning Objectives

- ✓ Describe and model the movement of the moon.
- ✓ Describe what causes moon phases and predict the appearance of the moon.

Lesson Activities

- student observation
- reading
- discussion
- writing
- making and describing diagrams
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

Identifying **Patterns** is important to this lesson because students will look for patterns to describe the parts of the Earth/moon/sun system and how they work together. Students will **Analyze and Interpret Data** such as diagrams, tables, and models in order to identify and describe patterns. Students can use patterns to make predictions about the movement of Earth, the moon, and the sun in space.

In this lesson, students will examine and describe patterns of movement they can observe in the moon. Students will read about and create diagrams to describe, explain, and predict these movements.

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 purple 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 151–152 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.

lunar eclipse	reflect	**solar eclipse**
moon phase	shadow	

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 purple above.

Instructional Resources

Student Reader

Ch. 4

Activity Page

AP 7.1

Student Reader, Chapter 4
"The Moon from Earth"

Activity Page
Phases (AP 7.1)

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

Materials and Equipment

Collect or prepare the following items:

- flashlights (1 per group of students)
- larger balls (1 per group of students)
- smaller balls (1 per group of students)
- space for students to be able to move freely to demonstrate revolution and rotation
- handheld mirror
- glue sticks
- scissors
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

The Core Lesson 45 min

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

What are moon phases and eclipses? Review with students that in Lesson 6, they modeled the movements of Earth and its moon as Earth revolves around the sun. Begin by asking students to describe the moon. Ask the following:

» How does the moon look each day or night? (*It is of different shapes and also sometimes it is large and sometimes it is smaller.*)

» What causes the moon to shine? (*The moon shines because it reflects sunlight.*)

» Is there ever a time when you cannot see the moon at all? (*It could be covered by clouds or completely blocked by Earth's shadow.*)

» Describe how the moon moves. (*It rotates, and it revolves around Earth.*)

SUPPORT—Help students think about the moon and how it changes. Encourage students to think about the different ways that the moon looks. Ask if students have ever seen the moon during the day. Explain that the moon is always there, moving around Earth. Remind students about the difference between rotation and revolution. If needed, have students review these terms using the cards in their Core Vocabulary card deck.

2. Read and discuss: "The Moon from Earth." 15 MIN

Student Reader

Ch. 4

Prepare to read together, or have students read independently, "The Moon from Earth," Chapter 4 in the Student Reader. The selection explains the changes that occur in the appearance of the moon.

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.

lunar eclipse **moon phase** **solar eclipse**

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 19

After students have read this page, probe for understanding about the sun, Earth, and the moon. You might want to show an animation of the rotation of Earth. Ask the following:

» Which of these three objects—the sun, Earth, and the moon—creates light? (*the sun*)

» Why can we only ever see one side of the moon? (*Because the moon rotates with the same period as it revolves around Earth, only one side of the moon is visible.*)

Online Resources

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

www.coreknowledge.org/cksci-online-resources

SUPPORT—Confirm that students understand from context the use of the word *bodies* in reference to celestial objects, "things in space."

Page 20

Before reading this page, have students look at the classroom lights reflected in a handheld mirror. Ask the following:

- Can you see the light in the mirror? (*yes*)
- Is the light coming from the mirror? (*No, it is only reflected in the mirror.*)

Explain that this is how the moon is lit; it reflects sunlight from its surface. Have students hold their hand in front of the mirror. Ask the following:

- What happens to the light when you put your hand in front of the mirror? (*It blocks it.*)

After reading this page, have students go back and circle the explanation for the moon's phases. Explain that students may need to return to this page at the end of the lesson. (See **Know the Science 1** for support.)

Pages 21–22

After reading about solar eclipses and lunar eclipses, ask students to describe the difference between them to a partner. (See **Know the Science 2** for support.) Ask the following:

- What is needed for a shadow to exist? (*a light and a solid object to block it*)
- When you hold your hand in front of the light, what shape can you expect the shadow to be? (*the shape of your hand*)
- How do shadows change during the day? (*They become longer and shorter.*)
- What causes shadows on the moon? (*Earth*)

Online Resources

Unlike a lunar eclipse, when Earth's shadow completely covers the moon, the moon's shadow on Earth during a solar eclipse is smaller than Earth itself. Show students a video of the moon's shadow on Earth taken from space to illustrate this point.

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 Science

1. Why does the moon appear to shine? The moon does not emit its own light, so how does it shine? It reflects sunlight from its surface. You can compare this phenomenon to a mirror reflecting the classroom lights to help students understand the concept. You can see the light in the mirror, but the light is not actually coming from the mirror! Also, keep in mind that the phases of the moon are actually not caused by Earth's shadow on the sun but by the way we see the sunlit portion of the moon from Earth's surface. Students may also believe that the moon is only visible at night, but this is not true. Point out to students that the only time that the moon is hardly visible from Earth is when it is a "new moon." Probe students to remember or observe that sometimes the moon is visible during the day.

2. Address Misconceptions: Pause here to make sure that students understand that the moon blocks out the sun during a solar eclipse and casts its shadow on Earth. Impress upon students that it must be daytime for a solar eclipse to occur.

After reading the final page of the chapter, ask the following:

» How can scientists predict eclipses? (*They can use computers and models and analyze patterns using math.*)

3. Facilitate the activity. 15 MIN

Activity Page

AP 7.1

This activity can be modeled by the teacher or one student for the class if needed. Drawings can be done as a class. Remind students to keep in mind that moon phases occur from our point of view on Earth. If additional resources are needed, show video demonstrations.

Follow these steps:

1. Dim the lights in the classroom.
2. To represent the sun, place the lit flashlight on a center table.
3. Have students carry the large ball around the flashlight to demonstrate a year's revolution.
4. Next, ask students to rotate the ball as they revolve around the "sun" to demonstrate day and night.
5. Now have another student hold up the small ball, the moon, and orbit around Earth as Earth revolves around the sun.
6. Discuss how sunlight reflects on the daytime Earth. (*Half of Earth is always lit.*)
7. Discuss how much sunlight reflects on the daytime moon. (*Half of the moon is always lit.*)
8. Position the moon between Earth and the sun but not eclipsing Earth.
9. Discuss how much sunlight is reflected on the moon. (*Half of the moon is always lit.*)
10. Discuss how much of that light you could see from Earth. (*none*)
11. Position the moon and Earth into a full moon phase with the moon on the other side of Earth.
12. Discuss how much sunlight is reflected on the moon. (*Half of the moon is always lit.*)
13. Discuss how much of that light you could see from Earth. (*the entire lit half*)
14. Position the moon and Earth into quarter moon and gibbous moon phases.
15. Discuss how much sunlight is reflected on the moon. (*Half of the moon is always lit.*)
16. Discuss how much of that light you could see from Earth. (*part of the lit half*)

Online Resources

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

www.coreknowledge.org/cksci-online-resources

Ask the following:

- What do the flashlight, the small ball, and the large ball represent? (*the sun, the moon, and Earth*)
- How does the amount of light on the small ball change as it moves around the large ball? (*It doesn't. The appearance from different angles makes smaller or larger portions of the constantly lit surface visible.*)
- What does this represent? (*the phases of the moon*)
- How long does it take this pattern of shadows to occur? (*about a month*)

Distribute one copy of Phases (AP 7.1) to each student. Also distribute a pair of scissors and a glue stick to each pair of students.

Review the directions with the class. Explain that students are to cut out the pictures of the moon and glue them on the diagram. Encourage students to add labels and descriptions as needed. (See **Know the Science 3** for additional information.)

SUPPORT—Allow students to reference "The Moon from Earth," Chapter 4 in the Student Reader, which describes and has diagrams of the moon phases. The diagrams will also allow students to see the relative positions of the sun, moon, and Earth for reference. Remind students that during a lunar eclipse, Earth has a shadow, and that during a solar eclipse, the moon has a shadow. Explain that shadows do not appear during moon phases. It is the different amounts of light reflected toward Earth based on where the moon is in its orbit. Tell students to pay attention to where the sun is located in the diagram.

4. Teach Core Vocabulary. 5 MIN

Prepare and Revisit Core Vocabulary Cards

Direct student attention to the Core Vocabulary words displayed earlier in the lesson.

lunar eclipse **moon phase** **solar eclipse**

Have students locate the Core Vocabulary cards they prepared in the previous lesson for *lunar eclipse* and *solar eclipse*. Also have students prepare a new card for *moon phase*.

Have students write the definition of each of the Core Vocabulary words on the front of each index card in their own words.

Word Work

- **moon phase:** (n. a stage in the repeating, predictable pattern of change in the moon's appearance from Earth) On the back of the card, have students explain why the moon goes through different phases and explain how long it takes for the moon to go through all phases.

Review lesson concepts by discussing Core Vocabulary.

» What is the difference between a lunar and solar eclipse? (*In a lunar eclipse, Earth casts a shadow on the moon so the moon becomes shadowed. In a solar eclipse, the moon casts a shadow on Earth, so Earth becomes shadowed. In both cases, the light from the sun is blocked and forms shadows.*)

» How are the phases of the moon different from an eclipse? (*In an eclipse, Earth comes between the sun and the moon and casts a shadow on the moon. The phases of the moon occur because various areas of the moon reflect sunlight at different times during the moon's orbit around Earth.*)

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

5. Check for understanding. 5 MIN

Activity Page

AP 7.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Phases (AP 7.1), and check to see that students have correctly modeled the moon phases. Be sure students have placed each moon phase in the correct location on the model. Address any misconceptions or incomplete responses before moving on to the next lesson.

LESSON 8

Changing Star Patterns

Big Question: How do star patterns provide evidence of Earth's movement?

At a Glance

Learning Objectives

- ✓ Provide evidence to support explanations of Earth's movement.
- ✓ Describe observable patterns in the movement of stars in the night sky.

Lesson Activities

- student activity
- analyze and interpret data
- use evidence to support an explanation
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

By **Analyzing and Interpreting Data, Patterns** can be identified by looking for similarities and differences between photos of the night sky, and predictions can be made.

In this lesson, students will examine data and look for patterns. They will make predictions based on the data about how stars move in the night sky. Students will create an explanation for what causes the patterns of movement in the stars.

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.

constellation	orbit	revolve/revolution	universe
galaxy	pattern	rotate/rotation	

Instructional Resources

Activity Page

AP 8.1

Activity Page
Moving Stars (AP 8.1)

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

The Core Lesson 45 min

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

How do star patterns provide evidence of Earth's movement? Begin this lesson by asking students to snap their fingers. Explain that a camera or phone takes a picture in about the same amount of time that it took to snap. Ask the following:

» What happens when you take a photo of something moving? (*The image blurs.*)

Online Resources

Now, show students a long exposure photo of the stars. Explain that a long exposure photo is taken much more slowly than common photos. It can take an hour to take the photo, or even all night. Ask the following:

» What is making the streaks of light across the sky? (*stars*)

» What causes the streaks of light? (*the light from the stars as they appear to move across the sky*)

» What are the streaks evidence of? (*the rotation of Earth on its axis*)

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—Help students think about Earth and its place in the universe. The universe is full of stars. The star patterns appear to move across the sky at night as Earth rotates on its axis. They are still there during the day, but it is too bright to see them. The darker the area, the better view of the stars people have.

2. Facilitate the activity. 30 MIN

Activity Page

AP 8.1

Distribute one copy of Moving Stars (AP 8.1) to each group of two or three students. Have students begin by answering the first question. Next, have students examine the two diagrams showing the location of the star Pollux in the night sky. Point out the labels on the diagrams and that the diagrams show the star at different times during a three-month period. Have students analyze this data to make a prediction for the location of Pollux in the two empty boxes. Have students share their predictions with a small group. Ask the following:

- Did everyone draw Pollux in the exact same location? (*close to it*)
- How did you know where to draw Pollux? (*by predicting the pattern*)
- What causes the pattern of movement in the star Pollux? (*the revolution of Earth around the sun*)
- Pollux is part of a larger pattern of stars called a constellation. What can you predict about the movement of the other stars in the pattern? (*They will move across the sky in the same pattern.*)
- Will Pollux ever disappear from view in Earth's night sky? (*It will appear to but will still be visible to a different part of Earth.*)

(See **Know the Science** for more support.) Give students time to complete the Activity Page. Circulate around the room, and check students' predictions and explanations, looking for misconceptions that can be addressed.

Know the Science

Why do we only see some constellations during certain times of the year? The constellations shift gradually to the west across the sky throughout the year. Earth's revolution around the sun is responsible for this pattern of movement. At different times of year, Earth is facing a different direction in space at night. You can only ever see the stars that are opposite the sun because the other stars are too faint to be seen in the sunlight.

SUPPORT—If needed, review the difference between revolution and rotation. Also, if needed, refer students back to "Earth's Movement," Chapter 3 in the Student Reader.

- » What pattern (constellation) is Pollux part of? (*Gemini*)
- » What galaxy in the universe is Pollux in? (*the Milky Way galaxy*)
- » Why can't you see Pollux during a sunny day? (*In Earth's rotation on its axis, the sun's light is stronger than the light of the star.*)
- » Why is Pollux in different locations in Earth's night sky at different times of the year? (*because of Earth's changing position in its revolution as it orbits around the sun*)

3. Check for understanding. 5 MIN

Activity Page

AP 8.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Moving Stars (AP 8.1), and check to see that students correctly predicted the location of the star Pollux in both empty boxes. Address any misconceptions or incomplete responses before moving on to the next lesson.

PART C

Stars

Overview

Lesson	Big Question	Advance Preparation
9. Brightness and Distance	What is apparent brightness?	Gather materials for hands-on investigation. (See Materials and Equipment, pages 12–13.)
10. Brightness of Stars	Why do some stars appear brighter than others?	Read Student Reader, Chapter 5.
11. Constellations	What are constellations?	Read Student Reader, Chapter 6.
12. Diagramming Seasonal Constellations	Why does the night sky change throughout the seasons?	Gather materials for hands-on investigation. (See Materials and Equipment, page 13.)

Part C: What's the Story?

A foundation of how Earth revolves around the sun helps to explain changes in the night sky. As Earth completes its orbit around the sun, patterns of stars can be seen at different locations of Earth. Some groupings of stars, constellations, are visible all year long. Others can only be seen during certain seasons, because of the way Earth moves. Some are brighter than others depending on their natural brightness and their distance from Earth.

In Lesson 9, students explore the relationship between the distance of stars and their apparent or absolute brightness. Students recognize that if two stars have the same absolute brightness, the closer object will appear brighter than the more distant object.

In Lesson 10, students consider the relationships between the absolute brightness and distance of stars and how those factors affect what we see when we look at a star. A brighter distant star, for example, may appear dimmer than a less bright star that is closer to Earth.

In Lesson 11, patterns of stars or constellations are the subject of the reading, as students learn more about seasonal and circumpolar constellations in the Northern and Southern Hemispheres.

In Lesson 12, students focus on seasonal constellations. The lesson emphasizes the patterns of the phenomenon as Earth makes its revolution around the sun.

So, to repeat, **with the understanding of Earth's movement in its solar system, students look to the patterns in the night sky**. Students recognize that the brightness of a star viewed from Earth depends on the absolute brightness of the star and its distance from Earth. The patterns of stars that are visible are dependent on the orbit of Earth. Some constellations can only be seen in one hemisphere. Some constellations are seasonal, while others are visible all year long. This series of lessons addresses NGSS Performance Expectations 5-ESS1-1 and 5-ESS1-2.

LESSON 9

Brightness and Distance

Big Question: What is apparent brightness?

At a Glance

Learning Objective

✓ Describe and model the relationship between the distance of stars and their brightness.

Lesson Activities

- student activity
- vocabulary instruction
- modeling and observation
- discussion and writing

NGSS References

Performance Expectation 5-ESS1.1: Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.

Disciplinary Core Idea ESS1.A: The Universe and Its Stars

Crosscutting Concept: Scale, Proportion, and Quantity

Science and Engineering Practice: Engaging in Argument from Evidence

Engaging in Argument from Evidence is important to this lesson because students will be looking for evidence to support their argument about the relative brightness of stars. Students may gather evidence by making observations, from measurements, from creating and examining models, or from researching reliable sources of scientific information.

In this lesson, students will examine and describe patterns in the brightness of stars as we see them on Earth. Students will model using flashlights and determine the pattern between distance and brightness of stars.

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 purple 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 151–152 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.

absolute brightness **apparent brightness** **light-year**

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 purple above.

Instructional Resources

Activity Page

AP 9.1

Activity Page
Star Light, Star Bright (AP 9.1)

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

Materials and Equipment

Collect or prepare the following items:

- flashlights (2 identical per group of students)
- new batteries
- meterstick
- colored painter's tape
- large area that can be darkened, such as a gym or auditorium
- photo of the night sky
- 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

What is apparent brightness? Begin by showing students a photo of the night sky. Ask the following:

» What do you notice about the stars in the photo? (*Some are brighter, and some are dimmer.*)

» Why are some of the stars brighter than other stars in the photo? (*It is a combination of the actual brightness* [*magnitude*] *of a star and how far it is from Earth.*)

» Which star is the brightest star to us on Earth? (*the sun*)

» Why does the sun have a large apparent brightness? (*Many stars are actually brighter, but the sun is so very close it has the greatest apparent brightness.*) (See **Know the Science** for more support.)

Online Resources

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

www.coreknowledge.org/cksci-online-resources

2. Teach Core Vocabulary. 10 MIN

Prepare Core Vocabulary Cards

Write each of the following Core Vocabulary words on the board or chart paper, or display them in an area where students can see them throughout the lesson.

light-year **apparent brightness**

Distribute two index cards to each student. Instruct students to write each of the terms in the upper left corner of the card and underline it. Encourage students to pay special attention to these terms throughout the lesson.

Word Work

Explain to students that these two vocabulary words are ways that scientists talk about the brightness of stars. The apparent brightness of a star is how bright it seems to us from Earth. This is due to both its distance, described in light-years, and its absolute brightness considered together. Pair students, and ask them to briefly discuss the challenges that scientists would face when trying to make measurements in space. Ask them to share what they discussed with the class.

- **light-year:** (n. the distance that light travels in one Earth year) Ask students what a light-year measures. (*distance in space*) Explain that a light-year is a distance. Explain that light from the sun takes about eight minutes to reach Earth. A light-year is the distance light can travel in an entire year.

Know the Science

Which star appears brightest from Earth after the sun? ***Alpha Canis Majoris, called Sirius or the Dog Star, appears to be brightest!*** It is the seventh closest star to Earth. Why don't the closer stars appear brighter? Because they are dwarf stars. Even though they are closer, they are smaller and red in color, so they do not appear as bright as the Dog Star does. If time permits, show students a simple H-R Diagram, and have them describe the pattern they see. Students should describe that the brighter stars are hotter and white/blue in color and the less bright stars are not as hot and orange/red in color.

- **apparent brightness:** (n. how bright a star appears compared with other stars when all are viewed from Earth) Explain that apparent brightness is one way to measure the brightness of stars. It means how bright a star looks. Apparent brightness compares how bright a star is compared to other stars when we view it from Earth. (Students will define absolute brightness and contrast it with apparent brightness in the next lesson.) Apparent brightness may also be referred to as *relative brightness*, as it compares the brightness of a star's appearance relative to others. Ask what are the variables when measuring brightness of stars from Earth? (*distance from Earth and how bright the star really is*)

Instruct students to keep the Core Vocabulary cards nearby so that they can add information to them as needed throughout the lesson.

3. Facilitate the activity. 25 MIN

Activity Page

AP 9.1

Divide the class into small groups. Distribute one copy of Star Light, Star Bright (AP 9.1) to each group of students. Read over the procedure for the activity, and check for understanding.

Give each group of students two flashlights with fresh batteries. Ask the following:

» Why is it important to turn both flashlights on at the same time and keep them both on for the whole activity? (*so that the variable is controlled and the batteries do not affect the observations or results of the activity*)

Have students make predictions about how they think the light will change the farther that they get from the wall.

» What does the flashlight represent? (*a star*)

» What does the wall represent? (*Earth*)

» Is distance the only factor in a star's apparent brightness? (*No, both distance and absolute brightness must be considered.*)

Give students time to complete the activity. Circulate throughout the room, offering assistance as needed to each of the groups as they measure the distances and observe the light from each tape line.

SUPPORT—This activity can be modeled by the teacher for the class if needed due to lack of space. The distances on the Activity Page may be adjusted as needed. Try to keep as many variables controlled as possible to ensure the validity of the results. To ensure the success of the activity, be sure to have students work in a large, empty room that can be darkened, such as a gym or auditorium, where they can have plenty of room to shine the flashlights on the wall. In order to save time, measure the distances ahead of time so students simply need to stand at each marked location and shine the light on the wall.

Give students time to answer the discussion questions following the activity with their group. Discuss students' answers to the questions as a whole class.

Invite students to add any information that they wish to the Core Vocabulary cards, and then ask them to store the cards with the rest of their deck for use in future lessons.

4. Check for understanding. 5 MIN

Activity Page

AP 9.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Star Light, Star Bright (AP 9.1), and check to see that students have correctly identified the pattern between distance and brightness and described how the light grew dimmer as the distance from the wall increased. Students should be able to provide evidence to explain this pattern. Address any misconceptions or incomplete responses before moving on to the next lesson.

LESSON 10

Brightness of Stars

Big Question: Why do some stars appear brighter than others?

At a Glance

Learning Objectives

- ✓ Compare the brightness of stars.
- ✓ Describe connections between brightness and distance of stars.

Lesson Activities

- student observation
- reading, discussion, writing
- making and describing diagrams
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-1: Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.

Disciplinary Core Idea ESS1.A: The Universe and Its Stars

Crosscutting Concept: Scale, Proportion, and Quantity

Science and Engineering Practice: Engaging in Argument from Evidence

Engaging in Argument from Evidence is important to this lesson because students will be finding evidence to support their argument about the relative brightness of stars. Students may gather evidence by making observations, from measurements, from creating and examining models, or from reading reliable sources of scientific information.

In this lesson, students will read to find out about the relationship between distance and the brightness of stars in the night sky.

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 purple 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 151–152 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.

absolute brightness	cycle	**star**
apparent brightness	**light-year**	

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 purple above.

Instructional Resources

Student Reader

Ch. 5

Activity Page

AP 10.1

Student Reader, Chapter 5
"Brightness of Stars"

Activity Page
Comparing Stars (AP 10.1)

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
- 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

Why do some stars appear brighter than others? Display a Hubble Space Telescope image for students, and ask them to note differences in the objects they see. (*The objects are different colors and vary in brightness.*)

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

Begin by asking students if they can name any stars.

Ask the following:

- What star is closest to Earth? (*the sun*)
- What star is the brightest in the sky? (*the sun*)
- What tools do scientists use to study the stars? (*telescopes, satellites, or probes*)
- What causes the stars to change position in the sky? (*Stars appear to move across the sky as the night goes by due to Earth's rotation. Stars also change with the seasons because Earth is revolving around the sun.*)

Ask students to remember the night sky. Explain that on some nights, more stars can be seen than on other nights. Ask students to explain why. Ask the following:

- What do you think it means if one star is brighter than other stars? (*It could be closer to Earth or bigger than other stars. Or it could be, and is, a combination of the two.*)

Online Resources

SUPPORT—Help students to remember that the sun is a star. Explain that the sun looks so different from other stars because it is so close to Earth. Also remind students that the distance from the sun to Earth, although it may seem extremely far, is actually one of the shortest distances between Earth and another space object. You might want to show a video explanation of the life cycle of stars to help explain why some stars are bigger and hotter than others. 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: "Brightness of Stars." 20 MIN

Student Reader

Ch. 5

Prepare to read together, or have students read independently, "Brightness of Stars" Chapter 5 in the Student Reader. The selection explains that the sun appears to be the brightest star in the sky to us because it is the closest star to us.

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.

absolute brightness **apparent brightness** **light-year** **star**

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Include suggested questions and prompts. (See **Know the Science 1** for additional support.)

Page 23

After students have read this page, ask students to be sure they understand the definition of a star. Ask the following:

- What is a star made of? (*gases*)
- Why are stars so hot? (*The gas is undergoing nuclear reactions that release energy and heat.*)
- Do stars move the way planets do? (*Most do not revolve, but they do rotate.*)
- What are some ways that stars differ? (*size, brightness, color, distance from Earth*)
- Why can we only see the stars at night? (*They are so far from us that we can only see them when it is dark; our sun is so bright compared to them.*)

Ask students to list the characteristics of a star on their Core Vocabulary card for *star*.

Page 24

Before reading this page, activate background knowledge by reviewing what a life cycle is. Ask the following:

- What is a life cycle? (*the pattern of growth and development an organism goes through in its lifetime*)
- How do life cycles differ between living things? (*Some are shorter or longer; some include different stages.*)
- Do you think that a nonliving thing can have a life cycle? (*Answers may vary.*)

After reading this page, ask the following:

- Where is a star "born"? (*in a cloud of gas and dust*)
- What can affect a star's life cycle? (*its size* [*mass*])
- Describe where the sun is in its life cycle. (*in the middle*)

Know the Science

1. Stars produce light and heat. Stars are the only common objects in space that produce light and heat energy. (There are emission nebulae and some radio sources that produce light and heat energy, but these concepts are too far beyond the grade level to introduce.) All other objects that we see can reflect sunlight but cannot produce their own light. The light produced by stars is due to nuclear reactions of hydrogen and helium in the core producing great amounts of energy.

Page 25

After reading about the brightness and distance, ask students to think back to the activity that they completed with the flashlights. Review how perceived brightness can change with distance. (See **Know the Science 2** for more support.) Ask the following:

- Which flashlight seemed brighter even though the flashlights were exactly the same? (*the one that was closer to the wall*)
- Is the sun the largest star in the universe? (*no*)
- Then why is it so bright to us? (*because it is so close*)

Page 26

After reading this page, ask students to compare the sun and Sirius.

SUPPORT—Create a Venn diagram together on the board or on a large piece of chart paper to compare the two stars: the sun and Sirius. You can have students brainstorm in pairs to think of things that the two stars have in common and ways that they differ. Have each pair come up and write their comparisons on the diagram for the class to see and discuss.

3. Facilitate the activity.

10 MIN

Activity Page

AP 10.1

Have students work in pairs to complete this activity. Distribute one copy of Comparing Stars (AP 10.1) to each pair.

Instruct students to examine the H-R diagram. Ask the following:

- What does the horizontal axis indicate? (*temperature of stars*)
- What does the vertical axis indicate? (*the brightness of stars compared to the sun*)
- Where do most of the stars fall on the diagram? (*in the main sequence*)

Tell students that the sun is almost 6,000 kelvin and that it is an average-sized star. Ask students to decide with their partner where the sun would be located on the diagram, and have each pair place an X to mark that point on the diagram. Next, have students describe the patterns they see in the diagram and make a list of them. Have each pair of students share the patterns they see in the diagram with the class.

Know the Science

2. Address Misconceptions: Pause here to make sure that students understand that the sun is the only star that you can tell is closest by how bright it is. You cannot, for example, look at a constellation, pick out the brightest star, and assume that it is closest to Earth or that it is actually brighter than any other star in the constellation. Another star might be ten times as bright but much farther away, making its relative brightness to us on Earth seems less. Planets can easily be mistaken for a star when looking at the night sky. They can appear brighter than the stars. Again, this is because they are closer to Earth and strongly reflect sunlight.

SUPPORT—To help students identify patterns in the H-R diagram, ask them to describe the different types of stars. For example, giants are cooler and brighter, and white dwarfs are very hot but not as bright. Overall, the hotter the star, the brighter the star. As the star goes through its life cycle, it becomes cooler and dimmer.

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words displayed earlier in the lesson.

absolute brightness **apparent brightness** **light-year** **star**

Have students locate the cards they prepared in the previous lesson for *apparent brightness* and *light-year*. Then have students prepare new cards for *star* and *absolute brightness*.

Word Work

Invite students to add details or clarify their notes on their cards for *apparent brightness* and *light-year* after reading about those terms in Chapter 5. Then have them define the two new terms in their own words.

- **star:** (n. a space object that gives off its own heat and light)
- **absolute brightness:** (n. how bright a star is from a standard distance of 32.6 light-years) Ask students to clarify in their own words how a star with greater absolute brightness could have lower apparent brightness. (*It could be very far away.*)

5. Check for understanding. 5 MIN

Activity Page

AP 10.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Comparing Stars (AP 10.1), and check to see that students have correctly indicated the location of the sun. Check that they have correctly answered the review questions that follow the activity.

LESSON 11

Constellations

Big Question: What are constellations?

At a Glance

Learning Objectives

- ✓ Describe patterns in the stars.
- ✓ Predict the movement of constellations over time.
- ✓ Explain why some constellations change over time, while some do not.

Lesson Activities

- student activity and observation
- reading, discussion, writing
- vocabulary instruction

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Analyzing and Interpreting Data

Identifying **Patterns** is important to this lesson because students will look for patterns in constellations and explain what causes those patterns. Students will use the patterns they identified to predict the appearance of constellations throughout the year. Students will **Analyze and Interpret Data** from a planisphere or star map in order to identify and describe patterns in constellations.

In this lesson, students will describe what constellations are and make a planisphere to observe and describe patterns of change in the constellations.

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 purple below. During instruction, expose students repeatedly to this term, which is 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 151–152 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.

circumpolar **constellation** Polaris pole sphere/spherical

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 purple above.

Instructional Resources

Student Reader

Ch. 6

Activity Page

AP 11.1

Student Reader, Chapter 6
"Constellations"

Activity Page
Patterns in the Constellations (AP 11.1)

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

Materials and Equipment

Collect or prepare the following items:

- stapler
- scissors
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

The Core Lesson 45 min

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

What are constellations? Ask students to think about floating somewhere on a boat. Ask students how they would know which way they are going. Students may respond that they would use GPS, look for landmarks, or use some other method. Point out that people sailed in ships long before the invention of GPS technology, using objects in the sky for navigation. Ask:

» Why do you need to know what time of year it is to navigate using the stars? (*At different times of the year, different stars are visible.*)

» Can you name any constellations or patterns of stars that you have seen? (*Big Dipper, Orion's Belt, etc.*)

» How do you think that the constellations such as Big Bear, Southern Cross, and Big Dipper got their names? (*People look for shapes in the stars, the same way that you can look at clouds and imagine shapes.*)

SUPPORT—You may wish to show students some images of common constellations at this point in the lesson. Darkening the room and projecting the images onto the ceiling if possible may help to develop student interest in the topic.

2. Read and discuss: "Constellations." 15 MIN

Student Reader

Ch. 6

Prepare to read together, or have students read independently, "Constellations," Chapter 6 in the Student Reader. The selection explains what constellations are and the patterns of change that constellations go through.

Preview Core Vocabulary Term

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

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 this page, probe for understanding about constellations. (See **Know the Science** for additional support.) Ask the following:

» How are constellations named? (*by the shape that people can see in the outline*)

» Why do different constellations contain different numbers of stars? (*There isn't a set number of stars required to form a made-up picture.*)

Pages 28–30

Probe for understanding about patterns that cause changes in the appearance of constellations. Ask the following:

» If you look at the sky for many consecutive nights at the same time, will the same stars be visible? (*Yes, but they shift westward across the sky each night over*

Know the Science

Address Misconceptions: Constellations have different names in different parts of the world. For example, the Big Dipper is called the Plow in England and the Wagon in Germany, and even in America during the time of the Civil War, many people called it the Drinking Gourd. Actually, though, the Big Dipper is not a constellation. It is called a star pattern that is part of the constellation Ursa Major, or Great Bear. In China, there is a completely different way of visualizing patterns in the night sky.

a period of a couple months and then some are no longer visible and new ones become visible.)

- » What affects the constellations that can be seen at any season? (*how close the stars are to the poles, the time of year, and the time of night*)
- » Why are circumpolar stars best for navigation? (*because they can be seen in essentially the same position year-round*)
- » Why can circumpolar stars be seen year-round? (*because Earth's poles always point toward the same regions of space*)

SUPPORT—Support students who need more information to understand what *circumpolar* means by showing them an animation.

Online Resources

After reading about the different types of constellations, show a video or print a picture of some of the constellations that can be viewed where you live at night during this time of year. Show students the pictures, and, if you are outside major urban areas with light pollution that prevents visibility of stars, encourage them to look for these constellations tonight. Be sure to check the sky ahead of time to verify that these constellations can be seen where you live.

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

www.coreknowledge.org/cksci-online-resources

3. Facilitate the activity. 15 MIN

Activity Page

AP 11.1

This activity may be completed by students working in pairs, in small groups, or individually. Each student will need a copy of Patterns in the Constellations (AP 11.1), access to a stapler, and scissors.

Explain that a planisphere is a star chart. It has two adjustable disks that can turn to display visible stars for any time and date. It helps to recognize stars and constellations. You may wish to create an example to show students how the planisphere should look when it is complete. Circulate throughout the classroom to assist students with making their planisphere as needed. After students have completed the planisphere, ask the following questions:

- » Which constellations can be seen right now? (*Answers will vary.*)
- » How long will fully visible constellations be able to be seen in the sky? (*about two or three months*)
- » Are there any constellations on the planisphere that can be seen year-round? Why? (*Answers will vary; because they are close to the poles.*)
- » Why does the planisphere have the small window in it? (*This represents the view from Earth during that particular time of year.*)
- » Where do the other constellations go when they cannot be viewed from the window? (*They are still there but not in our field of view from our location on Earth.*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary term. Have students write the definition of **constellation** on the front of an index card in their own words.

Word Work

- **constellation:** (n. a group of stars that forms a recognizable pattern in the sky)
  - Ask students to circle the prefix *con-* and underline the letters *stella* in the word.
  - Ask students to discern the meanings of the parts of the word. (Con- *means "together" or "with," and* stella *means "star." A constellation is a group of stars together.*)
  - Ask: What is the difference between a star and a constellation? (*A constellation is a group of stars that makes a pattern.*)

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

5. Check for understanding. 5 MIN

Activity Page

AP 11.1
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key for correct answers and sample student responses.

Collect Patterns in the Constellations (AP 11.1), and check to see that students have correctly answered the questions. Address any misconceptions or incomplete responses before moving on to the next lesson.

LESSON 12

Diagramming Seasonal Constellations

Big Question: Why does the night sky change throughout the seasons?

At a Glance

Learning Objectives

- ✓ Describe the pattern of movement of the constellations.
- ✓ Predict the movement of a constellation over time.
- ✓ Write an explanation for the pattern of movement of constellations.

Lesson Activities

- vocabulary instruction
- student activity
- analyze and interpret data
- use evidence to support an explanation

NGSS References

Performance Expectation 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Disciplinary Core Idea ESS1.B: Earth and the Solar System

Crosscutting Concept: Patterns

Science and Engineering Practice: Engaging in Argument from Evidence

Engaging in Argument from Evidence is important to this lesson because students will examine photographic evidence of the movement of the stars and describe the pattern they see. Students will then make an argument to describe what is causing the pattern of movement. Evidence will be used to support students' statements. Evidence can be observations, measurements, models, and research from a reliable scientific source.

In this lesson, students will examine and describe patterns of change in constellations over time. Students will analyze and predict the movements and create explanations for what causes the apparent movement of the constellations.

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 purple below. During instruction, expose students repeatedly to this term, which is 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 151–152 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.

constellation seasonal

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 purple above.

Instructional Resources

Activity Page

AP 12.1

Activity Page
Constellations (AP 12.1)

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

Materials and Equipment

Collect or prepare the following items:

- soccer ball (or any ball of similar size)
- painter's tape or sticky tack to temporarily hang roll paper sheets
- wall space for students to hang their constellations
- clay
- bright sticker
- table lamp (no shade)
- roll paper (5 feet per group)

The Core Lesson 45 min

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

Why does the night sky change throughout the seasons? Begin by asking students to review what they learned in previous lessons about the movement of Earth in space. Ask the following:

» How do we know that Earth is moving in space? (*Shadows change, seasons change, days grow longer and shorter, and the moon's appearance changes.*)

» What kind of evidence can we gather here on Earth to support the idea that Earth is moving in space? (*We can create models, we can measure the change in shadows, and we can make observations of the stars.*)

» What are some ways that Earth changes with the different seasons? (*The temperature and length of day changes, and animals and plants behave differently in different seasons.*)

» How do stars change with the seasons? (*Some stars can only be seen during certain times of year.*)

SUPPORT—Help students think about Earth and its place in the universe. Earth moves around the sun. It takes a year to make one complete revolution. As Earth revolves around the sun, changes occur. Due to the tilt of Earth and its fixed direction in space, the seasons change. (See **Know the Science** on the next page.) Due to Earth's place in its orbit, the stars appear to change. Help students to understand that even though the stars appear to change, it is not they who are moving in space across each season, but us!

2. Teach Core Vocabulary. 5 MIN

Revisit Core Vocabulary Card

Direct student attention to the Core Vocabulary term **constellation**, and instruct students to take out their Core Vocabulary card prepared in the previous lesson.

Word Work

- **constellation:** (n. a group of stars that forms a recognizable pattern in the sky)
  - On the back of the Core Vocabulary card, tell students to draw and label one or more examples of constellations they have studied.
  - Make a class list of the constellations students have seen in the night sky. (*Big Dipper, Orion's Belt, the Seven Sisters, for example*)

3. Facilitate the activity. 25 MIN

Activity Page

AP 12.1

- Divide the class into four groups. Supply each group with a five-foot length of roll paper. Instruct each group to draw six to eight stars on the top third of the paper, to connect the dots into a picture, and to name the constellation. Then have each group create a second constellation on the bottom third of the paper.
- Hang the four posters centered on the four walls of the classroom and at the same height. Each group's constellation poster represents a different region of space, in four directions from the sun.
- Place a table lamp with no shade in the center of the classroom to model the sun.
- You will use a ball to model Earth and guide students through a demonstration of Earth's revolution and rotation within the space so that students can consider and diagram the visibility of the model constellations at different times.

- Prepare a soccer ball or basketball with lumps of clay to indicate the North Pole and South Pole. Also place a bright sticker on the upper half of the ball to represent an observer's location on Earth. Tell students that this is like the "You are here" indicator on a map.

Demonstrate Earth's axial tilt, angling the top pole on the model about twenty-three degrees toward the front center of the room. Maintain this tilt as a constant, in that same direction, for the duration of the demonstration as you complete the following steps:

1. Seat students so they can see you as you move around the room with the model for the demonstration. Holding the ball at its constant tilt toward the front of the room, walk around the lamp in the center of the room. Ask students to observe how for part of the revolution the model's North Pole is tilted toward the lamp/sun and for part of the revolution the axis is tilted away.
2. Then repeat the revolution, this time stopping four times, once each time you are directly between the lamp/sun and one of the constellation posters. In that position, draw students' attention to the "You are here" marker on the Earth model. Ask students to imagine themselves as tiny observers on that location on the model planet. Maintaining the model's tilt, rotate the ball around its axis.
3. Hold the ball in a stationary position with the "You are here" marker toward the lamp/sun. Ask students if this represents night or day for an observer from the model. (*day*) How do students know? (*because light from the lamp/sun is shining brightly on that side of the sphere*)
4. Rotate the ball, and hold it in a stationary position with the "You are here" marker toward the constellation poster on the wall that you are nearest. Ask students if this represents night or day for an observer from the model. (*night*) How do students know? (*because light from the lamp/sun is shining brightly on the opposite side of the sphere*)
5. Identify this poster as North, Night, Season 1. Have students diagram on Constellations (AP 12.1) the constellation that is visible to the "You are here" observer in his or her model night sky.

Know the Science

What causes seasons? A common misconception that students have is that we are closer to the sun in the summer and farther in the winter, but this is not the case! As was discussed in Lesson 5 and Chapter 3 of the Student Reader, the tilted axis of Earth is responsible for part of Earth leaning toward or away from the sun during different parts of the year. Earth's tilt is constant. The axial tilt does not vary; its orientation toward or away from the sun only changes with Earth's relative position. The orientation of the tilt causes the amount of daylight hours to increase and decrease throughout the year, the amount of solar energy per unit area to increase and decrease throughout the year, and weather to change throughout the year. Changes in season cause changes in living things all around Earth. When the seasons change, plants bloom, animals migrate or hibernate, and precipitation may increase or decrease.

6. Move ninety degrees around the lamp/sun to the position adjacent to the next poster. Identify this as North, Night, Season 2. Repeat Steps 4 and 5, and have students add to their diagram on AP 12.1.
7. Move ninety degrees around the lamp/sun to the position adjacent to the next poster. Identify this as North, Night, Season 3. Repeat Steps 4 and 5, and have students add to their diagram on AP 12.1.
8. Move ninety degrees around the lamp/sun to the position adjacent to the next poster. Identify this as North, Night, Season 4. Repeat Steps 4 and 5, and have students add to their diagram on AP 12.1.
9. Pause and move the "You are here" sticker to the lower half of the ball. Invite students to explain what this represents. (*The Earth observer in the model is now in the Southern Hemisphere, experiencing opposite seasons from the Northern Hemisphere.*)
10. Repeat Steps 4–8, this time identifying each stationary period as South, Night, Seasons 1–4.

CHALLENGE—Repeat the demonstration orienting the "You are here" halfway between what students have identified as full day and night positions. Ask students to analyze how this would affect the constellations visible to the model Earth observer at these times. Rotate the model very slowly, and ask students to consider how the appearance of the most visible constellation would change with this motion. This models how constellations visible during a particular season still change in appearance over the course of a single night, appearing to sweep across the sky in an arc from east to west.

4. Summarize and discuss. 5 MIN

Go to each constellation on the four posters, and ask students when it is visible in the night sky and from which hemisphere. Ask students to explain how the appearance of each constellation would vary in the sky from early one night to just before the following morning.

5. Check for understanding. 5 MIN

Activity Page

AP 12.1
Answer Key

Formative Assessment Opportunity

Collect Constellations (AP 12.1), and check to see that students understand how constellations appear to change when Earth rotates compared to when Earth revolves around the sun. Address any misconceptions or incomplete responses before moving on to the next lesson.

PART D

Gravity

Overview

Lesson	Big Question	Advance Preparation
13. Gravity	What is gravity?	Read Student Reader, Chapter 7.
14. Using Evidence About Gravity (2 days)	How can I use evidence to support an argument that Earth is a sphere?	Gather materials for hands-on investigation. (See Materials and Equipment, page 13.)

Part D: What's the Story?

The culmination of this series of lessons on astronomy focuses on gravity. It is the force that controls all of the celestial bodies students have explored in previous lessons: Earth and its moon, the sun, the solar system, stars, constellations, galaxies, and the universe. Understanding gravity as a universal force explains why objects of any mass stay in place or fall toward the center of Earth, why the moon revolves around Earth, and why the planets revolve around the sun.

In Lesson 13, students read about gravity on Earth as well as the gravitational force between Earth and its moon that controls Earth's tides. Students also consider the gravitational force that controls the bodies in a solar system. Students confirm that gravitational force exerted by Earth on objects is directed down to the center of the planet.

In Lesson 14, students gather evidence to prove that Earth is spherical. Students use this evidence and confirm their understanding of the direction of Earth's gravitational force.

So, to repeat, **understanding the force of gravity explains not only why objects stay in place on Earth, but also patterns of tides, the orbits of moons and planets in the solar system, and patterns of stars and other celestial bodies.** This set of lessons addresses NGSS Performance Expectation 5-PS2-1.

LESSON 13

Gravity

Big Question: What is gravity?

At a Glance

Learning Objectives

- ✓ Describe the shape of Earth.
- ✓ Identify the direction of Earth's gravity at two or more locations on Earth's surface.
- ✓ Explain the relationship between the moon's gravity and tides on Earth.
- ✓ Explain the relationship between the sun's gravity and the orbits of the planets around the sun.

Lesson Activities

- K–W-L (what I know, want to know, learned) chart
- teacher demonstration
- reading and discussion
- vocabulary instruction
- drawing a model and writing

NGSS References

Performance Expectation 5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.

Disciplinary Core Idea PS2.B: Types of Interactions

Crosscutting Concept: Cause and Effect

Science and Engineering Practices: Engaging in Argument from Evidence; Developing and Using Models

Developing and Using Models is the foundation of this lesson as students first use a physical model (a ball on a string) to understand the cause-and-effect relationship between the motion of an object and gravity. Later, students develop a diagrammatic model showing the effect of Earth's gravity on several objects of their choosing.

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 purple below. During instruction, expose students repeatedly to this term, which is 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 151–152 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.

gravitational	revolve	tide
gravity	sphere/spherical	

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 purple above.

Instructional Resources

Student Reader

Ch. 7

Activity Pages

AP 13.1

AP 13.2

Student Reader, Chapter 7
"Gravity"

Activity Pages
Diagramming the Direction of Earth's Gravitational Pull (AP 13.1)

Lesson 13 Check (AP 13.2)

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

Materials and Equipment

Collect or prepare the following items:

- tennis ball
- string (about 12 feet long)
- tape
- scissors
- books (for weights)
- globe
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (1 per student)

Advance Preparation

Assemble the string on a ball in advance. Tie the ball to one end of the string by wrapping it a few times to create a net over the ball. For extra safety, use tape to hold the string in place. Take the ball and string outdoors or into a gym, and whirl it over your head to practice demonstrating the movement of the moon around Earth.

The Core Lesson 45 min

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

What is gravity? Draw a K-W-L chart for the class. Have students complete the columns for what they know and what they want to know. Allow all answers at this point, and explain to students that you will return to the chart at the end of this lesson to finish it and make changes.

What do we KNOW?	What do we WANT to know?	What did we LEARN?

2. Demonstrate examples and guide discussion. 5 min

Present the ball on a string as a model, but don't tell students what it models. Take the class to an open area outdoors or in a gym. Have the students stand in a circle a good distance from you. Whirl the ball on the string over your head. While the ball is in motion over your head, release the string. Ask the following:

- In what direction did the ball move when the string was attached to me? (*in a circle*)
- In what direction did the ball move when the string was released? (*in a straight line*)
- What phenomenon in the natural world could this be a model for? (*Accept all plausible answers.*)
- What might the string represent? (*Accept all answers.*)

3. Read and discuss: "Gravity." 20 min

Student Reader

Ch. 7

Prepare to read together, or have students read independently, "Gravity," Chapter 7 in the Student Reader. This chapter defines gravity, presents evidence to support an argument that Earth is a sphere, explains the cause of tides, and describes the effects of gravity on objects in our solar system.

Preview Core Vocabulary Term

Before students read, write this term on the board or chart paper. Note that defining this term will answer the Big Question, and encourage students to pay special attention to this term as they read.

gravity

Guided Reading Supports

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

Page 31

After reading the page, focus students' attention on the photo. Ask the following:

- In what direction is the ball moving? (*It could either be on its way up or on its way down.*)
- How will the ball's motion eventually change? (*Assuming it is on its way upward, it will stop moving up and start to move down.*)
- What if the girl had held the ball straight over her head and then let go? How would it move then? (*It would move straight down.*)
- How do you know these things? (*Possible answer: I have done this many times, and it always happens the same way.*)

Have students identify other examples of the force of gravity in action. (*Possible answers: jumping up and falling down, throwing a baseball, riding a roller coaster, landslides*)

Pages 32–33

Before reading, have each student hold a small stack of books with both hands and their arms stretched out in front of them. Students should soon begin to groan under the strain of holding up the books. Ask the following:

- What makes this hard to do? (*The books are heavy and are being pulled down by the force of gravity.*)

After reading pages 32–33, have students think about other forces they have learned about (likely in Grade 3), such as electric and magnetic forces. Ask the following:

- How is the direction of these three forces similar and different? (*Electric and magnetic forces both attract and repel, but gravity only pulls, or attracts.*)

Point out to students that although the ground they stand on may appear flat, there is much evidence that Earth is round. (See **Know the Science** for more support).

Have students use the photo of Earth as evidence that Earth is a sphere. Explain that, in addition to this side of Earth, images exist of other sides of our planet. Ask the following:

» Why does it help to have several images? (*If you look at different parts of the sphere, you can see that it is round from every view. Only spheres appear this way.*)

SUPPORT—Provide a globe of Earth to students, and challenge them to move it to match the perspective of the image in the Student Reader. Then have students rotate the globe to look at different views. Point out to students that no matter which side of Earth you look at, the planet looks round. This can only happen when an object is a sphere.

Page 34

Before reading, ask students to define *mass*. Students should recall that mass is the amount of matter in an object. Remind students that mass is measured in grams and kilograms. Ask the following:

» Which has more mass, you or Earth? (*Earth*)
» Which has more mass, the moon or Earth (*Earth*)
» Which of these objects (you, the moon, Earth) have gravitational force? (*all of them*)

CHALLENGE—Have interested students look up the difference between mass and weight, including how each is measured, and share what they find with the class. Students should report that mass is measured using a gram or kilogram balance and is defined as the amount of matter in an object or a sample of matter. In contrast, weight is defined as a measurement of the force of gravity on an object and is measured on a scale using newtons or pounds as the units.

Know the Science

How long have people known that Earth is a sphere? *At least 2,700 years!* The Greek philosopher Aristotle wrote about the spherical shape of Earth. He made this inference based on the fact that the stars visible from different points on Earth are not the same. An ancient Greek mathematician observed that when the sun is overhead in one city, it was not overhead in another city. He made some measurements and was able to calculate the circumference of Earth—not exactly, but close enough! The knowledge of the ancient Greeks was available throughout Europe, and it is clear that Christopher Columbus and other educated people knew that Earth was a sphere. So, how did the idea that Columbus made his famous voyage to prove Earth was round come about? Most sources point to writings of the 1800s, such as Washington Irving's somewhat fanciful biography of Columbus.

Have students recall the model of the ball on the string. (See **Know the Standards**.) Ask the following:

» What did the string represent in this model? (*the pull of Earth's gravity*)

» What would happen to the moon if Earth had no gravity? (*It would travel off in a straight line, like the ball did.*)

Page 35

Online Resources

Show students online images of the same ocean shoreline scene during high and low tides. One striking example is at Hopewell Cape, Canada. Ask students to compare and contrast the two images. Then have them try to explain what caused the change. (*ocean water moving toward and away from the shore*)

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 reading page 35, have pairs of students take turns using the diagram to reteach a partner about high tides and low tides. Encourage them to use cause-and-effect statements. Extend their thinking by asking the following:

» If the moon had an ocean, would it also have tides? Explain. (*Yes, because Earth's gravity pulls on the moon.*)

» Why does the force of gravity seem to make a bigger change to the ocean than to the land? (*because liquid ocean water is easier to move than solid rock*)

Page 36

Before students read, ask the following:

» What are the types of solar system objects you learned about earlier in this unit? (*the sun; the rocky planets: Mercury, Venus, Earth, and Mars; the ice/gas giants: Jupiter, Saturn, Uranus, Neptune; other objects: dwarf planets, asteroids, meteoroids, and comets*)

» Which of these objects' motions are affected by gravity? How do you know? (*all of them, because they all have mass*)

» Which object has the greatest force of gravity of all of these, and why? (*the sun, because it has the greatest mass*)

After reading the page, remind students of the model of the ball on the string. Ask the following:

» How could we use this model to show what keeps planets in their orbits? (*The person whirling the end of the string can represent the sun, and the ball can represent a planet.*)

Know the Standards

Developing and Using Models: This NGSS Science and Engineering Practice is common to both scientific and engineering thinking. In Grades 3–5, instruction should concentrate on identifying the limitations of models, revising models based on evidence, developing a model to describe phenomena, developing diagrams and prototypes, and using models to test cause-and-effect relationships.

» What other objects in the solar system can the ball on the string represent? (*the sun plus any planet, dwarf planet, asteroid, meteoroid, moon, or comet*)

» From what you know of the model, what would happen to all these objects if the sun's gravity ceased to exist? (*They would all fly off in straight lines.*)

4. Teach Core Vocabulary. 5 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary word. Have students write the definition of **gravity** on the front of an index card in their own words.

Word Work

- **gravity:** (n. a force that pulls objects toward each other)
  - Discuss evidence of gravity. (*Things fall down. Space objects stay in orbit around other objects with gravitational pull. Tides.*)
  - Have students explain how gravity affects the orbit of the moon around Earth. (*Earth's gravitational pull on the moon is what keeps the moon in Earth orbit. At the same time, the moon's gravity also pulls on Earth as tides rise and recede in predictable patterns each day, mainly caused by the moon's gravitational force.*)

Return to the K-W-L chart you started at the beginning of the lesson. Have the class review the Know column to decide if what they knew was correct. Then have students complete the Learned column. Finally, ask students if all their questions in the Want column were answered. If not, let students know that the next lesson is also about gravity, so they may yet find answers.

5. Check for understanding. 10 MIN

Activity Pages

AP 13.1
AP 13.2
Answer Key

Formative Assessment Opportunity

Distribute Diagramming the Direction of Earth's Gravitational Pull (AP 13.1) and Lesson 13 Check (AP 13.2), and give students enough time to complete them. Use the Answer Keys for correct answers and sample student responses.

Prompt students to ask any new questions they may have. Discuss and answer questions as a class. Correct any misconceptions as needed.

LESSON 14

Using Evidence About Gravity

Big Question: How can I use evidence to support an argument that Earth is a sphere?

At a Glance

Learning Objectives

- ✓ Provide evidence that Earth's gravitational force pulls objects "down" toward the center of Earth.
- ✓ Describe the shape of Earth.

Lesson Activities (2 days)

- model demonstration
- vocabulary instruction
- preview the evaluation rubric (Day 1)
- evaluation and presentation of evidence (Day 2)

NGSS References

Performance Expectation 5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.

Disciplinary Core Idea PS2.B: Types of Interactions

Crosscutting Concept: Cause and Effect

Science and Engineering Practices: Engaging in Argument from Evidence; Planning and Carrying Out Investigations

Planning and Carrying Out Investigations: In this lesson, students are given the outlines of four investigations and have to do some collaborative planning to carry out one of them.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in purple below. During instruction, expose students repeatedly to this term, which is 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 151–152 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.

gravity sphere

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 purple above.

Instructional Resources

Activity Pages

AP 14.1
AP 14.2

Activity Pages
Earth's Shape Evaluation Guide (AP 14.1)

Identifying Evidence of Earth's Shape (AP 14.2)

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

Materials and Equipment

Collect or prepare the following items:

- clear plastic cup or bottle
- gravel
- teaspoon
- water
- tennis ball
- permanent marker
- rubber band that fits tightly over the tennis ball
- globe or large ball
- modeling clay
- flat toothpick
- small sticky note
- scissors
- solid shapes (cube, cylinder, cone, sphere)
- flashlight or lamp
- internet access and the means to project or print images for whole-class viewing

Advance Preparation

Use the marker to write N (North Pole) and S (South Pole) on opposite sides of the tennis ball. Draw a line around the widest part of the ball halfway between the N and S to represent the equator. Place the rubber band over the ball to make sure it is tight enough to stay on the ball.

The Core Lesson Two days, 45 min each

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

Recap the previous lesson in which students explored Earth's gravity by setting up a demonstration that students can share and use to show what they already know about gravitational force.

Fill a clear plastic cup or beverage bottle with gravel. Use a teaspoon to drop a small amount of water into the container. Have students observe through the side of the container and describe and explain the motion of the water. Encourage students to use the term *gravitational force* to explain how the water moves through the cup and where it stops.

Pass the container around, and allow a few students to add their own teaspoon of water. Encourage students to look closely at changes in direction of the moving water.

Then, introduce the Big Question: **How can I use evidence to support an argument that Earth is a sphere?** Remind students that people experience gravity the same way on all sides of the sphere. This is because gravity pulls matter toward the center of the sphere.

Acknowledge that it is not obvious from standing on Earth that our planet is round. This is why the class needs to conduct some investigations to gather evidence that Earth is round.

2. Demonstrate examples and guide discussion. 5 min

Place a rubber band over the marked-up tennis ball so that it covers the N and S and fits tightly and will not fall off. Explain to students that the ball is a model of Earth and that the rubber band can be used to model the force of gravity. Place your finger between the N and the rubber band, and say that your finger represents a person. Ask: What should I feel if I place my finger away from the ball and try to "jump up"? (*Your finger would be pulled back toward the ball by the force of the band.*) (See **Know the Science** for more support.)

Know the Science

Is Earth's gravitational force the same at all places on its surface? *Almost, but there are slight differences.* Gravity varies a bit with latitude, altitude, and differences in the local geology. Consider geology: Earth is not a perfect sphere. Landforms vary from place to place. Some landforms contain more matter, and therefore more mass, than others. Because the amount of gravity is due to the amount of mass, Earth's surface has variations in how much gravity pulls downward. Scientists know this because NASA's two GRACE mission spacecrafts were launched in 2002 and made measurements through 2017 to map variations in Earth's gravity over time. The results provide evidence that Earth's gravitational field is always changing. However, the differences are tiny—less than one percent.

Next, pass the ball to a student. Tell them to place a finger at the South Pole on "Earth" and tell the class what they feel when they lift their finger up under the band. (*The force pulls toward the ball.*)

Have students continue to pass the ball around the class. Allow students to reposition the band so that they can place their finger under it at any place on Earth. Each time, ask what students feel.

When several students have had a chance to try the model, ask the following:

» How does this model represent what "down" means on Earth? (*No matter where on Earth you stand, Earth's force of gravity pulls you toward its center. That is what "down" means.*)

3. Teach Core Vocabulary. 5 MIN

Revisit Core Vocabulary Card

Discuss how the definition of **gravity** is not limited to Earth. Have students contrast a description of gravity on Earth with the force as it applies to all objects in space.

Word Work

- **gravity:** (n. a force that pulls objects toward each other)
  - » How do you know gravity exists on Earth? (*Everything that has any mass falls down. Some force is pulling objects downward.*)
  - » How do we depend on gravity? (*We expect to sit, stand, and move around under the force of gravity, and we expect that buildings, furniture, and everything else will stay in place or fall to the ground.*)
  - » What evidence is there that gravity is a force in the solar system? (*Planets revolve around the sun, and moons revolve around planets.*)

CHALLENGE—Challenge students to consider how gravity acts as a force in water. What causes some objects to sink to the bottom of a body of water and others to float? What causes some objects to sink rapidly and others to sink slowly?

4. Preview the investigation. 5 MIN

Activity Page

AP 14.1

Set the stage for the performance task by explaining to students that they will work in groups on science investigations. Each group will carry out one investigation, and then, when all groups are ready, the class will hold a science symposium. Cultivate student understanding of what a symposium is. It is a conference to share ideas about a single topic. The symposium topic is Earth's shape.

Distribute one copy of Earth's Shape Evaluation Guide (AP 14.1) to each student. Direct students to focus on the Expert level descriptors, and explain that these are the student behaviors you will be looking for during this lesson. Answer any questions students may have about the expectations described in the rubric.

5. Facilitate the investigation.

20 MIN

Activity Page

AP 14.2

Explain to students that much of this lesson is about understanding the shape of planet Earth. (See **Know the Standards**.) Ask the following:

- What are the names of some three-dimensional shapes? (*cubes, cones, cylinders, and spheres*)
- Which of these shapes best describes planet Earth? (*a sphere*)
- What other familiar objects are shaped like a sphere? (*marbles, basketballs, soccer balls, baseballs, world globes, soap bubbles, the moon, the sun*)
- What are the attributes of a sphere? (*A sphere is a solid shape in which all points on its surface are an equal distance to the center point of the sphere. A sphere has only one surface and no edges or corners.*)

Advise students to keep their understanding of *sphere* in mind throughout their investigations.

Distribute Identifying Evidence of Earth's Shape (AP 14.2). Arrange students in small groups. Divide the four investigations among the groups. Depending on the size of your class, some investigations may have to be carried out by more than one group. Explain to the class that each group will carry out a different investigation and share what the members learn with the rest of the class. At the end of the class, all students will be responsible for understanding the results of each investigation.

Have students in each group takes roles such as materials getter, investigators, and presenter. Assign one of the four investigations to each group.

Circulate among the groups, and troubleshoot as needed. Investigations 2 and 4 require internet access for image searching and a printer for printing images. Remind students to use trusted scientific sites such as from NASA and the European Space Agency (ESA).

Know the Standards

What have students learned in mathematics about 3-D shapes? The Common Core State Standards for Mathematics address shapes under the Geometry domain. Kindergarteners are required to correctly name three-dimensional ("solid") shapes, regardless of their orientation. They also learn to distinguish them from two-dimensional shapes and identify the attributes of shapes, such as sides and vertices ("corners"). First graders compose 3-D shapes and composite shapes, and second graders count the number of faces on a 3-D shape. When students reach sixth grade, they will use formulas to find the volume of a rectangular prism and represent certain 3-D figures using nets (though not a sphere).

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

How can I use evidence to support an argument that Earth is a sphere?
Review the work students did on Day 1, and identify which investigation each group will present.

2. Facilitate the investigation. 30 MIN

Explain the rules of the science symposium. Each group should appoint a speaker to present the results of their investigation. The speaker will have two minutes to describe the evidence from their investigation to support the argument that Earth is a sphere. Then, there will be a question and answer (Q&A) period of two minutes.

> **SUPPORT**—Circulate among the groups as they are choosing their speaker and reviewing their evidence. If you see groups that are struggling, pick the speakers yourself, and then ask some guiding questions to help organize their presentation: What did you do during your investigation? What were your results? How do the results support the argument that Earth is a sphere?

Make sure the audience understands that its role is to pay close attention to each argument and to be ready to ask questions.

> **CHALLENGE**—If one or more speakers quickly formulate a strong argument that is accepted by the audience, challenge them to go a step further. Ask them to recall what they learned in Lesson 13 and explain what Earth's shape has to do with gravity. (*Earth formed as a sphere because space particles pulled together and more particles were attracted in every direction toward its center.*)

After each presentation, have students in the audience use Identifying Evidence of Earth's Shape (AP 14.2) to write the answer to the question at the end of each investigation based on what they heard in the presentation. Explain that all students are responsible for understanding evidence from all the investigations.

3. Summarize and discuss. 5 MIN

Once all groups have had a turn to speak at the symposium, sum up for the class the results, including how Earth's spherical shape is due to its gravity (see Challenge above).

Then, ask students if the evidence presented seems sufficient to support the claim that Earth is round. One way to do this is to poll the audience to determine if the argument that Earth is round had enough evidence to be accepted. If there are any negative replies, ask those students to describe additional evidence they would need to support the claim.

Next, focus on the significance of the spherical shape of Earth, the moon, and other planets. Ask:

- What is the common shape of all the planets in the solar system? (*They are all spheres.*)
- What might gravity have to do with the shape of planets and moons? (*All objects pull toward a common center of gravity, which creates a sphere. A planet's gravity pulls equally from all sides.*)

4. Check for understanding. 5 MIN

Activity Pages

AP 14.1
AP 14.2
Answer Key

Summative Assessment Opportunity

The completed tasks in Lessons 13 and 14 fulfill NGSS Performance Expectation 5-PS2-1.

Collect Activity Page 14.2.

Use Earth's Shape Evaluation Guide (AP 14.1) to evaluate each student's performance of the Science and Engineering Practice, Disciplinary Core Idea, and Crosscutting Concept associated with 5-PS2-1.

Use the Answer Key for Identifying Evidence of Earth's Shape (AP 14.2) for correct answers and sample student responses. Evaluate each student's answers for all four investigations.

Prompt students to ask any new questions they may have. Discuss and answer questions as a class. Correct any misconceptions as needed.

UNIT REVIEW

Women and Studying Space

Big Question: How have people learned about space systems?

At a Glance

Learning Objective

✓ Fluently discuss the unit's astronomy-related topics.

Lesson Activities

- unit review
- vocabulary review
- reading and discussion
- research and writing

NGSS References

This unit addresses the following Grade 5 Performance Expectations for the NGSS topic *Earth's Place in the Universe*.

Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth. (5-ESS1-1)

Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (5-ESS1-2)

Support an argument that the gravitational force exerted by Earth on objects is directed down. (5-PS2-1)

The Unit Review is intended to support students as they summarize their learning about these Performance Expectations and prepare for the Unit Assessment. 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

Earth has a place in the solar system, galaxy, and universe. This lesson reviews patterns of movement and stars that help to explain gravity and the orbits of Earth and its moon.

This lesson also reviews many of the Big Questions students have explored throughout the unit that focus on the concept of gravity and its effects on Earth and as the force that explains how bodies in space move, a prerequisite for understanding why there is day and night and seasons, why different stars appear at different times of year, and why the sun is brighter to us than other stars in the sky.

Core Vocabulary

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

absolute brightness
apparent brightness
axis
constellation
galaxy
gravity
light-year
lunar eclipse
moon phase
orbit
solar eclipse
solar system
star
universe

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

Instructional Resources

Student Reader

Ch. 8
Activity Pages

AP UR.1
AP UR.2

Student Reader, Chapter 8
"Women and Studying Space"

Activity Pages
Space Systems Big Questions (AP UR.1)

Vocabulary Review (AP UR.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

The Core Lesson 45 min

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

How have people learned about space systems?

Explain to students that, although they will be reading about women investigating space, discussing the chapter will give them an opportunity to apply what they have learned throughout all the lessons about space systems.

Briefly review each section of the unit by asking the following questions:

» What parts of the universe did you learn about? (*galaxies, solar systems, stars, planets, moons*)

- How do people know what we know about the universe? (*technology, including telescopes and spacecrafts that collect data*)
- How does Earth's movement affect life on Earth? (*The calendar year is based on Earth's revolution around the sun. Day and night are based on Earth's rotation. The seasons are the result of Earth's movement.*)
- How does Earth's movement affect our view of the night sky? (*Depending on the movement of Earth in its revolution and rotation, some stars can be seen all year long, only at certain times of the year, or only in one hemisphere.*)
- What affects how bright a star appears? (*distance, actual brightness*)
- What does gravity have to do with astronomy? (*Gravity is the force that results in the position and movement of stars, planets, moons, and all objects in the universe.*)

2. Read and discuss: "Women and Studying Space." 20 MIN

Student Reader

Ch. 8

Prepare to read together, or have students read independently, "Women and Studying Space," Chapter 8 in the Student Reader. This chapter introduces several women who have been involved with studying and exploring what students have been learning about in this unit.

Review Core Vocabulary Terms

Activity Page

AP UR.2

Before students read, distribute Vocabulary Review (AP UR.2). Together or individually, have students complete the page and review their responses.

Explain that by now, students have had much exposure to the terms throughout the unit. Tell students to keep these terms and other terms that are associated with them in mind as they read through the Student Reader.

Guided Reading Supports

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

Page 37

Reflect on the number of spacecrafts that NASA has launched.

- Prompt students to suggest NASA projects and missions they know of. (*Apollo mission to the moon, space shuttle, Voyager, mission to Mars, for example*)
- Discuss the diverse roles of people who are involved in a successful mission. (*astronauts, engineers, mathematicians, computer programmers, maintenance technicians, artists, designers*)

Online Resources

CHALLENGE—If time permits, challenge students to develop a timeline of key NASA missions starting in 1958 and going through the present and share with the class. 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**

Pages 38–40

After reading these pages, discuss what an astronaut does. Clarify that *cosmonaut* refers to Russian space travelers and that *astronaut* refers to American and other space travelers. Show a short video of an astronaut, Anne McClain, for example.

Online Resources

SUPPORT—For more information about what astronauts do and what it takes to be an astronaut, go to the NASA website. 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**

Point out that Russia and the United States are not the only nations with people who have traveled into space. For example, the International Space Station has been occupied at different times by about four hundred people from eighteen countries. Fewer than forty of them have been women.

Pages 41–42

After reading pages 41–42, ask the following:

- How did Nancy Grace Roman and Katherine Johnson contribute to our understanding of space? (*made discoveries, helped plan and develop the Hubble Space Telescope, oversaw operations, used mathematics to plan space missions*)
- What role do scientists, engineers, and mathematicians play in space missions? (*Scientists establish hypotheses to test. Engineers design spacecrafts. Mathematicians calculate distances and measurements to make sure missions are successful. Computer programmers create models of space.*)

3. Summarize and discuss. 10 MIN

Challenge students to think about jobs people could have to learn more about what they have been studying in this unit. Ask the following:

- What types of jobs might be involved with learning about stars and their distances from Earth? *(for example, discovering stars and planets, measuring distances in space, building telescopes)*
- What types of jobs might be involved with learning about seasonal changes and the movement of Earth? *(for example, measuring temperature and climactic changes, using solar and wind power at different times of the year)*
- What types of jobs might be involved in learning more about gravity? *(for example, finding ways to use gravity as a power source, measuring gravitational pull in space, designing space travel in weightless environments)*

4. Check for understanding

10 MIN

Activity Pages

AP UR.1
AP UR.2
Answer Key

Distribute Space Systems Big Questions (AP UR.1).

Assign students to work in pairs to discuss and develop written answers to the unit's Big Questions. Assign each pair one or two Big Questions to answer from the Activity Page.

Instruct students to draft their answers first on scrap paper as they work with their partner.

Before administering the Unit Assessment, collect and evaluate Space Systems Big Questions (AP UR.1). Address any misguided or incomplete responses. Return the Activity Page to students, and have selected students read their responses to the whole class. Reviewing these Big Questions will support students in preparation for the Unit Assessment. For additional reinforcement, use the Answer Key to revisit student answers to Vocabulary Review (AP UR.2).

See Teacher Resources pages 149–150 for guidance in administering the Unit Assessment to conclude the unit.

Know the Standards

Engineering Design: A major theme throughout the NGSS standards is an emphasis on engineering design, defining a problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, and cost. Technology developed to learn more about space and space travel are examples of engineering design problems that have been addressed in many different ways. The creativity involved in designing a space suit, living quarters in space, a space probe, a new telescope, or any other technology has led to significant advancements in our understanding of space.

UNIT 5

Teacher Resources

Activity Pages

Name _____ Date _____

Activity Page 1.1 (Page 1 of 2) Use with Lesson 1.

Exploring Space, Part 1

Each of the following tools has helped us learn more about space. Choose one from the list below. Use library resources to research the technology and advancements that made the tool possible.

land-based telescope

space-based telescope

space probe

rover

human-made satellite

International Space Station

Which advancement did you choose? _____

Complete the chart to explain how your advancement has contributed to human understanding of space.

What is it?	
When was it first invented or established?	
What does it do?	
What discoveries has it helped scientists to make?	

Exploring Space, Part 2

Each of the following objects exists in outer space. Choose one from the list below. Use the library's resources to research that object.

star

planet

moon

dwarf planet

asteroid/meteoroid

Which space object did you choose? _____

Complete the chart to describe your space object.

What is it?	
When was it first discovered?	
Where in space is it located?	
What are its characteristics?	

Name _____ Date _____

Activity Page 1.2 Use with Lesson 1.

Space Collage

Make a collage showing what people know is in space. Use the following criteria to complete the collage:

- Decide as a class what you want the collage to show: the universe as a whole, a single galaxy, or our solar system.
- Determine the order in which groups will place their cutouts in the collage. For example, if the collage is of the solar system, should the sun be placed on the collage first? Where should it be placed?
- Once it has been decided what the collage will show, draw a model of the collage in the box below.

- Before each group places its cutouts on the collage, choose a member of your group to briefly explain what your group learned about its space object.

Name _____ Date _____

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

Objects in the Solar System

Our solar system contains many objects, including planets. Complete the table to describe the planets. In the last column, list three or more characteristics that describe each planet.

The first example has been done for you.

Planet	Name its position from the sun.	Describe some of its characteristics.
Mercury	first	very hot; rocky; short revolution period around the sun; very small; has no moon
Venus		
Earth		
Mars		
Jupiter		
Saturn		
Uranus		
Neptune		

What are some other objects that exist in the solar system?

_____

<u>Complete</u> the table with the characteristics of each of the following celestial objects.

The first example has been done for you.

Object	**Describe characteristics.**
moon	a natural satellite that orbits a planet, which orbits a star; smaller than a planet
asteroid	
meteoroid	
meteor	
comet	
gases	
dwarf planet	

Name _____ Date _____

Activity Page 3.1 Use with Lesson 3.

The Universe

We know a great deal about the universe and many of its galaxies. Much of this information comes from technology we have invented.

Complete the table to describe the technology used to learn about each object in space. Some technologies may be used for more than one object, and we may have learned about some objects using more than one technology.

The first example has been done for you.

Object in Space	Technology
the surface of Mars	rover
planets	
moons	
stars	
distant galaxies	
the Pillars of Creation	

Name _____ Date _____

Activity Page 4.1 (Page 1 of 2) Use with Lesson 4.

The Movement of Earth

1. Draw diagrams to explain each of the following. Be sure to include labels and descriptions as needed.

Rotation	**Revolution**
What makes day?	**What makes night?**

Examining Shadows

2. Place the ruler or stick about one inch into the soil so that it is standing upright. Record your observations in the table.

Time of day	Drawing of the stick and its shadow

a) How did the shadow change throughout the day?

b) What caused the appearance of the shadow to change?

Name _____ Date _____

Activity Page 5.1 Use with Lesson 5.

Patterns and Evidence of Movement

Complete the table to describe the patterns of movement and the evidence to explain how we know the movement occurs.

Pattern of Movement	Evidence to Support
Earth rotates on its axis.	
Earth's axis is tilted.	
Earth revolves around the sun.	
Earth is a sphere.	

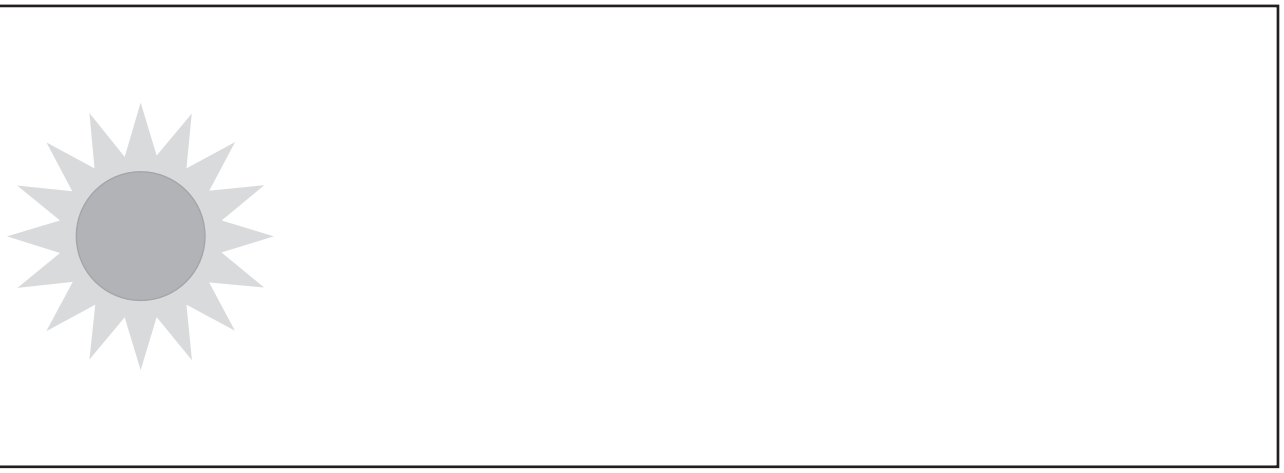
Name _____ Date _____

Activity Page 6.1 Use with Lesson 6.

Shadows

1. Complete the diagram, and explain how a solar eclipse occurs. Draw Earth and the moon in place, and add labels and descriptions as needed.

2. Complete the diagram, and explain how a lunar eclipse occurs. Draw Earth and the moon in place, and add labels and descriptions as needed.

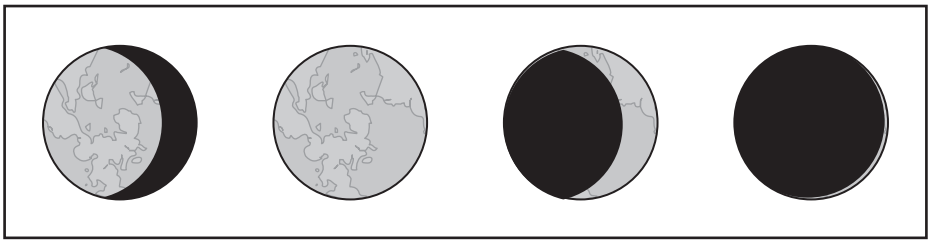


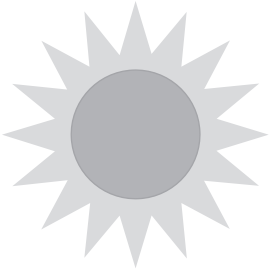
Name _____ Date _____

Activity Page 7.1 Use with Lesson 7.

Phases

<u>Complete the diagram</u> to show the phases of the moon. Draw each moon phase from the bank, or cut and paste, to the correct place on the model. Then explain why our view of the moon changes during moon phases.





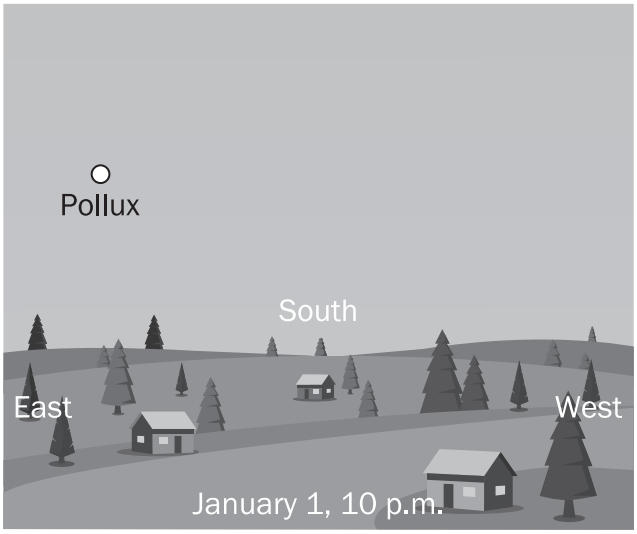
Name _____ Date _____

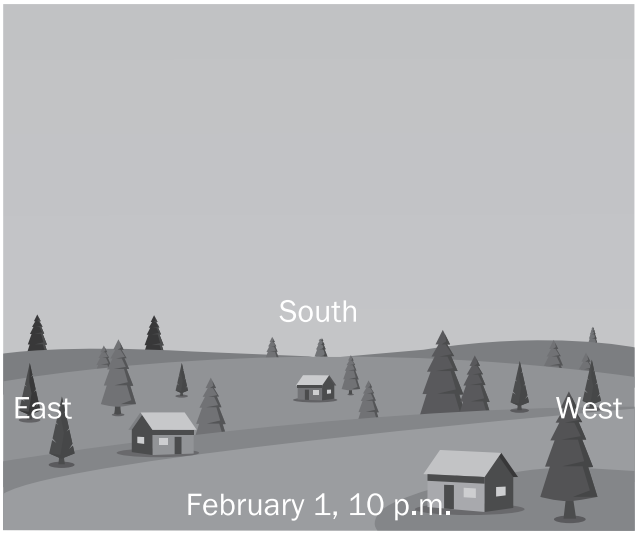
Activity Page 8.1 (Page 1 of 2) Use with Lesson 8.

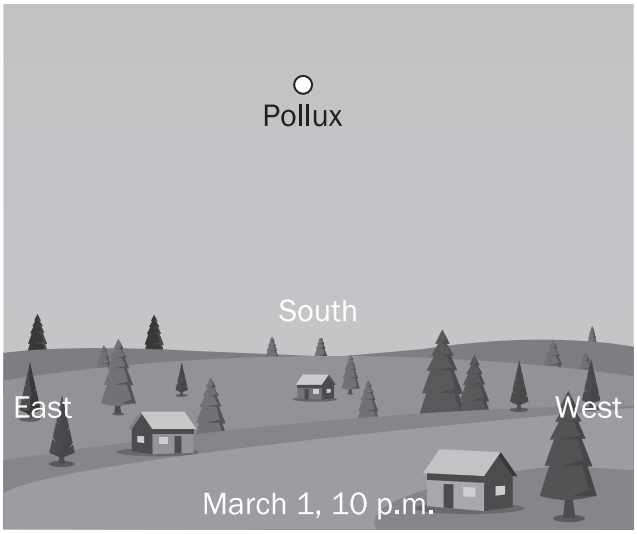
Moving Stars

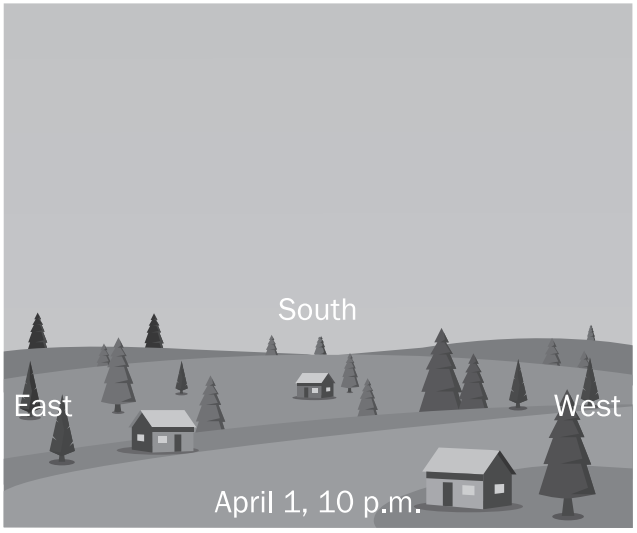
1. Explain what causes stars to blur in a long exposure photo. _____

2. Pollux is the brightest star in the constellation Gemini. Gemini can be seen in the night sky in the Northern Hemisphere from December until April. Examine the following diagrams showing the location of the star Pollux in the night sky. Predict where it will be on the given dates by drawing and labeling it in the February and April boxes.









3. Explain your placement of Pollux in February and April. _____

_____

4. Why does Pollux appear in different positions in the sky even though the diagrams were drawn at the same time each night?

5. Where does Pollux go when it is no longer visible in the night sky?

6. What does Pollux have in common with the sun?

7. How does the pattern of Pollux's apparent movement explain Earth's movement?

Name _____ Date _____

Activity Page 9.1 Use with Lesson 9.

Star Light, Star Bright

Procedure

1. Put new batteries in both of the flashlights.

2. Using the meterstick, measure the following distances in the room where you will be conducting your investigation: 5 meters, 10 meters, 15 meters, 20 meters. Use tape to mark each place.

3. Next, turn both flashlights on at the same time, and keep them on. Have one person stand at the 5-meter mark while the other person moves to the other marks.

4. Record your observations on the table below.

Distance	How does the light look compared to the one shining at 5 meters?
10 meters	
15 meters	
20 meters	

a) What variables were controlled in your investigation?

_____

b) What pattern did you observe in the light as you increased the distance between the light and the wall? _____

c) How does this relate to the stars? Provide evidence to support your answer.

_____

d) Is the sun so bright because it is such a large star? _____

_____

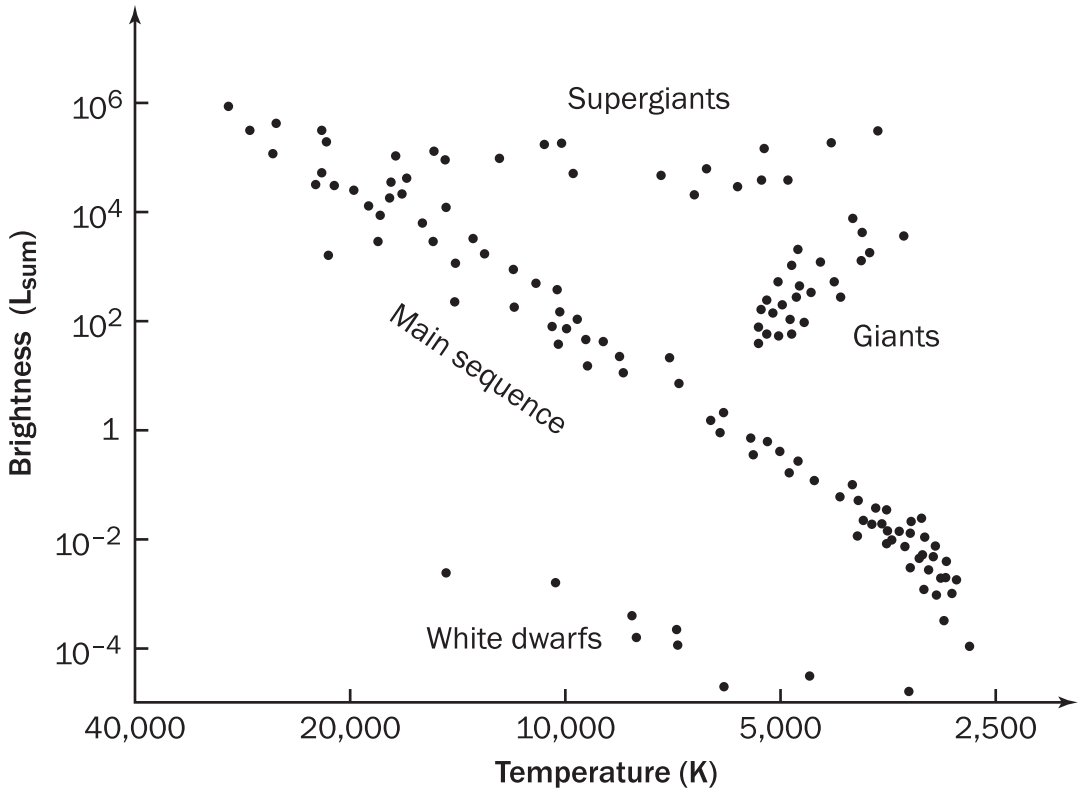
e) What will happen if you keep backing up farther and farther? _____

_____

Name _____ Date _____

Activity Page 10.1 Use with Lesson 10.

Comparing Stars



Examine the H-R diagram.

1. The sun is a main sequence star with a surface temperature of almost 6,000 kelvin. Place an X on the area of the diagram where the sun would be located. (Kelvin is a type of temperature scale.)

2. Describe a pattern you see in the diagram to your partner. Make a list of the patterns that you discover in the diagram. Be ready to share your answer with the class.

_____

_____

_____

3. Sirius is a very bright star that can be seen in the night sky. It is larger, hotter, and brighter than the sun. Write an explanation for why it does not look that way to us on Earth. Use evidence to support your answer.

_____

_____

Name _____ Date _____

Activity Page 11.1 (Page 1 of 3) Use with Lesson 11.

Patterns in the Constellations

Make a planisphere!

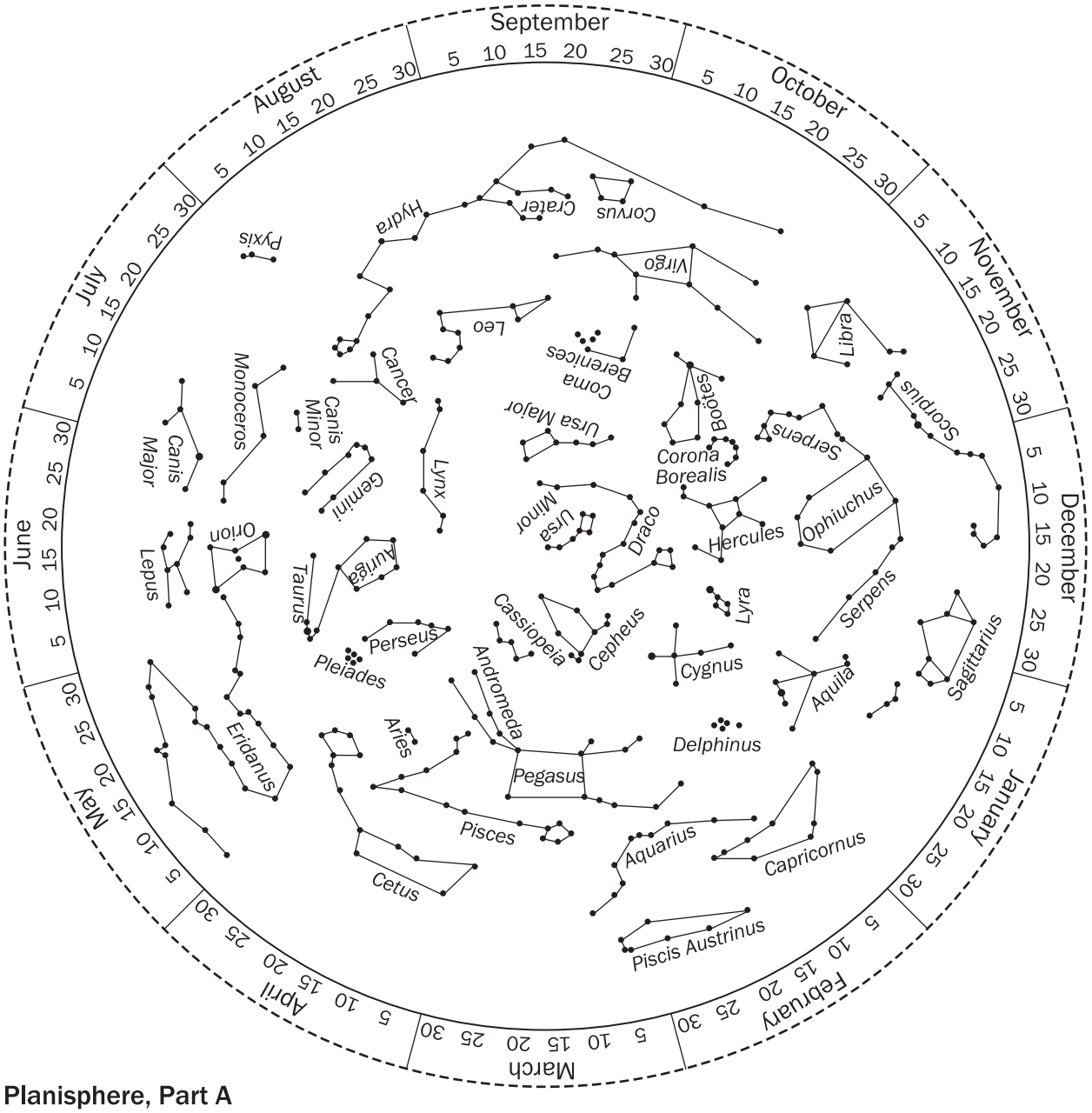
Cut out the two parts of the planisphere. **Assemble** the planisphere according to the directions shown with each part. Then use the planisphere to **answer** the following questions.

1. What constellations are visible in the sky where you live during this time of year?

2. Describe any patterns you notice in the constellations as you move the planisphere.

3. Why is the planisphere in a circular shape?

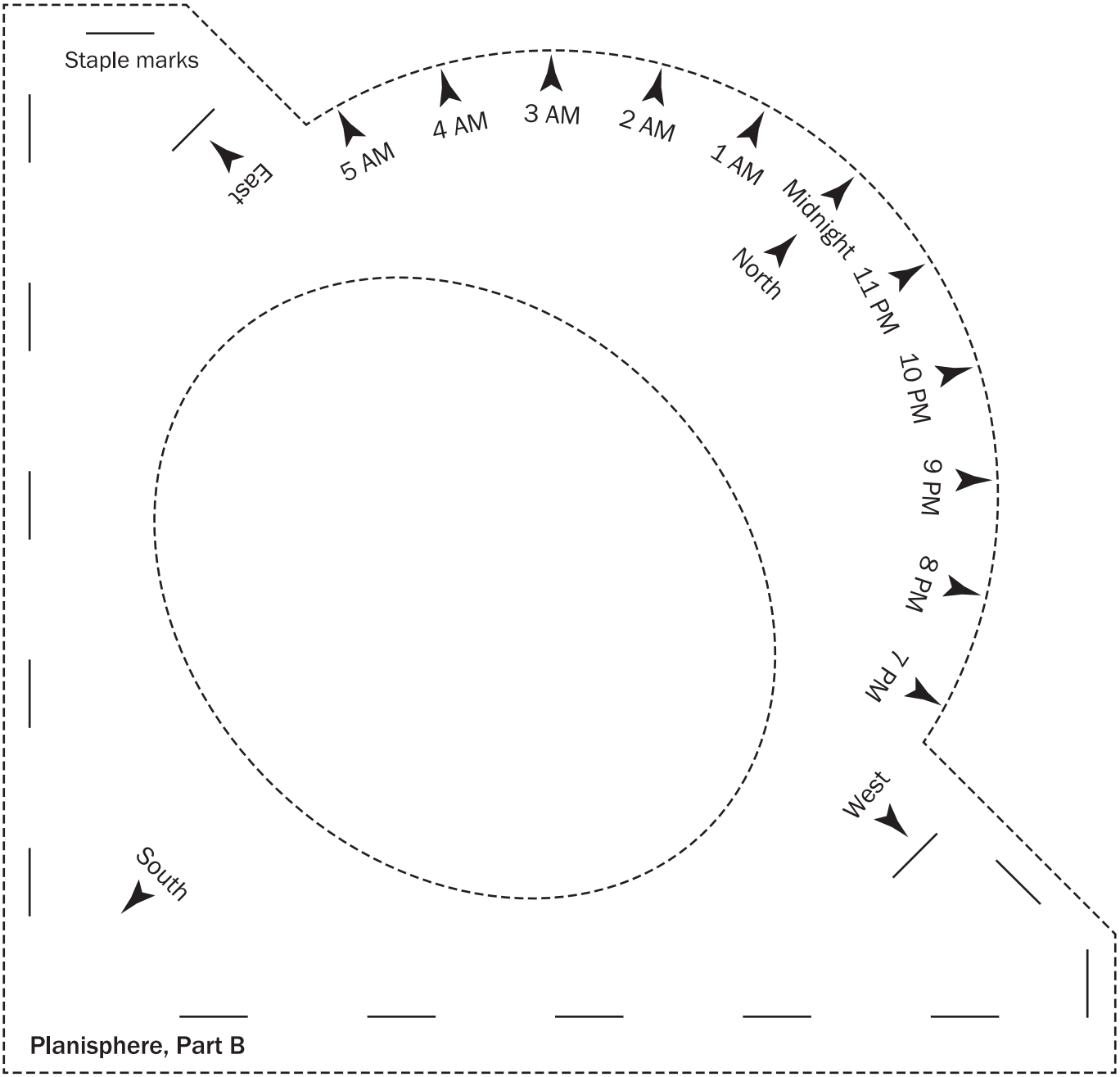
Cut out the constellation map along the dashed circle outline. Slide the map into the pocket you make with Part B. The circular map should rotate freely in the pocket.



Planisphere, Part A

Cut out Part B on the dashed lines. Then carefully cut and remove the oval area from the center to make the viewing window. Staple Part B to another piece of paper to make a pocket. Place staples only where marked.

Slide Part A into the pocket. Rotate Part A to see which constellations are visible in the night sky at different times.



Name _____ Date _____

Activity Page 12.1 (Page 1 of 2) Use with Lesson 12.

Constellations

North, Night, Season 1

North, Night, Season 2

North, Night, Season 3

North, Night, Season 4

South, Night, Season 1

South, Night, Season 2

South, Night, Season 3

South, Night, Season 4

Name _____ Date _____

Activity Page 13.1 Use with Lesson 13.

Diagramming the Direction of Earth's Gravitational Pull

Draw the whole Earth. **Add** a few objects on or above its surface. **Draw arrows** to show the direction of the pull of Earth's gravity on each object.

Name _____ Date _____

Activity Page 13.2 Use with Lesson 13.

Lesson 13 Check

Answer the questions to show you understand the key ideas in this lesson.

1. Suppose you could travel anywhere you wanted. How would you gather evidence to argue what "down" means?

2. How do lunar eclipses and photos from space provide evidence of Earth's shape?

3. What happens to ocean water on the side of Earth facing the moon? Why?

4. What causes planets to stay in their orbits around the sun?

Name _____ Date _____

Activity Page 14.1 Use with Lesson 14.

Earth's Shape Evaluation Guide

There has been a lot of talk online about Earth being flat. Astronomers have even made videos to explain this is not so. But some people still need to be convinced. Your task is to support an argument about Earth's shape. **Read the evaluation guide and discuss it with your class.**

Earth's Shape Argument Evaluation			
	Expert	**Intermediate**	**Beginner**
Identifying evidence	I collect data in an investigation and identify evidence related to the question of the investigation.	I collect data in an investigation but do not relate it to the question of the investigation.	I do not try to collect data related to the question of the investigation.
Using reasoning	I connect evidence from my investigation with my claim by stating cause-and-effect relationships.	I connect evidence from my models with my claim but do not try to state cause-and-effect relationships.	I do not try to discuss a claim or state cause-and-effect relationships.
Presentation	My group's presenter speaks clearly using formal language, and our group answers all questions from the audience completely.	My group's presenter speaks clearly and uses formal language most of the time. We answer all questions but not always completely.	My group's presenter does not try to speak clearly or use formal language. Our team does not answer most questions from the audience.
Group work	I always work well with my group. All members of the group get to participate equally.	I sometimes work well with my group. Members of the group sometimes get to participate equally.	I do not work well with my group. Some group members did not get to participate.

Name _____ Date _____

Activity Page 14.2 (Page 1 of 2) Use with Lesson 14.

Identifying Evidence of Earth's Shape

Your teacher will assign one investigation to your group. Carry out the investigation, including writing for the last step.

Investigation 1: How does a ship look as it sails away?

A. Use the scissors to cut a small flag shape out of the sticky note. Stick the flag on the toothpick (flagpole).

B. Place a small ball of modeling clay anywhere on the globe or ball. Stand the flagpole in the clay. This represents the mast and flag on a ship.

C. Hold the ball at arm's length so you can see the entire flag on the horizon.

D. Have a partner rotate the ball slowly away from you. This models the motion of a ship sailing away. Notice how the flagpole appears.

E. Describe any changes you saw. How is this caused by the shape of Earth?

Investigation 2: What does a lunar eclipse show about Earth's shape?

A. Find several images of how the moon looks during a lunar eclipse.

B. Observe the shape of the shadow edges on the moon carefully.

C. Explain how the shape supports the claim that Earth is a sphere.

Investigation 3: Could Earth be any solid shape?

A. Get some geometric solid shapes, such as cubes, cylinders, cones, and spheres.

B. Draw a circle on the board or sheet of paper hung on the wall.

C. Turn on a strong flashlight or lamp. Hold the shape between the light and the circle. Rotate the shape in as many directions as you can, observing the shape of the shadow cast.

D. Explain how this investigation supports the claim that Earth is a sphere.

Investigation 4: How does Earth look from space?

A. Search for images of Earth taken from the moon by NASA or from the International Space Station. Find several images of different sides of Earth taken from space.

B. Compare the shape of Earth in each view.

C. Explain how what you see supports the claim that Earth is a sphere.

Name _____ Date _____

Activity Page UR.1 Use with Unit Review.

Space Systems Big Questions

The table below contains most of the Big Questions you have explored in the unit *Astronomy: Space Systems*.

Circle the question that was assigned for you to answer.

How do people know what is in space?	What is apparent brightness?
What is the solar system?	Why do some stars appear brighter than others?
What is the universe, and what are galaxies?	What are constellations?
How can I model the ways that Earth moves in space?	Why does the night sky change throughout the seasons?
How does Earth move in space?	What is gravity?
How can I model the relationship among the sun, Earth, and the moon?	How can I use evidence to support an argument that Earth is a sphere?
What are moon phases and eclipses?	How have people learned about space systems?
How do star patterns provide evidence of Earth's movement?	What have I learned about space systems?

Write three or four sentences to answer the Big Question that was assigned to you and your partner.

Prepare a rough draft of your answer first on scrap paper, and then write your final draft below. Underline any terms in your answer that have a card in your Core Vocabulary deck.

Name _____ Date _____

Activity Page UR.2 Use with Unit Review.

Vocabulary Review

Write the word from the word bank that matches each definition. Not every word in the word bank will be used. Review the cards in your Core Vocabulary deck before you begin.

axis	circumpolar	constellation	galaxy	gravity	life cycle	light-year
lunar eclipse	orbit	phase	planet	reflect	relative brightness	
revolution	rotation	season	shadow	solar eclipse	solar system	
star	universe					

1. _____ a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris

2. _____ moving in a path around something

3. _____ a large sphere-shaped object that revolves around a star

4. _____ a collection of dust, gas, stars, and their solar systems

5. _____ all existing matter in space

6. _____ to spin on an axis

7. _____ an imaginary line through the center of an object that provides a fixed point of reference

8. _____ to bounce back light

9. _____ repeating, predictable pattern of change in the moon's appearance from Earth

10. _____ an event during which the moon's shadow blocks all or some of the sun's light

11. _____ a space object in a fixed point in the sky that gives off its own heat and light

12. _____ the distance that light travels in one Earth year

Name _____ Date _____

Unit Assessment: *What Have I Learned About Space Systems?*

Answer the following items to show what you have learned.

1. Which of the following technologies have helped humans learn more about what is in outer space? Circle all the correct answers.

a) telescopes **b)** probes

c) meteors **d)** rovers

e) oil wells **f)** wind turbines

g) satellites **h)** lunar landing

2. Write the number of each planet's order from the sun. The planet closest to the sun should be 1. The planet farthest from the sun should be 8.

_____ Neptune

_____ Mars

_____ Saturn

_____ Mercury

_____ Jupiter

_____ Uranus

_____ Earth

_____ Venus

3. Write the word from the bank next to the correct definition. Then answer the question that follows.

solar system	universe	galaxy

_____ all existing matter and energy in space

_____ a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris

_____ a collection of stars, and their solar systems, dust, and gas

Scientists divide space into different systems. Give the order of the systems from smallest to largest by writing the numbers 1 to 3 on each line. The smallest system should be 1, and the largest system should be 3.

_____ solar system

_____ universe

_____ galaxy

4. In the box below, draw a model of how Earth moves with regard to the solar system. Be sure to include the sun and the moon, as well as a few other planets. Then answer the question that follows.

Your model must do the following:

a) show how Earth moves in the solar system

b) show how the moon moves in the solar system

What's the difference between Earth's rotation and its revolution or orbit?

5. Complete the table by drawing the positions of Earth, the moon, and the sun in a solar eclipse and a lunar eclipse.

Solar Eclipse

Lunar Eclipse

6. Which of the following are reasons that some stars may appear brighter or dimmer than other stars? Circle all the correct answers.

a) They are brighter and/or closer in distance.

b) They are brighter and/or father away in distance.

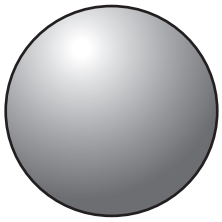
c) They are dimmer and/or closer in distance.

d) They are dimmer and/or farther away in distance.

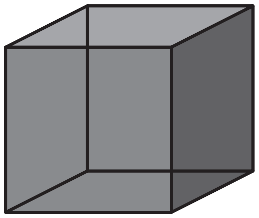
7. Give one example of a constellation. Tell which part of the year it can be seen and how it got its name. Explain why it can only be seen during that part of the year.

8. Which of the following is Earth's shape most like?

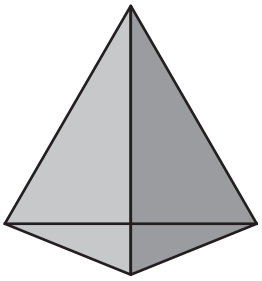
a)



b)



c)



d)

Unit Assessment (Page 6 of 6)

9. Pick two locations on the globe. Draw arrows in those locations to show the direction of Earth's gravity.

10. Which of the following are evidence of the direction in which Earth's gravity pulls objects? Circle all the correct answers.

a) A pencil falls off a desk.

b) A girl drops her notebook.

c) A bird soars overhead.

d) An airplane takes off.

e) An apple falls to the ground.

f) A rocket launches into space.

11. Gravity from which of the following causes tides?

a) other planets

b) Earth

c) the moon

d) asteroids

12. Write the correct words from the word bank to complete the sentence to describe how our solar system maintains its system. Not all the words in the bank will be used.

gravity	sun	planet	moon

Each _____ is held in orbit by _____ from the _____.

Activity Pages Answer Key: *Astronomy: Space Systems*

This answer key offers guidance to help you assess your students' learning progress. Here you will find descriptions of the expectations and correct answers for each Activity Page of this unit.

Exploring Space (AP 1.1) (pages 113–114)

Students should choose a technological advancement from the list on the page and complete the chart. Students should choose a space object from the list on the page and complete the chart.

Space Collage (AP 1.2) (page 115)

Students should draw a model of the collage.

Objects in the Solar System (AP 2.1) (pages 116–117)

- Planets

  Mercury – closest to the sun; very hot; rocky; short revolution period around the sun; very small; has no moon

  Venus – second from the sun; hottest; rocky; dense atmosphere; about same size as Earth; has no moon

  Earth – third from the sun; supports life; has water; has only one moon

  Mars – fourth from the sun; thin atmosphere; rocky; very cold; reddish looking; no life now but may have supported life once

  Jupiter – fifth from the sun; largest planet; gas giant; has 79 moons; has Great Red Spot

  Saturn – sixth from the sun; large; gas giant; has 62 moons; has seven "rings"

  Uranus – seventh from the sun; large; ice giant; mostly water and gases; no solid surface; blue-green in color; very cold and windy; has "rings"; tilted on its side while revolving around sun

  Neptune – eighth from the sun; large; ice giant; no solid surface; dark, windy, and cold; possibly has a hot ocean

- Accept plausible student responses such as dwarf planets, human-made satellites, and Kuiper Belt objects.

- Celestial Objects

  moon – a natural satellite that orbits a planet, which orbits a star; smaller than a planet

AP 2.1, continued

  asteroid – rocky body revolving around the sun that is too small to be called a planet or dwarf planet

  meteoroid – small parts of asteroids that are created when asteroids smash into each other

  meteor – bits of rock from a meteoroid that appear as a streak of light as they enter Earth's atmosphere, sometimes called "shooting stars"

  comet – icy rock that lets off gas and dust that can form "tails" when flying close to the sun

  gases – loose collections of atoms

  dwarf planet – a small planet that revolves around the sun and has some but not all characteristics of a regular planet

The Universe (AP 3.1) (page 118)

the surface of Mars – rover; planets – probe, satellite; black holes – satellite, telescope; stars – telescope; distant galaxies – telescope; the Pillars of Creation – telescope

The Movement of Earth (AP 4.1) (pages 119–120)

1. Student diagrams should show that rotation is the spinning of Earth on its axis, revolution is the movement of Earth around the sun, and day and night are both caused by the rotation of Earth.
2. **Examining Shadows –** Student observations should show that the stick's shadow changes position throughout the day.
   - **a.** Its length and position changed.
   - **b.** the position of the light source producing the shadow

Patterns and Evidence of Movement (AP 5.1) (page 121)

Earth rotates on its axis – The sun rises and sets; shadows change; the stars and moon move across the sky.

Earth's axis is tilted – The seasons change throughout the year.

Earth revolves around the sun – Different constellations are visible in the night sky at different times of the year.

Earth is a sphere – the sun rising and setting; curved shadow edges on moon during lunar eclipses

Shadows (AP 6.1) (page 122)

1. Students should note that a solar eclipse occurs when the moon casts a shadow on Earth when it moves between the sun and Earth.
2. Students should note that a lunar eclipse occurs when Earth casts a shadow on the moon when it moves between the sun and the moon.

Phases (AP 7.1) (page 123)

Students should note that each month the moon goes through different phases as different amounts of light that can be seen from Earth are reflected.

Moving Stars (AP 8.1) (pages 124–125)

1. Earth rotating
2. Students should depict the star higher in the sky and to the right of the position shown for January 1, but not as high and centered in the sky as it appears on March 1.
3. Students should depict the star lower in the sky and to the right of the position shown for March 1.
4. because Earth is revolving around the sun
5. It is still there, but it is in the daytime sky, where it cannot be viewed,
6. They are both stars that produce light that reaches Earth.
7. The view of Pollux is in a recurring pattern because Earth is revolving around the sun and provides different views of the galaxy.

Star Light, Star Bright (AP 9.1) (page 126)

4. Students' observations should note that the light looks dimmer and/or less focused as the flashlight is moved farther away.

   a) using new batteries and keeping both flashlights on the whole time

   b) The more distance, the dimmer the light.

   c) If two stars are the same brightness, the one that is closer will appear brighter.

   d) No, the sun is so bright because it is closest to Earth.

   e) The light source will appear to grow dimmer.

Comparing Stars (AP 10.1) (page 127)

1. Students should place an X in the area where the temperature is 6,000 K and the lumosity is around 1.
2. Giant stars are cooler than main sequence stars. The highest-luminosity stars are the hottest. Supergiant stars are luminous even though some are cooler than other stars.
3. Sirius is further away than the sun, so it does not look bigger and brighter. If both were the same distance from Earth, Sirius would outshine the sun.

Patterns in the Constellations (AP 11.1) (pages 128–130)

- Students should note constellations visible in the local night sky.
- Accept reasonable student observations, but they should note that the constellations appear to move in a circular pattern.
- It is in a circular shape because it is a pattern that repeats again each year.

Constellations (AP 12.1) (pages 131–132)

Responses should reflect the student-drawn constellations that would be visible from the unlit side of the model Earth (ball) during the respective model seasons. Check responses to ensure that students understand that constellations are not visible when the sun is positioned between the stars and the viewer.

Diagramming the Direction of Earth's Gravitational Pull (AP 13.1) (page 133)

Student diagrams should show that Earth's gravitational pull is always directed toward the center of Earth.

Lesson 13 Check (AP 13.2) (page 134)

1. Example: I would take a ball and a video camera to places on the other side of Earth, such as China or Australia. Each place I go, I would throw the ball up in the air and record where it went next. Then I would compare the videos and use them as evidence that they all fall toward Earth's center.
2. During a lunar eclipse, the edge of Earth's shadow is always curved. Photos from space, no matter which part of Earth you look at, always show a rounded surface.
3. The water bulges toward the moon, due to the force of the moon's gravity.
4. the force of gravity between the sun and planets, other moons, asteroids, and so on, plus the speed of these moving objects

Identifying Evidence of Earth's Shape (AP 14.2) (pages 136–137)

Investigation 1: As the model ship sailed away, first the clay disappeared, then the toothpick disappeared, and finally the top of the flag disappeared. This change happened because Earth is round.

Investigation 2: During a lunar eclipse, you can see the shadow of Earth cast onto the moon. Since the shadow is always curved, it is evidence that Earth itself is curved.

Investigation 3: The shapes of the shadows of the cube, cylinder, and cone change as you rotate the solid objects. Only the shadows of the sphere never change. This is evidence that planet Earth is a sphere.

Investigation 4: The photos from any side of Earth show the planet has a rounded shape. This is evidence that Earth can only be a sphere.

Vocabulary Review (AP UR.2) (page 139)

1. solar system
2. orbit
3. planet
4. galaxy
5. universe
6. rotation
7. axis
8. reflect
9. phase
10. solar eclipse
11. star
12. light-year

Unit Assessment: Teacher Evaluation Guide

The Unit Assessment on pages 140–145 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 longer, 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.** telescopes (5 points)
b. probes
d. rovers
g. satellites
h. lunar landing

2. 8, 4, 6, 1, 5, 7, 3, 2 (8 points)

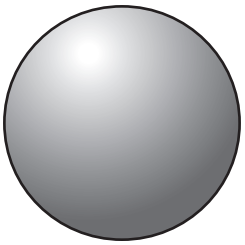
3. universe; solar system; galaxy (3 points)
1, 3, 2

4. Student drawings will vary but should show the sun as the center of the solar system. Models should show that Earth revolves around the sun, while the moon revolves around Earth.
Correct answer to question: Earth's rotation is how it spins on its axis. Earth's revolution or orbit is how it travels around the sun. (8 points)

5. For *Solar Eclipse*, students should draw the moon between Earth and the sun. For *Lunar Eclipse*, students should draw Earth between the sun and the moon, with Earth's shadow being cast upon the moon. (6 points)

6. **a.** They are brighter and/or closer in distance.
d. They are dimmer and/or farther away in distance. (2 points)

7. Sample answer: Orion. It can be seen in winter. This is because of where Earth is in its path around the sun. It was named by the ancient Greeks. (5 points)

8. **a.**  (2 points)

9. No matter the location, all arrows should point toward the center of Earth. (3 points)

10. **a.** A pencil falls off a desk.

b. A girl drops her notebook.

e. An apple falls to the ground. (3 points)

11. **c.** the moon (2 points)

12. planet, gravity, sun (3 points)

Appendix A

Glossary

Purple words and phrases are Core Vocabulary terms for the unit. **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

absolute brightness, n. how bright a star is from a standard distance of 32.6 light-years (25)

apparent brightness, n. how bright a star appears compared with other stars when all are viewed from Earth (25)

axis, n. an imaginary line through the center of an object that is a fixed point of reference (16)

C

circumpolar, adj. describing something that revolves around one of Earth's poles

constellation, n. a group of stars that forms a recognizable pattern in the sky (27)

crew, n. an individual or team of people working to complete a mission

crewed, adj. describing a space mission that carries people aboard spacecraft

cycle, n. a series of steps, often in a repeating pattern

E

ellipse, n. an oval shape

elliptical, adj. in the shape of an ellipse

G

galaxy, n. a collection of stars, their solar systems, dust, and gas (7)

gravity, n. a force that pulls objects toward each other (32)

gravitational, adj. related to the force of gravity

L

light-year, n. the distance that light travels in one Earth year (25)

lunar eclipse, n. an event during which the moon passes directly behind Earth and into its shadow (21)

M

moon phase, n. a stage in the repeating, predictable pattern of change in the moon's appearance from Earth (20)

O

orbit, n. the oval-shaped path an object follows as it revolves around another object in space (**v**. to revolve around another object) (1)

P

pattern, n. a recognizable or recurring design or sequence of events

planet, n. a celestial body moving in an elliptical orbit around a star

Polaris, n. the North Star

pole, n. the center point (one each at Earth's Northern and Southern Hemispheres) through which its axis passes

probe, n. a spacecraft sent to gather data about a space object

R

reflect, v. to bounce off of

revolution, n. a single trip around another object

revolve, v. to travel around

rotate, v. to spin around a fixed point

rover, n. an uncrewed probe that is launched from Earth, lands on another object in space, and travels around on that body's surface to gather data

S

satellite, n. an object that orbits another object

seasonal, adj. relating to Earth's changing seasons

shadow, n. a darkened area behind an object that blocks light

solar eclipse, n. an event during which the moon's shadow blocks all or some of the sun's light from reaching Earth (22)

solar system, n. a system of objects in space that includes at least one star, planets, their moons, asteroids, comets, and other space debris (1)

space station, n. a spacecraft in long-term orbit that is inhabited by a crew

sphere, n. a ball shape

spherical, adj. in the shape of a sphere

star, n. a space object that gives off its own heat and light (23)

system, n. parts taken together in a process

T

telescope, n. a device for detection and magnification of faraway objects

terrestrial, adj. related to solid earth

tide, n. a fluctuation in the water level at a shoreline

U

uncrewed, adj. without human occupants

universe, n. all of the existing matter and energy in space (9)

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

Appendix C

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.

Appendix D

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 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.

Appendix E

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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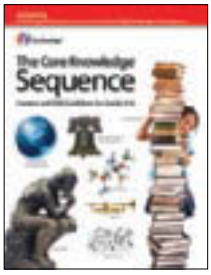
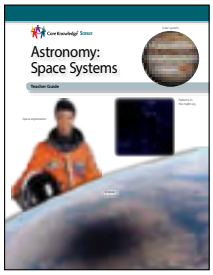


What is the Core Knowledge Sequence?

The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including Earth and space, physical, and the life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.



For which grade levels is this book intended?

In general, the content and presentation are appropriate for readers from the middle to upper elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Grade 5 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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