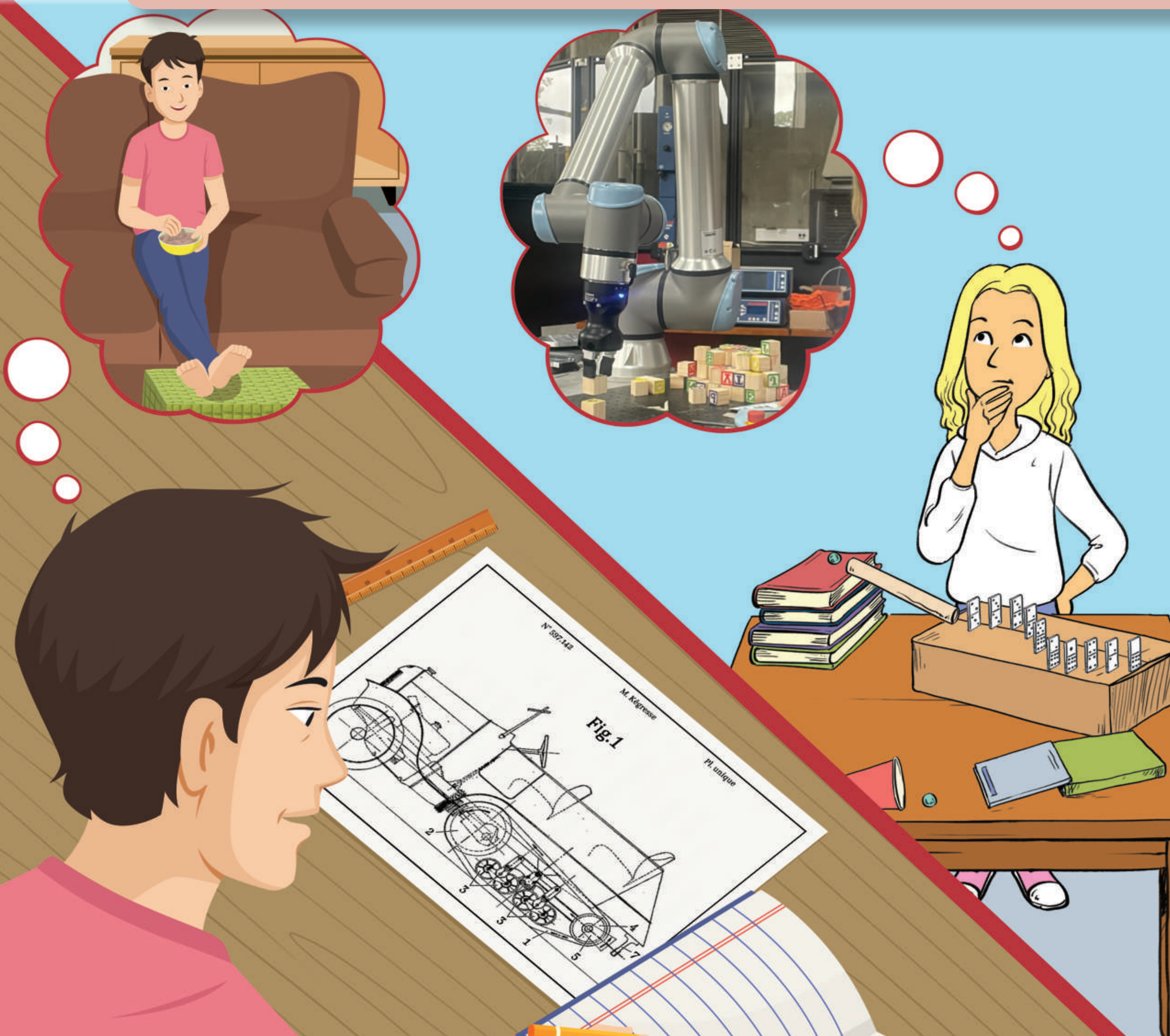
Core Knowledge® SCIENCE

Rosalind Franklin

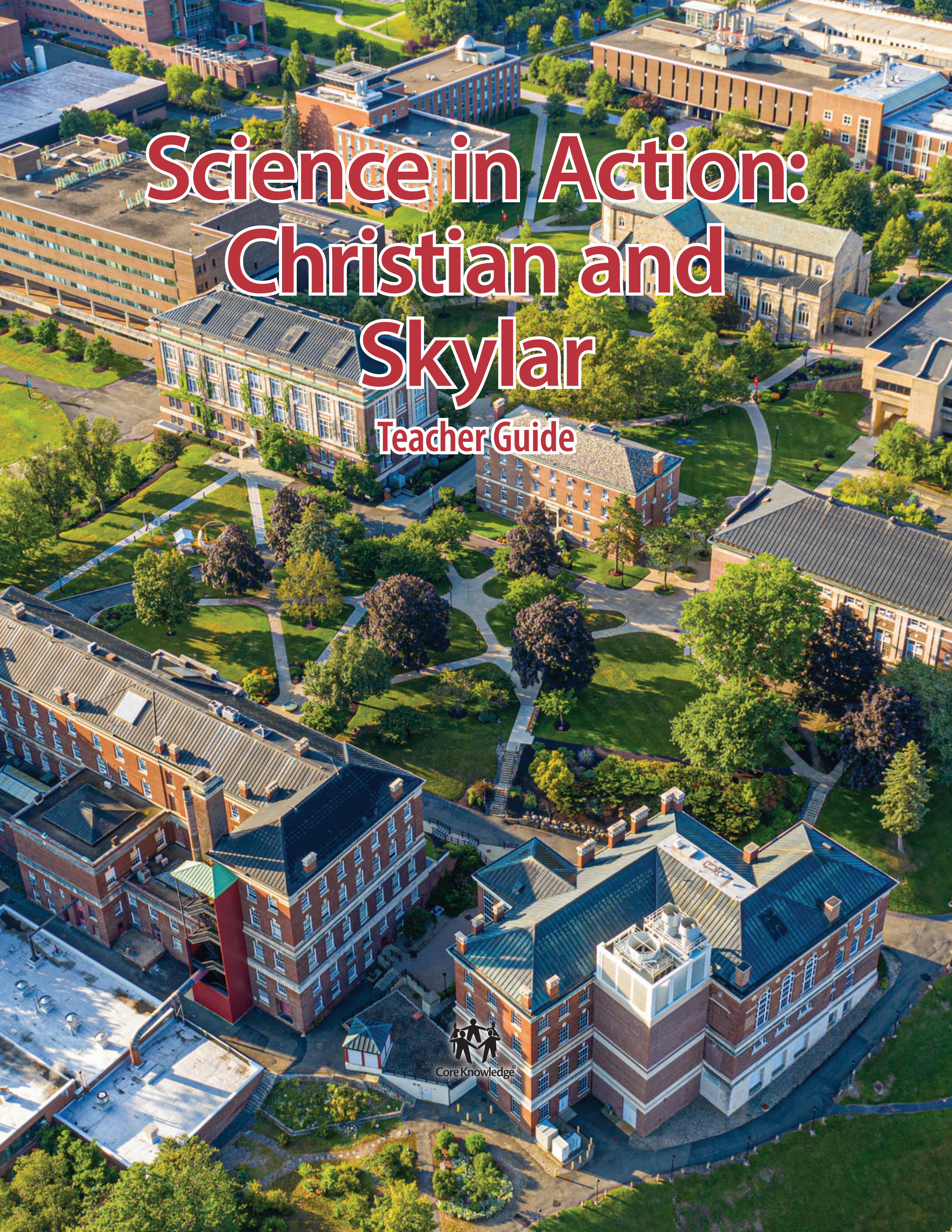
Science in Action: Christian and Skylar

Teacher Guide



Science in Action: Christian and Skylar

Teacher Guide



Core Knowledge®

ISBN: 979-8-88970-567-3

Science in Action: Christian and Skylar

Table of Contents

Science in Action: Christian and Skylar

Science in Action Teacher Guide

Core Knowledge Science™ Grade 3

GRADE 3

Introduction

About Science in Action

The goal of teaching students science from kindergarten through high school graduation is not to turn every student into a scientist by profession. However, scientific advances occur at a faster rate year after year, and this leads to a job market and society that needs people comfortable with science as part of their daily work lives. And while students traditionally receive an education in science, they may not be familiar with how learning about science leads to a career in the sciences. Students may have an imperfect understanding of how science will impact their future and future career. Students may be undecided about their futures and have no background or understanding about how science could inform their career as adults.

While STEM is now taught as a portion of classes in many grades, there are very few schools with dedicated engineering classes. Many industries have a focus on engineering, which can change rapidly as a result of the faster evolution of technology. As a result, many students receive little exposure to this vital aspect of their future careers. Students are asked to learn about engineering and adapt to new engineering skills in a short time frame without developing the depth and breadth of how to put science in action.

With this in mind, Core Knowledge has developed the Science in Action readers. Each reader features two or more chapters. Students learn first about the early childhood of the subject and how their interest in the sciences and engineering was piqued. The second part features the subject in the present day and explores their academic and engineering experiences in college, their work experiences as they relate to their scientific and engineering experiences, and in some cases their careers post-college. Each account ends with an "Inspired by . . ." section that features one or more scientists or engineers who provided inspiration for their path. The goal is to help young students connect their own experiences at a younger age to their future endeavors and careers as part of the larger society outside the classroom.

Core Knowledge Foundation is committed to educating students in many disciplines. *Science in Action* is intended to show that a person, no matter what age, encounters science and engineering in their everyday experiences. Further, the program intends to help students connect their personal lives with the broader needs and interests of society so when they get to high school and beyond in their academic careers, they will be more familiar with the paths they follow.

Standards

Core Knowledge Science offers units that comprehensively address all of the Next Generation Science Standards (NGSS) in a three-dimensional approach that integrates Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs). The program clusters the NGSS Performance Expectations into physical science, life science, and Earth and space science units.

Stemming from the commitment that background knowledge is essential, the units build around Student Books, which largely center on all of the NGSS DCI concepts. However, the pure NGSS approach de-emphasizes reading, and the standards do not treat the Science and Engineering Practices or the Crosscutting Concepts as *content*, or discrete ideas to be taught and learned. This omission makes the SEPs and CCCs logical concepts for focus of direct student attention. Core Knowledge maintains that it is favorable and valuable for students to read or hear stories that are specifically about practices and overarching concepts.

The lessons in Grade 3 Core Knowledge Science in Action are constructed to cultivate student exposure to and understanding of the ideas present in the following NGSS dimensions. Lessons also cite relevant support of Common Core State Standards for English and Language Arts. Additional cross-curriculum standards relevant to specific lessons will be listed at the lesson level.

Nature of Science

NOS1. Scientific Investigations Use a Variety of Methods

- Science methods are determined by questions.
- Science investigations use a variety of methods, tools, and techniques.

NOS2. Scientific Knowledge Is Based on Empirical Evidence

- Science findings are based on recognizing patterns.
- Scientists use tools and technologies to make accurate measurements and observations.

NOS3. Scientific Knowledge Is Open to Revision in Light of New Evidence

- Science explanations can change based on new evidence.

NOS4. Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Science theories are based on a body of evidence and many tests.
- Science explanations describe the mechanisms for natural events.

NOS5. Science Is a Way of Knowing

- Science is both a body of knowledge and processes that add new knowledge.
- Science is a way of knowing that is used by many people.

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.

National Governors Association Center for Best Practices, Council of Chief State School Officers. 2010. *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects*. National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington DC.

NOS6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems.
- Basic laws of nature are the same everywhere in the universe.

NOS7. Science Is a Human Endeavor

- Men and women from all cultures and backgrounds choose careers as scientists and engineers.
- Most scientists and engineers work in teams.
- Science affects everyday life.
- Creativity and imagination are important to science.

NOS8. Science Addresses Questions About the Natural and Material World

- Science findings are limited to what can be answered with empirical evidence.

Science and Engineering Practices

SEP1. Asking Questions (for science) and Defining Problems (for engineering)

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas. Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.

- Ask questions about what would happen if a variable is changed.
- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
- Use prior knowledge to describe problems that can be solved.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

SEP2. Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions, and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs. Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Identify limitations of models.
- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regularly occurring events.

- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.
- Develop and/or use models to describe and/or predict phenomena.
- Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
- Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural or designed system.

SEP3. Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions. Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Evaluate appropriate methods and/or tools for collecting data.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- Make predictions about what would happen if a variable changes.
- Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

SEP4. Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis. Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective. Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.

- When possible and feasible, digital tools should be used.
- Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

- Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
- Use data to evaluate and refine design solutions.

SEP5. Using Mathematics and Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.

- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- Organize simple data sets to reveal patterns that suggest relationships.
- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
- Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.

SEP6. Constructing Explanations (for science) and Designing Solutions (for engineering)

The end products of science are explanations, and the end products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints. Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Apply scientific ideas to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

SEP7. Engaging in Argument from Evidence

Argumentation is the process by which evidence-based conclusions and solutions are reached. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims. Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Compare and refine arguments based on an evaluation of the evidence presented.
- Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
- Construct and/or support an argument with evidence, data, and/or a model.
- Use data to evaluate claims about cause and effect.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

SEP8. Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs. Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

Crosscutting Concepts

CCC1. Patterns

Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. In grades 3–5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause-and-effect relationship.

Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products. Patterns of change can be used to make predictions. Patterns can be used as evidence to support an explanation.

Patterns . . . are a pervasive aspect of all fields of science and engineering. When first exploring a new phenomenon, children will notice similarities and differences, leading to ideas for how they might be classified. The existence of patterns naturally suggests an underlying cause for the pattern. For example, observing snowflakes are all versions of six-side symmetrical shapes suggests something about how molecules pack together when water freezes; or, when repairing a device, a technician would look for a certain pattern of failures suggesting an underlying cause. Patterns are also helpful when interpreting data, which may supply valuable evidence in support of an explanation or a particular solution to a problem.

CCC2. Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts. In grades 3–5, students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions. Cause-and-effect relationships are routinely identified, tested, and used to explain change. Events that occur together with regularity might or might not be a cause-and-effect relationship.

Cause and effect lies at the heart of science. Often, the objective of a scientific investigation is to find the cause that underlies a phenomenon, first identified by noticing a pattern. Later, the development of theories allows for predictions of new patterns, which then provides evidence in support of the theory. For example, Galileo's observation that a ball rolling down an incline gathers speed at a constant rate eventually led to Newton's Second Law of Motion, which in turn provided predictions about regular patterns of planetary motion, and a means to guide space probes to their destinations.

CCC3. Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance. In grades 3–5, students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume. Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Scale, proportion, and quantity are essential considerations when deciding how to model a phenomenon. For example, when testing a scale model of a new airplane wing in a wind tunnel, it is essential to get the proportions right and measure accurately or the results will not be valid. When using a computer simulation of an ecosystem, it is important to use informed estimates of population sizes to make reasonably accurate predictions. Mathematics is essential in both science and engineering.

CCC4. Systems and System Models

Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

In grades 3–5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions. A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.

Systems and system models are used by scientists and engineers to investigate natural and designed systems. The purpose of an investigation might be to explore how the system functions or what may be going wrong. Sometimes investigations are too dangerous or expensive to try out without first experimenting with a model.

CCC5. Energy and Matter—Flows, Cycles, and Conservation

Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. In grades 3–5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change. Matter is made of particles. Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. Energy can be transferred in various ways and between objects.

Energy and matter are basic to any systems model, whether of a natural or a designed system. Systems are described in terms of matter and energy. Often, the focus of an investigation is to determine how energy or matter flows through the system, or in the case of engineering to modify the system, so a given energy input results in a more useful energy output.

CCC6. Structure and Function

The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. In grades 3–5, students learn different materials have different substructures, which can sometimes be observed, and substructures have shapes and parts that serve functions. Different materials have different substructures, which can sometimes be observed. Substructures have shapes and parts that serve functions.

Structure and function can be thought of as a special case of cause and effect. Whether the structures in question are living tissue or molecules in the atmosphere, understanding their structure is essential to making causal inferences. Engineers make such inferences when examining structures in nature as inspirations for designs to meet people's needs.

CCC7. Stability and Change (factors to always consider)

For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study. In grades 3–5, students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change. Change is measured in terms of differences over time and may occur at different rates. Some systems appear stable, but over long periods of time will eventually change.

Stability and change are ways of describing how a system functions. Whether studying ecosystems or engineered systems, the question is often to determine how the system is changing over time and which factors are causing the system to become unstable.

Engineering and Design

ED.A. Defining and Delimiting Engineering Problems

Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.

- Define - Specify criteria and constraints that a possible solution to a simple problem must meet.

ED.B. Developing Possible Solutions

Designing solutions to engineering problems begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.

- Develop solutions - Research and explore multiple possible solutions.

ED.C. Optimizing Design Solutions

Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

- Optimize - Improve a solution based on results of simple tests, including failure points.

Science, Technology, Society, and the Environment

STSE1. Interdependence of Science, Engineering, and Technology

- Science and technology support each other; Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.

STSE2. The Influence of Engineering, Technology, and Science on Society and the Natural World

- People's needs and wants change over time, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. When new technologies become available, they can bring about changes in the way people live and interact with one another.

Common Core State Standards for English and Language Arts

Reading Standards for Informational Text

Key Ideas and Details:

- **CCSS.ELA-LITERACY.RI.3.1:** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- **CCSS.ELA-LITERACY.RI.3.2:** Determine the main idea of a text; recount the key details and explain how they support the main idea.
- **CCSS.ELA-LITERACY.RI.3.3:** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

Craft and Structure:

- **CCSS.ELA-LITERACY.RI.3.4:** Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 3 topic or subject area*.
- **CCSS.ELA-LITERACY.RI.3.5:** Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently.
- **CCSS.ELA-LITERACY.RI.3.6:** Distinguish their own point of view from that of the author of a text.

Integration of Knowledge and Ideas:

- **CCSS.ELA-LITERACY.RI.3.7:** Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).
- **CCSS.ELA-LITERACY.RI.3.8:** Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).
- **CCSS.ELA-LITERACY.RI.3.9:** Compare and contrast the most important points and key details presented in two texts on the same topic.

Range of Reading and Level of Text Complexity:

- **CCSS.ELA-LITERACY.RI.3.10:** By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text complexity band independently and proficiently.

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.

Features

Using the Reader

The *Science in Action* Reader includes four chapters, intended to be read aloud by the teacher as the students look at images on each page. The Reader opens with stories of the source of inspiration for a scientist when they were young. The parts that follow the chapters introduce the scientist as an adult and the work they do as an adult in a science-based field. The final part discusses how they were inspired by scientists of the past.

Online Resources

The Reader is spiral-bound to allow students to lay it flat when reading or following along.

While some advanced students may be able to read words on a given page of the Reader, as a general rule, students should not be expected or asked to read aloud the text on the Student Book pages. The text in the Student Book is there so that teachers and parents can read it when sharing the Student Book with students.

The intent of the Grades 3–5 CK Science in Action lessons is to build students' understanding and knowledge of science concepts, as well as of associated practices and skills, using a teacher Read Aloud, accompanied by example images and diagrams. Cognitive science research has clearly documented the fact that students' listening comprehension far surpasses their reading comprehension well into the late elementary and early middle school grades. Said another way, students are able to understand and grasp far more complex ideas and texts that they hear read aloud than they would ever be able to read or comprehend when they read to themselves. For a more thorough discussion of listening and reading comprehension and the underlying cognitive science research, teachers may want to refer to Appendix A of the Common Core State Standards for English Language Arts, noting in particular the Speaking and Listening section of the appendix.

Online Resources

Use this link to download the CKSci Online Resources for this unit, where the specific link to this appendix can be found:

www.coreknowledge.org/cksci-online-resources

Using the Teacher Guide

The *Science in Action* Teacher Guide is set up with lessons that parallel the chapters of the Reader. Additionally, there are experiences that follow some of the lessons. Experiences are class-length labs that support the science content in the Reader. Within the Teacher Guide is a list of the Nature of Science, SEPs, CCCs, and Literacy standards that students may encounter within the lessons and experiences.

Activity Pages

Activity Pages

Black line reproducible masters for activity pages, as well as an answer key, are included in Teacher Resources on pages 46–54. The icon shown to the left appears throughout the Teacher Guide wherever activity pages (AP) are referenced.

Make sufficient copies for your students in advance of each lesson segment.

AP 1
AP 2
AP A.1
AP A.2
AP A.3
AP 3
AP 4
AP B

Lesson 1—What Would They Say? 46

Lesson 2—We Want You! 47

Experience A—Design a Tablet Stand: Describe the Problem 48

Experience A—Design a Tablet Stand: Develop Solutions 49

Experience A—Design a Tablet Stand: Test and Compare Solutions 50

Lesson 3—Plan a Rube Goldberg Contest 51

Online Resources

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

Materials and Equipment

These lessons suggest a moderate variety of materials to support activities that enhance the Science in Action chapter readings. Prepare in advance by collecting the materials and equipment needed for all the demonstrations and hands-on investigations.

Internet access and the means to project images/videos for whole-class viewing are also required in many lessons but not repeated below.

Lesson 1

- pencils (one per student)
- string

Experience A

- toy car
- butterfly clips
- pieces of corrugated cardboard
- plastic building bricks
- beanbags
- electronic tablet without a built-in stand

Lesson 3

- small set of dominoes

Lesson 4

- chart paper
- marker
- drawing materials

Experience B

- large beverage cups
- ping-pong balls
- rulers with grooves
- dominoes
- craft sticks

Pacing

The Core Knowledge *Science in Action* Reader consists of four chapters, each ten pages long. This accompanying Teacher Guide contains one lesson of instructional support per chapter. Each lesson offers prompts for the teacher to use to facilitate class discussion. Many lessons offer brief hands-on activities, teacher demonstrations, or online enhancements in addition to the reading support. All lessons include an activity page reproducible master.

The Science in Action lessons, requiring 30–45 minutes each, can be implemented in sequence, as a stand-alone unit across six consecutive class sessions. The unit can also serve as the basis of an enrichment program. Or teachers may elect to use the lessons in tandem with other physical, life, and earth/space science content units. To assist with the latter approach, the following table provides a key suggesting the science domain most prominently emphasized in each Science in Action chapter to help pair the chapters meaningfully with other units.

Science in Action Chapter/Experience	**Has content that ties to …**	**Core Knowledge Grade 3 Units**
1. A Little Brother's Problem	Physical science, STEM	• Investigating Forces • Reading About Science
2. Christian Yamada: Becoming an Engineer	Physical science, STEM	• Investigating Forces • Codes and Computers • Reading About Science
Experience A: Be a Problem Solver: Design a Tablet Stand	Physical science, STEM	• Investigating Forces • Codes and Computers • Reading About Science
3. Problem Solved!	Life science, STEM	• Human Senses and Movement • Codes and Computers • Reading About Science
4. Skylar Neilsen: Learning to Be an Engineer	Life science, STEM	• Human Senses and Movement • Codes and Computers • Reading About Science
Experience B: Score a Goal!	Physical science, STEM	• Investigating Forces • Reading About Science

Online Resources

Also, see the Online Resources Guide for recommendations about when to best enhance instruction to support these chapters.

www.coreknowledge.org/cksci-online-resources

LESSON 1

A Little Brother's Problem

At a Glance

Learning Objectives

✓ Describe how people solve design problems.

✓ Explain that everyone can solve design problems.

Instructional Activities

- teacher Read Aloud / Read Along
- class discussion
- vocabulary reinforcement
- hands-on activity (lashing)

NGSS and CCSS References

ETS1.A. Defining and Delimiting Engineering Problems: Possible solutions to a problem are limited by available materials . . . The success of a designed solution is determined by considering the desired features . . .

ETS1.B. Developing Possible Solutions: At whatever stage, communicating with peers about proposed solutions is an important part of the design process . . .

ETS1.B. Developing Possible Solutions: Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

RI.3.1. Key Ideas and Details: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

SL.3.1.D. Comprehension and Collaboration: Explain their own ideas and understanding in light of the discussion.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

The Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

ottoman **problem** **solution**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

constraints **criteria** **design** **frame** **lashing** **palm**

Instructional Resources

Reader

Ch. 1

Reader, Chapter 1
"A Little Brother's Problem"

Activity Page

AP 1

Activity Page
What Would They Say? (AP 1)

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images/video for whole-class viewing
- pencils (one per student)
- string

Advance Preparation

Cut string into 3-meter lengths, one for every pair of students in your class.

THE CORE LESSON

1. Focus attention on the lesson purpose.

Ask students how they felt when they asked to share something with a family member and were not allowed. For example, perhaps they asked to share a couch, a game, or a piece of sports equipment. Invite students to discuss their emotions, such as anger, frustration, or disappointment.

2. Read and discuss: "A Little Brother's Problem."

Reader

Ch. 1

Prepare to read together, or have students read independently, Chapter 1 "A Little Brother's Problem." When reading aloud together as a class, instruct students to follow along. Pause for discussion using prompts and questions such as the following:

Page 2

- Which details in the story are clues that Christian was excited to enjoy the game? (*He brought two favorite snacks. He said he was ready to watch the game.*)
- What does the word ***ottoman*** mean? (*It is a piece of furniture that you can sit on or put your feet up on.*)
- Lead a class discussion, encouraging students to share their own ideas and respond to those of others. Ask: Why do you think Christian's brothers nudged his feet off the ottoman? (*Sample answers: They didn't like to share. There wasn't enough room for three pairs of feet.*)

Page 3

- Christian and his brothers cheered for their home team. In what state does Christian live? (*Hawaii*) Show students an interactive online world map. Begin where your school is and then move the map to show where Hawaii is.
- What **problem** does Christian want to solve? (*how he is going to put his feet up next time he watches a football game with his brothers*)
- How can you express this problem as a *need*? (*Christian needs to find a way to put his feet up during the games that does not involve using the family ottoman.*) (See **Know the Standards**.)

Page 4

- Why is it a good idea to talk over possible **solutions** with another person? (*If one person thinks of a solution, the other person can think about why it might or might not work. Also, two people can think of more possible solutions than one person.*)
- What possible solutions did Christian and Kai discuss? (*buying his own ottoman, complaining to his parents, building his own ottoman*)
- What might Kai have said when Christian said, "Maybe I could build an ottoman"? (*He might have said, "That's a good idea because then you don't have to ask your brothers to share."*)

Page 5

- What characteristic of the living room ottoman was not important for Christian's solution? (*It was not important to him that the ottoman be a round shape.*)
- Focus on the term *criteria*. Ask: What features, or criteria, of a new ottoman were important to Christian? (*It was important to him that his ottoman be the right height and be soft on top.*)
- Focus on the term *constraints*. Ask: What limits, or constraints, did Christian put on finishing his solution? (*It couldn't cost much or any money. It had to be finished the following week.*) (See **Know the Standards**.)

Know the Standards

STSE2. The Influence of Engineering, Technology, and Science on Society and the Natural World Help students understand that the needs of people change, and to meet new needs, they often develop a new or improved object, tool, process, or system.

ETS1.A. Defining and Delimiting Engineering Problems Students in Grade 3 can be exposed, with scaffolding, to the terms *criteria* and *constraints*. Criteria are the features or conditions that must be present for success. Constraints on a successful solution may include what materials can be used as well as financial costs and time limits.

- If you are reading the story aloud, pause before turning the page and ask: What materials might Christian and Kai find outside? (*Students may predict that they will find items in a recycling bin, gardening items, and so on.*)

Page 6

- What difficulty did the boys have when they tested the ottoman made of tape and cardboard? (*The ottoman made of tape and carboard could not hold up the weight of Christian's legs and feet.*)
- Read the text question to students and allow students to brainstorm answers: What do YOU think went wrong? (*Maybe Christian did not use enough tape along all the edges or the pieces of cardboard were too thin.*)

Page 7

- Read the text question to students and allow them to brainstorm answers: What do YOU think they could use to hold the sticks together? (*Sample answers: nails, screws, rubber bands, glue*)
- What did Christian mean when he said the frame would be "sturdy"? (*The sticks seem strong.*)

SUPPORT—The false koa is an invasive species not native to Hawaii. As an invasive species, it takes resources away from native plants. The false koa drops tens of thousands of seeds at a time and can grow rapidly. It is very difficult to control and is kindling for brush fires when dry, posing a fire hazard to everyone.

Page 8

- Lead a discussion about lashing, asking students if they have ever seen string or rope used to connect one object to another.
- Explain to students that a traditional Hawaiian canoe is often carved from a single tree log, but lashing is needed to attach parts called *outrigging* to the hull of the canoe. An *outrigger* is a piece of wood that sits in the water parallel to the canoe and is connected to the canoe by narrow pieces of wood. The function of an outrigger is to make the canoe more stable in the ocean waves so that the canoe does not capsize.

Online Resources

SUPPORT—Show students an online video where traditional outrigging lashing is demonstrated. Point out the canoe and its attached outrigger. Reiterate that there are many traditional ways to lash and that at least five ways are still used by Hawaiian boat makers today.

- Have students work in pairs to try lashing. Give each pair two unsharpened pencils or dowels and a 3-meter length of household string. Have one student hold the pencils to form a plus (+) sign. Have the other student use the string to try lashing them together. Show students how to tie a clove hitch knot around the pencil on the bottom, leaving a tail that can be knotted later (use an online video to guide you). The students can try different ways to wrap the string to attach the top pencil to the bottom pencil. Have them finish off by tying a square knot using the two ends of the string. When the lashing is completed, have the student holding the pencils test how well they stay fixed in their position.
- What problem did Christian's brothers cause? (*They would not let him put his feet up when he watched football games with them.*)

Page 9

- Discuss why it was important that Kai realized the ottoman design should be tried out. Point out that in the engineering design process, one of the three steps is to improve a solution based on the results after testing it. (See **Know the Standards**.)
- Why does Kai think only the top of the ottoman needs to be soft? (*because when you put your legs up on an ottoman, they only touch the top*)
- Direct students to look at the palm leaves in the illustration. Discuss what properties they have that make them suitable for weaving. (*They are flat, smooth, sturdy, and long.*)
- Read the text questions to students: What do YOU think? Will it work? Allow them to offer opinions supported by reasoning. (*Sample answers: No, because Christian probably does not know how to weave palm leaves. Yes, if he weaves enough leaves, they will build up like a cushion and be comfortable.*)

  EXTEND—Traditional Hawaiian weavers use coconut palm leaves to make floor mats, baskets, and other objects. Provide interested students with 1-inch-wide paper strips in two contrasting colors and show them how to weave a tabletop mat. Place several strips of the first color parallel to one another on a table. Hold a strip of the other color perpendicular to the base strips and weave over and then under. Start the second by weaving under first.

- How did each cousin contribute to the solution by communicating? (*Kai helped by noticing that the frame needed cushioning. Christian shared his idea about what material to use to make the cushioning.*)

Page 10

- How did the cousins test their design? (*They carried the ottoman into the living room, and Christian put his feet on it.*)
- What part of their design needed improvement? (*The top of the ottoman was not soft enough.*)
- Read the text question to students: Do YOU think that change will work? Allow them to offer opinions supported by reasoning. (*Answers will vary but should include reasoning based on the materials chosen and the skill of the weaver.*) (See **Know the Standards**.)

Page 11

- Why was Christian's solution a success? (*because he was able to put his feet up comfortably to watch the game alongside his brothers*)

Know the Standards

ETS1.B. Developing Possible Solutions In Grades K–2, students are expected to compare different solutions to a problems, use a test, and decide which works best. In Grades 3–5, testing should become more rigorous, and students should try to revise their design based on the test. In Grades 6–8, they will be expected to test and revise their solutions a number of times to get to the best design they can.

SL.3.1.D. Comprehension and Collaboration Research indicates that young students comprehend new ideas in the content areas through listening earlier or more easily than through reading. This supports the idea that reading aloud to young students is a good idea.

- What design would you have used to solve the problem? (*Sample answers: I would have blown up a beach ball and put my feet on it. I would have strapped some bed pillows to the top of a skateboard.*)
- Once several students have had a chance to respond to the previous question, ask: How could you figure out which of these ideas is the best solution? (*We could test them and compare the results.*)

3. Connect to lived experience.

Activity Page

AP 1

Invite students to share any details from the chapter that resemble someone or something familiar to them. Ask students to tell details about the chapter that interested them most. Invite students to ask questions about details that might not have been clear to them.

Use AP 1 to reinforce students' reflections on the chapter.

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

CHALLENGE—Have students look around your classroom and identify an object, a toy, or a tool that they often have to wait to use. Pair students to define the problem and decide what the requirements and limits should be for solutions to the problem. Then, give them time to generate possible solutions and present their ideas to the rest of the class. Explain to students that solutions can be something people do (a way to fairly share, writing a letter of request, etc.) as well as an object.

LESSON 2

Christian Yamada: Becoming an Engineer

At a Glance

Learning Objectives

✓ Describe some of the experiences people have who are preparing to become engineers.

✓ Write a job ad for an engineer.

Instructional Activities

- teacher Read Aloud / Read Along
- class discussion
- vocabulary reinforcement
- mime activity
- job ad

NGSS and CCSS References

STSE2. The Influence of Engineering, Technology, and Science on Society and the Natural World: Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

ETS1.A. Defining and Delimiting Engineering Problems: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria) . . .

RI.3.7. Integration of Knowledge and Ideas: Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text . . .

L.3.4.D. Vocabulary Acquisition and Use: Use glossaries or beginning dictionaries, both print and digital, to determine or clarify the precise meaning of key words and phrases.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

A Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

civil engineer **computer engineer** **engineer** **inspired**

inventor **materials engineer** **mechanical engineer** **patent**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

calculator **electrical energy**

Instructional Resources

Reader

Ch. 2

Reader, Chapter 2
"Christian Yamada: Becoming an Engineer"

Activity Page

AP 2

Activity Page
We Want You! (AP 2)

Materials and Equipment

Collect or prepare the following items:

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

Advance Preparation

none

The Core Lesson

1. Focus attention on the lesson purpose.

Tell students that when nine-year-old Christian, who they read about in Chapter 1, grew up, he wanted to become an engineer. Explain that people who want to be engineers go to college after high school. Have students share what they know about what it is like to go to college.

2. Read and discuss: "Christian Yamada: Becoming an Engineer."

Reader

Ch. 2

Prepare to read together, or have students read independently, Chapter 2 "Christian Yamada: Becoming an Engineer." When reading aloud together as a class, instruct students to follow along. Pause for discussion using prompts and questions such as the following:

Page 12

- Prompt students to summarize the story they read in Chapter 1 about Christian, his brothers, and Kai, and have them point out the specific pages in Chapter 1 that are the basis for their answers. (*Sample answer: Christian wanted to put his feet up on the family ottoman, but his brothers would not let him. So, together with his cousin Kai, he solved the problem by building his own ottoman out of materials he found for free.*)
- How do you think Christian felt by the end of the story? (*Sample answers: pleased, happy, confident, smart*)

Page 13

- Analyze the term **engineer**, highlighted in the glossary box, with students. Point out the root word *engine*, and explain that engines are machines that use all kinds of energy sources to produce forces and motion. Call attention to the suffix *-eer,* and explain that it refers to a person who does something. Explain that one meaning of *engineer* is a person who works with engines but that another meaning is a person who solves problems and designs things, including engines.
- Where did Andrew learn to be an electrical engineer? (*at a college*)
- What do you think Christian tells middle school kids to get them interesting in engineering? (*Sample answers: that it is fun to solve problems, that engineers use math and science, that they can go away to college to become an engineer*)

Page 14

- Explain to students that if they are interested in machines, forces, and motion, they might want to become a mechanical engineer like Christian. Have students think about designing a toy car that runs on wind power. Ask: What questions would you ask yourself when designing a sail that can move your toy car forward? (*Sample answers: How big does the sail need to be? What materials should it be made of? How will I attach it to my toy car?*)
- Invite students to ask questions about what it is like to be a student at an engineering college.

Online Resources

SUPPORT—Many students will not have close family members who can share the college experience with them. Show an online video that depicts the engineering college experience.

- Point out that even students who commute from home to engineering school have to spend long hours on campus and eat meals there. Allow students to share the kinds of foods they'd like to eat on campus.

Page 15

- What can you learn from the photos about life at an engineering college? (*that students do homework together, that they play sports, and that they might play musical instruments together*)
- Point out that **civil engineers**, **materials engineers**, **mechanical engineers**, and **computer engineers** all studied engineering as a general application and then specialized in a specific branch of engineering. These different branches also contribute to each other. For example, a computer engineer might develop software to help manage traffic in a new road system a civil engineer designs, or a materials engineer might develop a special type of rubber a mechanical engineer needs for a new type of tire they are developing.

- What does the author want you to think about life at an engineering college? (*Sample answer: that it is fun, but it is hard work*) What do you think? (*Sample answers: I'd like to try it. I'd miss my family. It sounds like hard work.*)

Page 16

- Tell students that the photo shows a close-up image of a computer chip. Explain that below the surface of the small black object at the center of the photo are billions of electrical connectors that turn the flow of electrical energy on and off.
- Point out that computer chips are not only found in computers. They are also used in refrigerators, microwave ovens, TV remotes, and video game consoles.

Page 17

- Why do you think the rooms where computer chips are made have to be so clean? (*because the dust or other particles can mess up the flow of electrical energy*)

  SUPPORT—Explain that the connectors on computer chips are so thin that if a piece of dust were to fall on them, it might be like a football stadium falling on a pencil.

- Have students stand up and mime the process people use to get ready to enter a clean room: empty their pockets, wash their face, drink water to wash out their mouths, put on a head covering, wipe their shoes and cover them with paper booties, put on a clean suit, tuck the pant legs into booties, put on a helmet, put on safety glasses, snap a face shield to the helmet, put on disposable gloves, look at themselves in the mirror to check.

  CHALLENGE—Just for fun, challenge students, without your cues, to mime the steps in reverse order for when they leave the clean room.

Page 18

- Have students point out the steps on the design process graphic and connect the steps to the story in the text about the robot. Ask: Where in the steps are you when you ask yourself, "What do you want the robot to do? What materials do you have on hand? How much time do you have to finish your robot?" (*on "Define a Problem"*)
- Where in the steps are you when you think about different ways to make a model robot and try one out? (*on "Develop Solutions"*)
- Where in the steps are you when you test your model and find out it doesn't work as you'd hoped? (*on "Test and Improve"*)
- Where in the steps are you when you decide after testing to look at other model robots and use their best ideas to make a new model? (*on "Develop Solutions"*)

Page 19

- Explain to students that some reusable hand warmers contain a substance called *calcium chloride*, a type of salt. When this substance is combined with water, heat is given off. If the wet mixture is placed in the sun, the water will evaporate, and dry salt will be left behind. This salt can be combined with water again, making it a reusable solution for producing heat.
- Have students think about having a greenhouse at your school. Ask: What fresh fruits and vegetables would you like to grow in a greenhouse to eat at lunchtime? (*Possible answers: corn on the cob, strawberries, peaches, apples*)
- Point out the solar cells in the photo and make sure students understand that when sunlight strikes them, they generate electrical energy to power the greenhouse lights and heaters. Ask: How does the amount of space the solar

cells take up compare to the space the greenhouse takes up? (*They seem to need about the same amount of space.*) Ask: Why doesn't the farmer save space by putting the solar cells on the roof of the greenhouse? (*because the greenhouse roof needs to allow sunlight in for the plants to grow*)

Page 20

- Have students examine each photo and identify details that it adds to the text. (*Sample responses: Roadways can be designed to be above the ground on tall posts; plastics can be made into all different shapes and colors for different uses; some machines are so big that the engineer has to climb inside to work on them; computer parts can be tested and fixed if they don't work as expected.*)
- What other kinds of machines might a mechanical engineer design? (*Sample answers: trucks, dune buggies, fire engines, trains, tractors, ice cream makers, skateboards, scooters*)

Page 21

- Point out the glossary box on this page. Ask students to share at what point in reading the page they use this feature. (*before I read, after I read, when I get to the featured word in the text*)
- Explain that a request for a **patent** statement must be sent to a U.S. government office in charge of patents. **Inventors**' requests include a drawing or photo showing the design. Have students discuss their answers to the text question: What did the inventor design that was new and different? (*It looks like a car, but instead of two back wheels, it has a caterpillar design like on a bulldozer.*)

Page 22

- Remind students that the glossary boxes help them identify important words to know when reading. Ask: What did Steve Wozniak inspire Christian to try? (*to become an engineer, to work with computers, to be an inventor*)
- Is there anything in the photo of Wozniak's computer that looks like something you saw earlier in this chapter? (*Yes, the circuit board looks similar to the one on page 16.*)
- What does Steve Wozniak think about trying to become an inventor? (*that you will love it, and it will be worth the time you put into it*)

  EXTEND—Point out that the year Wozniak completed his first computer was 1976. That year he and a friend named Steve Jobs started a company, called Apple Computer, to sell those computers. Ask a librarian to give your students books about "the two Steves" to read and learn more about their accomplishments, such as *Steve Jobs and Steve Wozniak: Geek Heroes Who Put the Personal in Computers* (2010) by Mike Venezia.

Page 23

- Point out to students that when Edith Clarke was alive, many homes and farms in the United State did not have electricity. Ask: What did Edith Clarke invent, and how was it helpful to people? (*She invented a calculator that helped set up electric power lines faster.*)
- What about Edith Clarke might also have **inspired** Christian Yamada? (*She was an engineer, and Christian also wanted to become an engineer.*)
- What do the Words of Wisdom spoken by Edith Clarke mean? (*Sample answer: She meant that if you can design or invent interesting things, you will always be able to get a job.*)

3. Connect to lived experience.

Activity Page

AP 2

Invite students to share any details from the chapter that resemble someone or something familiar to them. Ask students to tell details about the chapter that interested them most. Invite students to ask questions about details that might not have been clear to them.

Use AP 2 to reinforce students' reflections on the chapter.

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

EXPERIENCE A

Be a Problem Solver: Design a Tablet Stand

At a Glance

Learning Objectives

✓ Describe an engineering design problem by identifying a need and identifying the limits on solutions.

✓ Use an understanding of forces and materials to propose a solution.

✓ Test a solution and identify how well it addresses the problem.

✓ Use the results of fair tests to compare different solutions to the problem.

Instructional Activities

- hands-on activities
- discussion
- oral presentation

NGSS and CCSS References

ETS1.A. Defining and Delimiting Engineering Problems: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B. Defining and Delimiting Engineering Problems: Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

ETS1.C. Optimizing the Design Solution: Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

PS2.A. Forces and Motion: . . . 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. . . .

SL.3.4. Presentation of Knowledge and Ideas: Report on a topic . . . or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

The Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

engineer **problem** **solution**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

constraints **criteria** **design**

Instructional Resources

Activity Pages

AP A.1
AP A.2
AP A.3

Activity Pages

Design a Tablet Stand: Describe the Problem (AP A.1)

Design a Tablet Stand: Develop Solutions (AP A.2)

Design a Tablet Stand: Test and Compare Solutions (AP A.3)

Materials and Equipment

Collect or prepare the following items:

- toy car
- butterfly clips
- pieces of corrugated cardboard
- plastic building bricks
- beanbags
- electronic tablet without a built-in stand

Advance Preparation

- Cut corrugated cardboard into varied shapes (from narrow to wide strips), with pieces about the same length as the tablet.
- To determine quantities, decide if you will allow each team to choose materials or if you will assign different sets of materials to each team.

THE CORE LESSON

1. Focus attention and preview the investigation.

In a discussion, have students summarize the story from Chapter 1, in which Christian solves a **problem** by designing his own ottoman. Then have students turn to page 18 in their reader and review the graphic showing the engineering design process. Explain that they will use parts of this process now to solve another problem.

2. Facilitate the investigation.

- Show students an electronic tablet without a built-in stand. Tell students that when you loan the tablet to students to share, they need a way to stand it up on a table so that at least three people can see the screen without holding it.
- Define the problem by explaining the main criterion—any stand design has to be strong enough to hold up the tablet at a good angle for viewing.
- Tell students that there are also two constraints on their **solutions**—they may only use the materials set out in your classroom, and they have only 20 minutes to make their design.
- Push a toy car forward along a tabletop and review concepts about the effects of contact forces on the motion of objects. Ask: What force is causing this car's motion and in what direction? (*The hand holding the car pushes it in a forward direction.*) (See **Know the Science**.)
- Let the toy car come to a rest. Ask: What forces are acting on this car when it is not moving? (*Gravity is pulling the car down, and the table is pushing the car up.*)

Activity Page

AP A.1

- Point out to students that when forces on an object are balanced, the object will not be in motion. Tell students to keep this idea in mind as they solve the problem.
- Distribute AP A.1 and have students answer the questions.
- Divide the class into teams of three student **engineers**.

Activity Page

AP A.2

- Depending on how you want to handle the materials, either decide as a class which team will use which materials or allow each team to take whatever materials they need. Then allow teams to take turns visiting the materials table to pick up what they need. Remind students to bring back anything that they are not using so that other teams can access those materials.
- Distribute AP A.2 and have students answer the questions.
- Give students 15–20 minutes to design their tablet stands. Encourage them to think creatively and use the materials in novel ways.
- When teams have finished building their prototypes, have them test them. To ensure fair tests across all teams, have each team of three students sit on chairs facing the table holding their tablet stand. Then, *you* should place the same tablet on each stand.

Know the Standards

Motion and Stability: Forces and Interactions In the Grade 3 Performance Expectation 3-PS2-4, students are expected to define a simple design problem, including identifying criteria and constraints, that can be solved using magnets. They use the understanding that magnetic forces act at a distance, and the size of the force varies with distance and the orientation of the magnets. Students can apply that experience here, in Experience A, as they solve a problem involving contact forces.

- Ask after each test: What do you observe? How steady or unsteady is the tablet in the stand? Does your stand hold the tablet in a position that is good for three students sharing the tablet at a table? (*Answers will vary depending on the design.*)

Activity Page

AP A.3

- Distribute AP A.3 and have students answer the first three questions. Tell students to save the last question for after the oral presentation.
- Allow enough time for teams to prepare one-minute presentations of their solutions. Each presentation should explain what materials were used, how the solution successfully holds up the stand, and what the team learned when they tested their design. Encourage teams to have all members speak during the presentation.
- Just before the presentations, give students some coaching about effective speaking. Encourage them to speak loudly and clearly and share details and reasoning.

  SUPPORT—English Language Learners may benefit from additional scaffolding when preparing their presentations. Allow time for them to practice speaking about an aspect that they know well, and allow them to refer to an outline or mind map that they have made when they speak.

Activity Page

AP A.3

- After each presentation, permit additional time for the other teams to ask questions.
- Have students write and draw their answers to the last question on AP A.3.

3. Summarize and discuss.

- Review the process of fair testing in science and engineering design investigations. Explain that each time a test, called a *trial*, is performed, only one factor may change. Discuss how students know that they used a fair test.
- What one factor was changed in each trial? (*The only thing we changed was the stand.*)
- What other factors did we keep the same for each trial? (*Our teacher placed the tablet on the stand the same way and used the same tablet for all the trials.*)

4. Check for understanding.

- Have students refer to their activity pages to summarize what they have learned about the engineering design process.
- Collect AP A.1–A.3 and review their written answers to determine their understanding of the following concepts:
  - An engineering design problem expresses a need of people.
  - Forces act on objects in motion and at rest.
  - One step in designing a solution is to choose materials.
  - Solutions should be tested to see how well they solve the problem.
  - Solutions can be compared to observe how well each solves the problem.

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

LESSON 3

Problem Solved!

At a Glance

Learning Objectives

- ✓ Define an engineering problem by its desired features (criteria) and limits on any solutions (constraints).
- ✓ Interpret text to identify key ideas and describe the feelings of the characters.

Instructional Activities

- teacher Read Aloud / Read Along
- class discussion
- vocabulary reinforcement
- writing

NGSS and CCSS References

ETS1.A. Defining and Delimiting Engineering Problems: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria) . . .

PS2.B. Types of Interactions: Objects in contact exert forces on each other.

RI.3.1. Key Ideas and Details: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RL.3.1. Key Ideas and Details: Describe characters in a story (e.g., their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

The Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

engineering **force** **gravity**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

accountant **chain reaction** **design** **machine**

Instructional Resources

Reader

Ch. 3

Reader, Chapter 3
"Problem Solved!"

Activity Page

AP 3

Activity Page
Plan a Rube Goldberg Contest (AP 3)

Materials and Equipment

Collect or prepare the following items:

- small set of dominoes
- internet access and the means to project images/video for whole-class viewing

Advance Preparation

Practice setting up your demonstration of a domino chain reaction.

The Core Lesson

1. Focus attention on the lesson purpose.

Online Resources

Show students how to set up a series of dominoes such that when the first one is pushed over, it starts a chain reaction. Allow students to share their personal experiences setting up chain reactions. If dominoes are not available, show a video of a chain reaction using everyday materials.

2. Read and discuss: "Problem Solved!"

Reader

Ch. 3

Prepare to read together, or have students read independently, Chapter 3 "Problem Solved!" When reading aloud together as a class, instruct students to follow along. Pause for discussion using prompts and questions such as the following:

Page 24

- What characters are introduced on page 24? (*Skylar and her mother*)
- Why does Skylar think accounting would be a good career for herself? (*She is good at math, and accountants need to use a lot of math.*)
- What do you notice about how the dialogue is presented in this chapter? (*It looks something like a comic book, with the characters' speech in word balloons.*)

Page 25

- Have students find all the places on this page where the words *engineer* or ***engineering*** are located. What does each word mean? How are these words related? (Engineer *is the name of a job some people do*. Engineering *is all the activities engineers do at their work*.)

  SUPPORT—Have students return to Chapter 2 in their reader and find the glossary box for *engineer.* If students keep new or unfamiliar words in their own dictionary, have them add these two terms, each with a definition in their own words.

- Explain to students that high school students are allowed to choose some of the classes they take. Ask: How do you think Skylar feels about being able to choose what she learns? (*Sample answer: She probably feels happy because she can choose subjects that she is interested in*.)
- Survey your class to find out how many would be willing to try out an engineering class in high school. Invite them to share their reasoning.

Page 26

- Point out to students that the illustrations in this chapter were inspired by the work of the cartoonist Rube Goldberg. Explain that while Rube Goldberg did study to become an engineer, he really wanted to draw comics.

  Online Resources

  EXTEND—Show students online videos that explore the life and work of Rube Goldberg. Discuss how he used his understanding of machines and engineering to entertain people.

- What words on this page tell you how Skylar was feeling*?* (*"excited" and "surprised"*)
- How can you tell that Skylar was also feeling curious? (*She raised her hand and asked two questions.*)

Page 27

- Draw a mind map to consolidate what your students understand about **forces** and interactions. They can begin by identifying the concepts the students in Skylar's class spoke about. Point out that objects that touch exert forces on one another but that some forces act on objects without touching them. Ask: What kinds of forces act at a distance? (*magnetic forces, **gravity***)
- Ask: Why does Skylar's teacher want the students to discuss forces before making their Rube Goldberg machines? (*because the parts of these machines move when one part pushes or pulls another part*)

Page 28

- Make a T-chart that includes the word *criteria* at the top of one column and the word *constraints* at the top of the other column, and define these words for students. Have students interpret what the teacher said and record the details on the chart. A completed chart should look similar to the one below. (See **Know the Standards**.)

Know the Standards

ETS1.A. Defining and Delimiting Engineering Problems While students in Grades 3–5 should understand that engineering problems are defined by identifying the required features of the solution (criteria) and any limits on time, cost, or materials (constraints), its not essential until middle school that they use the words *criteria* and *constraints*.

Desired Features (Criteria)	Limits (Constraints)
A marble has to be pushed into a cup using forces and moving objects.	*The problem must be solved in one week.* *The students can only use the materials in the classroom or around the school.* *They must use a marble.* *They cannot buy anything.*

- What questions do you have about the problem the teacher asked the students to solve? (*Possible questions: Can they work in teams? Where can they build the machines? How big can their machines be?*)
- Why did Rube Goldberg tell the students that he never really built the machines he drew? (*Possible answer: Maybe he wanted them to know that some of his machines might not have worked.*)
- If you were in the class, how would you use the marble in your machine? (*Sample answer: I would drop it at the top of a ramp and let it roll down to hit the first domino.*)

Page 29

- How do you know that Skylar is very excited about solving the problem? (*She got started as soon as her teacher stopped talking.*)
- Why was it a good idea to begin with the marble? (*because her teacher said all solutions must include a marble*)

Page 30

- How do you think the words spoken by Rube Goldberg made Skylar feel? (*Sample answers: encouraged, excited, confident, ready to keep trying*)
- What pairs of objects in contact would produce forces in Skylar's solution? (*pairs of dominoes, pulleys and cars, a domino and a pulley, the toy car and the marble*)

Page 31

- Have students return to page 18 in their Reader to look at the design process graphic. Ask: Where in the process is Skylar when she says, "Then I'll test it again." (*She is in the "Test and Improve" part.*)
- How is Skylar planning to improve her design? (*by raising the height of the ramp*)
- How do you think Skylar is feeling at this point in the story? (*She is probably feeling a little disappointed that her design didn't work right, but she is also feeling determined to make changes so that it will work better.*)

Page 32

- What caused the force that moves the marble into the cup? (*the motion of the toy car hitting the marble and pushing it into the cup*)
- How did Rube Goldberg feel about Skylar's design solution? (*Sample answer: He seemed excited and proud of Skylar.*)

Page 33

- Have students think about what they read in Chapter 2. Ask: What could you tell Skylar about life at an engineering college? (*It is fun because you get to live, eat, study, and play with other students, but it is also hard work trying to solve problems to help people.*)

  SUPPORT—Allow students time to look back at Chapter 2 as needed. Pair ELL students with more fluent readers, and have them turn and talk to tell what they learned about engineering college life from the chapter.

- How do you think Skylar felt about herself at the end of the story? (*Sample answers: proud, satisfied, excited*)
- Ask: What questions do you have after reading this chapter? about the story? about the Rube Goldberg content? about Rube Goldberg himself? Briefly discuss students' responses, and make it clear that some questions might be answered by rereading the chapter or doing research, but others may not be answerable.

3. Connect to lived experience.

Activity Page

AP 3

Invite students to share any details from the chapter that resemble someone or something familiar to them. Ask students to tell details about the chapter that interested them most. Invite students to ask questions about details that might not have been clear to them.

Use AP 3 to determine how well students understand the problem-solving challenge described in the chapter.

Conclude by sharing and discussing the following quotation from Rube Goldberg: "The invention process is like a puzzle. Keep rearranging the pieces until a solution emerges." Invite students to reflect on how they feel when assembling a tabletop puzzle and when they have finished the puzzle. Suggest that if they find puzzles enjoyable and satisfying, they might want to consider becoming engineers, as Skylar did.

See the Activity Pages Answer Key for sample student responses.

LESSON 4

Skylar Neilsen: Learning to Be an Engineer

At a Glance

Learning Objectives

✓ Describe experiences Skylar Neilsen had that contributed to her interest in engineering.

✓ Use a diagram showing the engineering process to interpret text.

Instructional Activities

- teacher Read Aloud / Read Along
- class discussion
- vocabulary reinforcement
- hands-on activity using sign language

NGSS and CCSS References

ETS1.A. Defining and Delimiting Engineering Problems: . . . The success of a designed solution is determined by considering the desired features of a solution (criteria) . . .

ETS1.B: Developing Possible Solutions: At whatever stage, communicating with peers about proposed solutions is an important part of the design process . . .

STSE2. The Influence of Engineering, Technology, and Science on Society and the Natural World: Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

RI.3.1. Key Ideas and Details: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

The Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

engineer **engineering** **solution**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

biomedical engineer **robotic**

Instructional Resources

Reader
Ch. 4

Reader, Chapter 4
"Skylar Neilsen: Learning to Be an Engineer"

Activity Page
AP 4

Activity Page
Main Idea and Details (AP 4)

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images/video for whole-class viewing
- chart paper
- marker
- drawing materials

Advance Preparation

Preview the recommended online resources and evaluate them for suitability for your students.

The Core Lesson

1. Focus attention on the lesson purpose.

Online Resources

Have students watch an online video called "I Want to Be an **Engineer**." At the conclusion, ask: What surprised you as you listened to this video? (*Sample answer: that there are so many kinds of engineers*)

2. Read and discuss: "Skylar Neilsen: Learning to Be an Engineer."

Reader
Ch. 4

Prepare to read together, or have students read independently, Chapter 4 "Skylar Neilsen: Learning to Be an Engineer." When reading aloud together as a class, instruct students to follow along. Pause for discussion using prompts and questions such as the following:

Page 34

- Where on the page does the author explain who Rube Goldberg was? (*in the first paragraph*)

  SUPPORT—If your students want to know more about Rube Goldberg, ask a librarian to obtain a picture book biography for them to read, such as *Just Like Rube Goldberg*, written by Sarah Aronson and illustrated by Robert Neubecker.

- What clues in the text support the idea that Skylar's brothers are older than she is? (*She watched her brothers play video games, probably because she was too young to play herself. It is more likely she was interested in what older brothers were doing than younger brothers.*)

Page 35

Online Resources

- Point out that Skylar's teacher was not wrong about how fingers move, but the explanation just did not include the details Skylar was hoping for.
- Have students use the illustration to learn to sign their own names. Point out the black lines that show movement of the fingers, and make sure students understand that these motions are part of the sign. Demonstrate a few of these for students.
- Invite students to suggest answers to the text question: How do you think your brain controls your fingers? (*Possible answer: Maybe there is a connection, like a wire between the brain and the finger.*)

  CHALLENGE—If your students want more information to answer this question, explain that fingers have bones that connect at joints and that muscles pull on the bones so that the bones can move at the joints. Muscles get signals from the brain to move though nerves that connect to the brain.

Page 36

Online Resources

- Ask students to read the name of the poster that Skylar and her classmate made. Point out that the circulatory system is a group of body parts that work together to circulate (move) blood throughout the body.
- Have students ask questions about 3D printing. Then show them a video of a 3D printer at work. Discuss which of their questions were answered.

Page 37

- Have students find the word *biomedical*. Point out the word parts *bio*-and *medical.* Explain that *bio*- refers to life or living things and that *medical* refers to taking care of people who are sick or injured, so a *biomedical engineer* has learned about living things, including humans, and finds ways to help them get better.
- Ask: What experiences in high school drove Skylar toward **engineering**? (*She had fun with the Rube Goldberg contest, she liked science and math, and she was interested in 3D printing and what made the human body move.*)
- Invite students to ask questions about what they read on this page. (*Sample questions: Can kids really use 3D printers? How long does it take to print a body part?*)

Page 38

- Have students turn back to page 18 in their Reader to revisit the engineering process diagram. Remind them that the three steps can occur in any order and that engineers often repeat them.
- Explain that the text question "How did it work when Skylar made her Rube Goldberg machine?" is answered on the rest of the page.
- Ask: Which paragraph discusses how the problem was defined? (*the first paragraph*) Which discusses how **solutions** were developed? (*the second*) Where is improving solutions discussed? (*in the third paragraph*)

Page 39

- Have students answer and discuss the text questions: What do you think the problem was? What was the car supposed to do? What materials were allowed? (*The problem was how to make a car out of pasta; the car should roll along on its wheels; only pasta and glue.*)
- Provide drawing materials so that students can draw a labeled diagram for a pasta car they might build that could roll down a ramp.

  EXTEND—Pair students and have each pair discuss and identify the kinds of pasta they would need. Provide those and other materials such as glue so that they can construct their possible solutions, test their solutions, and make changes as needed. Allow students to measure how far each car moves from the bottom of the ramp and compare data for the class.

Page 40

- Ask: What do you think Skylar is teaching the robotic arm to do? (*Students may infer from the image that she is teaching it to pick up and stack wooden blocks.*)
- Have students answer and discuss the text questions: What would you teach a robotic arm to do? How would it help people? (*Sample answer: I'd teach it to make a peanut butter and jelly sandwich for me. It would make it easier for people to live independently.*) (See **Know the Standards**.)
- Remind students that they read about Christian Yamada in Chapters 1 and 2. Invite students to ask questions sparked by the text or photo. (*Sample questions: Does the robotic arm have to stay attached to the table? Can it be put in a kitchen so that it can cook dinner?*)

Page 41

- Ask: What was the engineering design problem Skylar's team worked on? (*how to speed up the construction of military vehicles*)
- Explain that military vehicles include land and amphibious machines for moving people and equipment. Examples include battle tanks, trucks, and armored ambulances.
- Discuss why communicating with teammates can result in a successful solution. (*People can compare their ideas for solutions. They can talk about who would work together well and develop the best solution.*)

Know the Standards

ETS1.A. Defining and Delimiting Engineering Problems These engaging questions invite students to identify the desired features, or criteria, of an engineering problem in their own words.

Page 42

- Using chart paper and a marker, draw a main idea and details graphic organizer that includes the term "biomedical engineers" in a bubble at the center, and have students identify three details in the text to add as bubbles connected to the main idea.

Page 43

- Have students identify the main idea and supporting details about biomedical engineers in the text on this page.

  SUPPORT—If students struggle to respond, show them how to analyze the page layout to answer. Often the main idea is stated at the top of the page and details are examples arranged below it.

- Invite students to ask questions about what they read on this page. (*Sample questions: How do they place those devices inside a human body? Does the engineer do it?*)

Page 44

- Point out the glossary box, and invite students to use the word *inspired* in a sentence. Ask: What person has inspired you to try something? (*Sample answers: Tony Hawk inspired me to try skateboarding. Simone Biles inspired me to try tumbling.*)
- What did Dr. Franklin mean when she said, ". . . by doing our best we shall come nearer to success . . ."? (*Sample answer: Maybe she meant that you cannot always solve a problem on the first try, but if you keep trying, you may solve it.*)
- Explain to students that DNA is inside every living thing and determines many traits. But it is such a small particle of matter that no one was able to see its shape until Rosalind Franklin used a microscope to photograph it. (See **Know the Science**.)

Page 45

- Point out that, when Pauling was a boy, toy chemistry sets came with powders and liquids that could be mixed in glass holders, called *test tubes*. Often, when the powders or liquids were mixed, a new form of matter would formed, sometimes changing color or producing heat.
- What did Dr. Pauling mean when he said, "Science is the search for truth . . ."? (*Sample answer: Science helps people discover things about the world. These are true things.*)

Know the Science

3-LS3-1. Heredity: Inheritance and Variation of Traits Grade 3 students should understand that many traits of plants and animals are inherited from their parents and provide evidence by describing patterns of similarities among offspring and their parents. However, it will not be until middle school that they learn how traits are connected to the structure of genes, and in high school they will explore how genes are segments of DNA molecules.

3. Connect to lived experience.

Activity Page

AP 4

Invite students to share any details from the chapter that resemble someone or something familiar to them. Ask students to tell details about the chapter that interested them most. Invite students to ask questions about details that might not have been clear to them.

Use AP 4 to reinforce students' reflections on the chapter.

See the Activity Pages Answer Key for sample student responses.

EXPERIENCE B

Score a Goal!

At a Glance

Learning Objectives

- ✓ Design and test a Rube Goldberg machine that has three links.
- ✓ Explain how thinking about patterns in motion helped them design solutions.

Instructional Activities

- hands-on engineering design task
- class discussion
- drawing and labeling a diagram

NGSS and CCSS References

ETS1.B. Developing Possible Solutions: Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

ETS1.C. Optimizing the Design Solution: Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

PS2.A. Forces and 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. . . .

SL.3.1.D. Comprehension and Collaboration: Explain their own ideas and understanding in light of the discussion.

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

www.coreknowledge.org/cksci-online-resources

Core Vocabulary and Language of Instruction

The Glossary at the end of this Teacher Guide lists definitions for Core Vocabulary and selected Language of Instruction.

Core Vocabulary terms are those that students should learn to use accurately in discussion. During instruction, expose students repeatedly to these terms but not through isolated drill or memorization.

force **motion** **pattern**

Language of Instruction consists of additional terms that you should use when talking about concepts in the lesson. Students benefit from your modeling the use of these words without the expectation that students themselves will use or explain the words.

chain reaction **design**

Instructional Resource

Activity Page

AP B

Activity Page
How Did You Score a Goal?
(AP B)

Materials and Equipment

Collect or prepare the following items:

- large beverage cups
- ping-pong balls
- rulers with grooves
- dominoes
- craft sticks

Advance Preparation

Cut each cup in half from one side of the rim to the other. Place the cut side of each half on a table to create a tunnel-like opening. Test rolling a ball into the cup half to make sure it fits and stays put.

The Core Lesson

1. Focus attention and preview the investigation.

Online Resources

Show students a video of a giant Rube Goldberg machine assembled by adults from ideas sent from many kids. Ask: What simple task did this Rube Goldberg machine do? (*It threw paint balls at the two people sitting on the couch.*)

2. Facilitate the investigation.

Point out to students that they have read about making Rube Goldberg machines, they have watched videos about them, they learned how to make a chain reaction from dominoes, and they defined their own challenges. Now it is time for them to make their own Rube Goldberg machines.

Online Resources

- Remind students that in Reader Chapter 4, Skylar's teacher asked the students to identify the science ideas that would help them solve the problem of making a Rube Goldberg machine.

- Ask: How does a chain reaction, like the one we saw with dominoes, make a **pattern**? (*There is a pattern of forces and motions in a chain reaction because it repeats the same way each time.*) (See **Know the Standards**.)
- How can thinking about patterns help you design your own machine? (*When we set up a chain reaction, we can expect the ways the objects move to happen the same way each time we test them.*)
- Group students into small teams, and provide each team with a cut half of a beverage cup, balls, rulers, dominoes, and craft sticks. Demonstrate how to place the cup on a table, and explain that it takes only a small **force** to roll the ball into the cup. Tell students that this is how students "score a goal."
- Challenge each team to design a Rube Goldberg machine that has at least three "links" in the chain reaction. The third link will produce a force that pushes the ball enough to roll it into the cup and score a goal.
- Hold up each materials available to students (cup, ball, ruler, craft sticks, and dominoes), and discuss ways they might be used in setting up the Rube Goldberg machine. (*Sample answer: the cup is the goal; the ball is like a soccer ball; the ruler can be used as a ramp or track; the dominoes can be used to hold up the ruler, to make a seesaw, or to knock each other over; the craft sticks can be used to hold back the ball on a ramp*)
- Give the teams some time to design solutions that will score a goal. Have teams call you over when they are ready to demonstrate their solutions to the design problem.

  SUPPORT—If some teams are struggling to get started, show them a video in which students used similar materials to make Rube Goldberg machines. Then, suggest that they begin by designing and testing the last part of the machine—the one that moves the ball into the cup.

- Circulate among the teams as they work, and ask probing questions to elicit their ideas about testing possible designs. Ask: Do you test each link in the chain reaction on its own? Or do you only test the machine as a whole? What is your reasoning? (*Sample answer: We test one link at a time to make sure it works before connecting it to another. That saves us time.*)

Know the Standards

Crosscutting Concept: Patterns Your students may be familiar with visual patterns, such as those made by arrays of geometric shapes, and counting patterns, such as skip counting by fives. Build on this understanding by encouraging them to use the idea of patterns related to time to predict what will happen next in the chain reactions they design.

3. Summarize and discuss.

Discuss the machines teams built. Allow the teams to take turns presenting their machines. Guide them to point out the three links in the chain reaction.

CHALLENGE—Students may wish to go further and add more links to their Rube Goldberg machines. Provide additional materials so that they can add more of the same kind of parts (say, more ramps) or different parts that put objects in motion in a new way.

- Ask: What pushes and pulls (forces) made your machine work? (*Sample answers: I pushed the first domino, and the rest of the dominoes pushed one another. Gravity pulled the ball down the ruler/ramp.*) (See **Know the Science**.)
- Ask: What patterns did you observe in the **motion** of the ball? (*Sample answer: When we released it at the top of the ramp, it always rolled into the cup.*)
- Ask: What did you learn when you tested a solution? (*Sample answer: what parts did not work as I thought they would*)
- Ask: What improvements did you make to your design? Why? (*Sample answer: We changed the height of the ramps the balls moved along. This change allowed the ball to roll far enough to score a goal.*)

4. Check for understanding.

Activity Page

AP B

- Distribute AP B to students and have them follow the directions to draw the Rube Goldberg machines that they built and shared with the class.

See the Activity Pages Answer Key for a sample student responses. Review the diagrams for accuracy and understanding that their design produced a chain reaction of motions resulting in scoring a goal.

Know the Science

PS2.A. Forces and Motion In Grade 3, students should understand that forces (pushes and pulls) have strength and direction and can stop or start motion. Though Grade 3 discussions focus on noncontact forces caused by electric and magnetic forces, students should be aware that Earth exerts a pulling force on objects without touching them. This is what causes the ball to move down a ramp.

GRADE 3

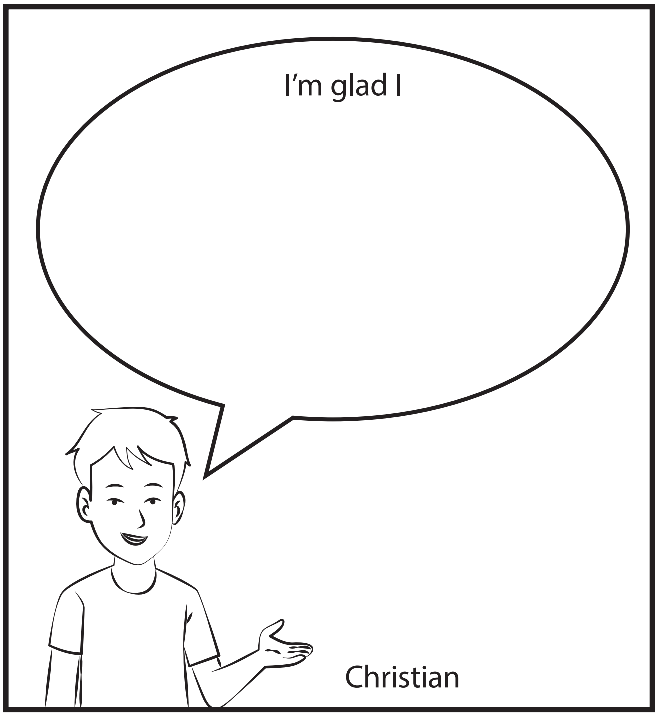
Teacher Resources

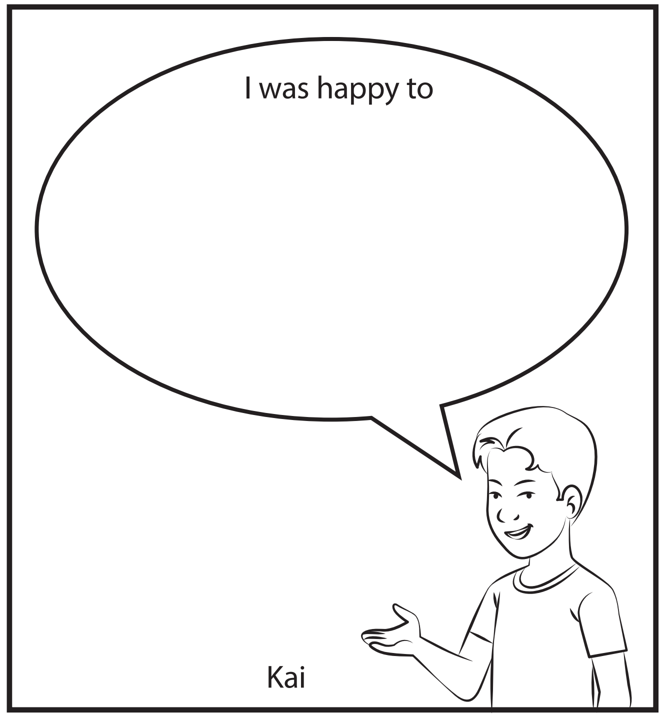
Activity Pages

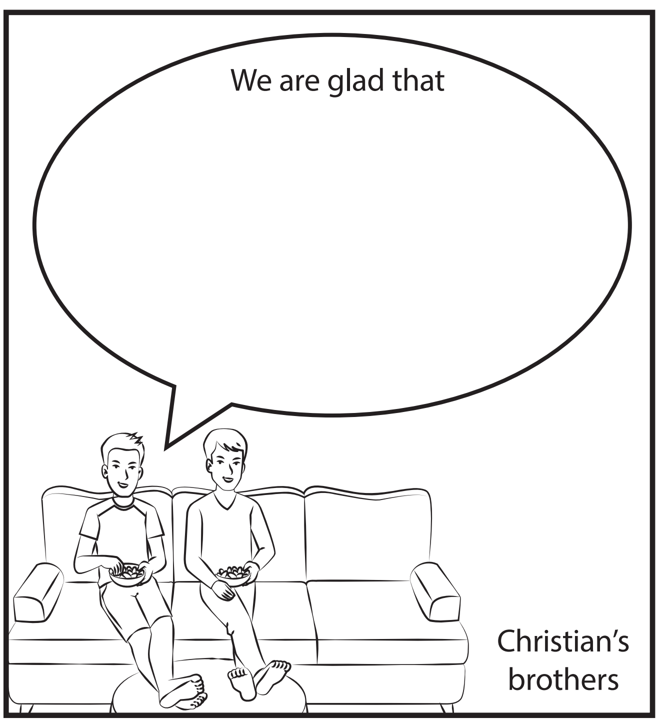
Name ______________________ Date ______________

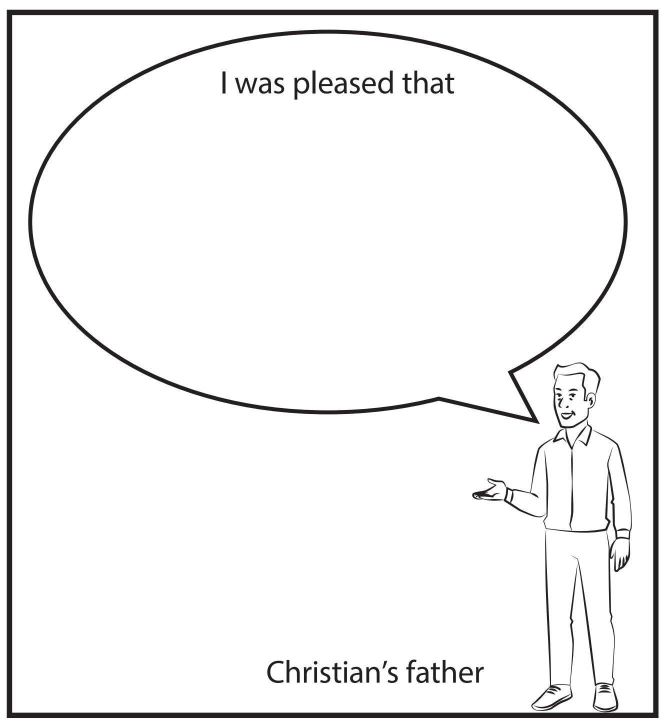
What Would They Say?

In each word balloon, write to complete the sentences. Tell what each person would say about the design problem and solution.









Name ______________________ Date ______________

Activity Page 2 Use with Lesson 2

We Want You!

You want to hire an engineer for your company. Write details to complete your job ad.

We Are Hiring!

Job title: ______________________

The work you will do: ______________________

____

What education you must have: ______________________

____

What's good about the job: ______________________

____

Name ______________________________ Date ____________________

Activity Page A.1 Use with Experience A

Design a Tablet Stand: Describe the Problem

Attention, junior engineers! You are needed to help to design and build a stand for a tablet. Talk about each question with your team. Then write your answers on this page.

What problem are you trying to solve?

____

____

What are the requirements of a successful design?

____

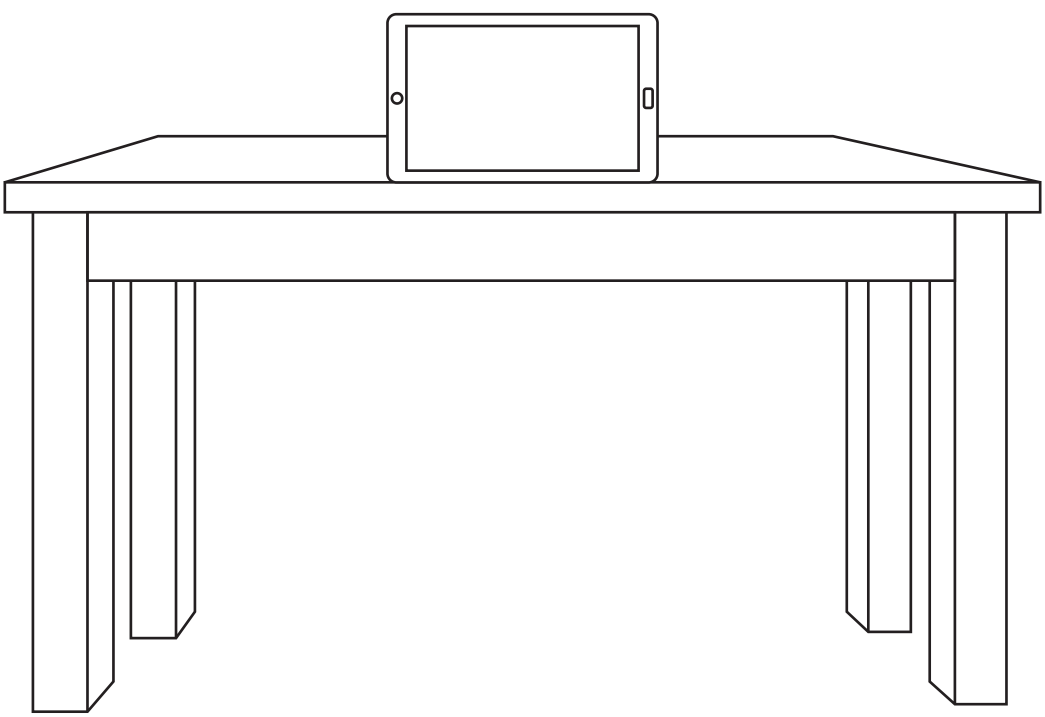
____

What are the limitations on any solution?

____

____

What do you know about forces and objects that will help you? Label the diagram to explain.



Name ______________________________ Date ____________________

Activity Page A.2 Use with Experience A

Design a Tablet Stand: Develop Solutions

Junior engineers, answer these questions to describe how you got started on your designs.

Who are the engineers on your team?

____

____

____

What needs of people will you address?

____

____

____

What materials will your team use to build a stand?

____

____

____

What is it about these materials that will make them useful?

____

____

____

____

____

____

Name ______________________________ Date ______________

Activity Page A.3 Use with Experience A

Design a Tablet Stand: Test and Compare Solutions

Junior engineers, answer the first three questions to reflect on how you tested your design and the results of the test. Answer the last question AFTER the team presentations.

Who are the engineers on your team?

____

How did you test your tablet stand?

____

How well did it solve the problem? Explain.

____

If you had to pick one other team's solution, which one seemed best? Why? Draw and label it here.

____

____

Name ______________________________ Date ____________________

Plan a Rube Goldberg Contest

Today, YOU are the teacher! Challenge your students to design complicated machines to do a simple task. Define the problem for your students.

What is the simple task you want the machines to do?

____

____

____

How much time will you give the students to design their machines?

____

____

____

Where may your students get the materials they need?

____

____

____

How much money can they spend on materials?

____

____

____

What safety rules will there be?

____

____

Name ______________________________ Date ____________________

Activity Page 4 Use with Lesson 4

Main Idea and Details

Use a pencil, crayon, or marker to trace your hand in the space below. Write the main idea of Chapter 4 on the palm of your hand. Write a favorite detail on each finger.

Name ______________________________ Date ____________________

Activity Page B Use with Experience B

How Did You Score a Goal?

Draw and label a diagram to show your team's Rube Goldberg machine. Show the three "links" in the chain reaction.

Activity Pages Answer Key

This answer key offers guidance to help you assess your students' understanding. Here, you will find descriptions of expectations, reasonable sample responses for open-ended items, and, where called for, singularly correct answers for each activity page of this grade level.

What Would They Say? (AP 1)
(Page 46)

Sample answer for Christian: I'm glad I made my own ottoman so I could put my feet up.

Sample answer for Kai: I was happy to help by talking about the solution with Christian.

Sample answer for Christian's brothers: We are glad that Christian figured out how to put his feet up, too.

Sample answer for Christian's father: I was pleased that my son solved a problem without needing my help.

We Want You! (AP 2)
(Page 47)

Sample answers: electrical engineer; You will help improve the power lines that carry electrical energy to farms.; You will need to go to engineering college.; You get to work on a team with other engineers. If your work is good, it will help farmers by giving them a steady supply of power.

Design a Tablet Stand: Describe the Problem (AP A.1)
(Page 48)

Students should note they are trying to make a tablet stand to hold a tablet up so two or more people can see it. They should note the limitations are the materials and time they have to make the stand. Student drawings should show that the forces on the table are balanced as gravity pulls the tablet down and the table pushes up.

Tablet Stand: Develop Solutions (AP A.2)
(Page 49)

Students should list their team and note that the tablet stand needs to hold the tablet up so three or more people can see the tablet. Students should note useful properties of the building materials.

Tablet Stand: Test and Compare Solutions (AP A.3)
(Page 50)

Students should list their team and how they tested the tablet stand. Students should note if their design solved the problem and provide feedback to another team.

Plan a Rube Goldberg Contest (AP 3)
(Page 51)

Students should identify a simple, performable task along with the criteria and constraints they set.

Main Idea and Details (AP 4)
(Page 52)

Sample answer: Main idea in palm: Skylar Neilsen had many experiences that made her want to be an engineer. Details on fingers: She made a model of a human heart.; She built a Rube Goldberg machine.; She watched her brothers and dad build computers.; She asked questions about the human body.

How Did You Score a Goal? (AP B)
(Page 53)

Student diagrams should include three links in their chain reaction that make the Rube Goldberg machine function. All materials should be items they would reasonably be able to find.

Appendix A

Glossary

Red words and phrases are Core Vocabulary in the lessons. **Boldface words and phrases** are additional vocabulary terms related to the lessons that you should model for students during instruction. Many of these also appear in the Student Book. Vocabulary words are not intended for use in isolated drill or memorization.

A

accountant, n. a person who job is to inspect and manage financial records

B

biomedical engineer, n. engineer who specializes in problems related to the human body

C

calculator, n. machine for performing mathematical calculations

chain reaction, n. a series of events caused by a previous event

civil engineer, n. engineer who specializes in working with public spaces and needs

computer engineer, n. engineer who specializes in designing and implementing the hardware and software of computers

constraint, n. a limitation on the designed solution to a problem

criteria , n. conditions that a solution to a problem must meet for the solution to be considered successful

D

design, v. to generate ideas for a planned solution

E

electrical energy, n. the flow of electrons from one location to another

engineer, n. a person who uses science to design solutions to problems, especially by constructing tools or devices

engineering, n. a process used to develop a solution to a problem

F

force, n. a push or pull that can change the motion of an object

frame, n. a rigid structure that supports an external structure

G

gravity, n. a force that pulls objects toward each other

I

inspired, v. to be made to want to try something

inventor, n. someone who creates something that did not exist before

L

lashing, n. cord wrapped around two or more sticks to hold them together

M

machine, n. a device that makes work easier

materials engineer, n. engineer who specializes in the design and application of materials

mechanical engineer, n. engineer who specializes in the design and application of machines

motion, n. the process of an object changing position

O

ottoman, n. an upholstered seat or footstool

P

palm, n. a type of tree that grows in tropical areas and has large leaves

patent, n. written statement giving the inventor the right to stop other people from copying their invention

pattern, n. a regular or repeated way in which something occurs

problem, n. a want or circumstance in need of correction or improvement

R

robotic, adj. related to or of the nature of a robot

S

solution, n. a process, action, or device that fixes a problem

Appendix B

Safety

Classroom Safety: 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 the Science in Action lessons make comparatively modest use of materials and hands-on science experiences. Some activities and demonstrations do 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 foods, 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.

Internet Safety: Though online resources present many rich opportunities for student learning, unsupervised online activity for children is not advised. The U.S. Department of Justice provides the following guidelines, Keeping Children Safe Online:

- Discuss internet safety and develop an online safety plan.
- Supervise young children's use of the internet.
- Review games, apps, and social media sites.
- Adjust privacy settings and use parental controls for online games, apps, social medial sites, and electronic devices.
- Tell children to avoid sharing personal information, photos, and videos online.
- Teach children about body safety and boundaries.
- Be alert to potential signs of abuse.
- Encourage children to tell a parent, guardian, or other trusted adult if anyone asks them to engage in sexual activity or other inappropriate behavior.
- Copy and distribute the Student Online Safety Contract, found on the next page. Prior to the start of the first lesson, do a read-along, and have students agree to the expectations for when they engage in computer and online activities.

Online Resources

For additional support concerning internet safety and online instruction, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Student Safety Contract

Dear Parent or Guardian,

During science class, we want to create and maintain a safe classroom. With this in mind, we want students to be aware of the behavior expectations for engaging in online science activities. Please review the safety rules below with your student and sign this contract. If you have any questions, please feel free to contact me.

For important safety information about children, computers, and the internet, consider resources at these sites:

https://protectyoungeyes.com/

https://sharedhope.org/

https://www.justice.gov/coronavirus/keeping-children-safe-online

____

Teacher signature and date

______________________________ ____/____/____/

Parent or guardian signature and date

______________________________ ____/____/____/

When doing online activities, I will do the following:

- Only do online activities with the supervision of an adult.
- Only visit websites and use apps that I am guided to by my teacher, parent, or trusted adult guardian.
- Never use my real name or reveal personal information if I communicate with others online.
- Tell a trusted adult right away if anyone online asks questions about my name, where I live, or where I go to school.
- Be careful around electronic devices and only plug them in or unplug them when an adult is supervising.

I understand and agree to the safety rules in this contract.

____

Student signature and date

______________________________ ____/____/____/

Print name

____

APPENDIX C

Strategies for Acquiring Materials

The materials used in the Core Knowledge Science in Action program are readily available and can be acquired through both retail and online stores. Some of the materials are reusable and are meant to be used repeatedly. This includes items such as plastic cups that can be safely used again. Often, these materials are durable and will last for more than one activity or even one school year. Other materials are classified as consumable and cannot be used more than once.

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 and technology can add up for an entire science program, even when the materials required for activities and demonstrations have been selected to be individually affordable. 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 in the teaching of science, as well as 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.

Core Knowledge®

CKSci™

Core Knowledge SCIENCE™

Editorial Director

Daniel H. Franck

Subject Matter Expert

Martin Rosenberg, PhD
Teacher of Physics and Computer Science
SAR High School
Riverdale, New York

Illustrations and Photo Credits

Allen Brown / Alamy Stock Photo: i, iii
History and Art Collection / Alamy Stock Photo: Cover D
Pictorial Press Ltd / Alamy Stock Photo: Cover A
Skylar Neilsen: Cover C

www.coreknowledge.org/contact-us/

Core Knowledge Foundation
801 E. High St.
Charlottesville, VA 22902

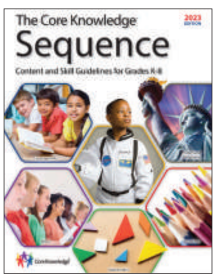
Core Knowledge Curriculum Series™

CKSci™

Core Knowledge SCIENCE™

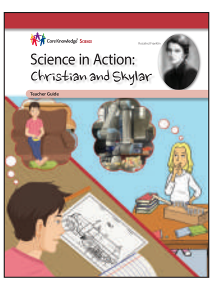
Science in Action: Christian and Skylar

Core Knowledge Science Grade 3



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, computer science, and the fine arts. In the domain of computer science, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progression coherently over time.



For which grade levels is this book intended?

In general, the content and presentation of this book are appropriate for students in the early elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Kindergarten 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**.

CKSci™

Core Knowledge Science™

A comprehensive program in science, integrating topics
from Earth and Space, Life, and Physical Sciences
with concepts specified in the Core Knowledge Sequence
(content and skill guidelines for Grades K–8).

CK Science in Action™

units in this series include:

Grade K: Kyle and Jamie
Grade 1: Daniela and Thaís
Grade 2: Laura and Sandra
Grade 3: Christian and Skylar
Grade 4: Pearl, Dan, and Ken
Grade 5: Rowan and Gianna

www.coreknowledge.org

Core Knowledge Curriculum Series™

ISBN: 979-8-88970-567-3