Core Knowledge® SCIENCE

Marie Curie

Science in Action: Rowan and Gianna

Teacher Guide

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Teacher Guide

Core Knowledge®

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Science in Action: Rowan and Gianna

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Science in Action: Rowan and Gianna

Science in Action Teacher Guide

Core Knowledge Science™ Grade 5

GRADE 5

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 Readers, 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 5 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.5.1:** Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.
- **CCSS.ELA-LITERACY.RI.5.2:** Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
- **CCSS.ELA-LITERACY.RI.5.3:** Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

Craft and Structure:

- **CCSS.ELA-LITERACY.RI.5.4:** Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*.
- **CCSS.ELA-LITERACY.RI.5.5:** Compare and contrast the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in two or more texts.
- **CCSS.ELA-LITERACY.RI.5.6:** Analyze multiple accounts of the same event or topic, noting important similarities and differences in the point of view they represent.

Integration of Knowledge and Ideas:

- **CCSS.ELA-LITERACY.RI.5.7:** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
- **CCSS.ELA-LITERACY.RI.5.8:** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).
- **CCSS.ELA-LITERACY.RI.5.9:** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

Range of Reading and Level of Text Complexity:

- **CCSS.ELA-LITERACY.RI.5.10:** 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 4–5 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 and a student Glossary that provides definitions to Core Vocabulary words. Engaging text, photographs, and diagrams encourage students to draw upon their own experiences and the world around them to understand scientific concepts. 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.

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

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.

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.

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

Activity Pages

Activity Pages

AP 1–2.2

Black line reproducible masters for activity pages, as well as an answer key, are included in Teacher Resources on pages 46–52. 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.

Experience A—pH Mystery Challenge 47

Experience B—Helping Hands 49

Experience B—Hand Blackline 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

- reference books and other research materials

Lesson 2

- reference books and other research materials
- vegetable oil
- water
- food coloring
- baking soda (or table salt)
- clear jar or bottle (for mixing)
- spoon or stick (for stirring)

Experience A

- reference books and other research materials
- 1 fluid oz each of everyday liquids (3–4 samples), such as lemon juice, vinegar, tap water, and baking soda solution, per group

- small cups (or containers), 1 for each liquid sample, per group
- pH test strips (litmus strips), 1 per cup, per group
- 1 marker per group

Lesson 3

- reference books and other research materials
- large sheets of paper
- markers, crayons, colored pencils
- pictures or cutouts of animals (or magazines to cut from)
- glue
- scissors

Lesson 4

- reference books and other research materials

Experience B

- cardstock paper
- ruler
- string or yarn
- straws
- double-sided tape or glue
- scissors

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. Reproducible activity page masters are included for activities requiring reproducible pages.

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 one lesson per week across the school year, layered 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 5 Units
1. Rowan and the Great Creek Rescue	Life science, STEM	• Energy and Matter in Ecosystems • Modeling Earth's Systems • Protecting Earth's Resources • Using Science Knowledge
2. Rowan Smith: Engineering a Greener Future	Life science, STEM	• Energy and Matter in Ecosystems • Modeling Earth's Systems • Protecting Earth's Resources • Designing Computer Programs • Using Science Knowledge
Experience A: pH Mystery Challenge	Life science, habitats	• Energy and Matter in Ecosystems • Modeling Earth's Systems • Protecting Earth's Resources • Using Science Knowledge
3. Gianna's Path	Life science, STEM	• Investigating Matter • Designing Computer Programs • Using Science Knowledge
4. Gianna Scire: Journey to Engineering	Life science, STEM	• Investigating Matter • Designing Computer Programs • Using Science Knowledge
Experience B: Helping Hands	Life science, life cycles	• Using Science Knowledge

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

Rowan and the Great Creek Rescue

At a Glance

Learning Objectives

✓ Identify the needs of an ecosystem.

✓ Explain how people can act like scientists.

✓ Describe problems and solutions.

Instructional Activities

- teacher Read Aloud
- class discussion
- vocabulary reinforcement

NGSS and CCSS References

NOS1. Scientific Investigations Use a Variety of Methods: Science investigations use a variety of methods, tools, and techniques.

NOS2. Scientific Knowledge Is Based on Empirical Evidence: Scientists use tools and technologies to make accurate measurements and observations.

NOS5. Science Is a Way of Knowing: Science is a way of knowing that is used by many people.

NOS6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems: Science assumes consistent patterns in natural systems.

RI.5.4. Craft and Structure: Determine the meaning of words and phrases as they are used in a text, including figurative language such as metaphors and similes.

L.5.4. Vocabulary Acquisition and Use: Determine or clarify the meaning of unknown and multiple-meaning 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

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.

acidic **alkaline** **ecosystem** **native** **pollution** **runoff**

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.

investigate **problem** **solution**

Instructional Resource

Reader

Ch. 1

Reader, Chapter 1
"Rowan and the Great Creek Rescue"

Materials and Equipment

Collect or prepare the following items:

- reference books and other research materials

Advance Preparation:

For the ecosystem balance game, prepare cards or slips of paper with different ecosystem elements (e.g., fish, plants, insects, birds, water, sunlight, pollution).

Have a whiteboard or poster where you can draw a simple food web or ecosystem chart.

THE CORE LESSON

1. Focus attention on the lesson purpose.

Play an ecosystem balance game. Give each student a card representing an element of the ecosystem. Explain that a healthy **ecosystem** relies on the balance between all these elements. Ask students to come forward one at a time, place their card on the chart, and describe how their element interacts with or depends on other parts of the ecosystem. Introduce a "pollution" or "overfishing" card halfway through and ask how it affects the other elements, prompting students to think about the impact on the balance.

Discuss why maintaining balance in an ecosystem is important for its health. Ask students to suggest ways to keep ecosystems healthy and how human actions can disrupt or support this balance.

Explain that today students will read a story about an ecosystem in a creek.

2. Read and discuss: "Rowan and the Great Creek Rescue."

Reader

Ch. 1

Prepare to read together, or have students read independently, Chapter 1 "Rowan and the Great Creek Rescue." 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

- Discuss what an ecosystem is. Draw on examples from the engagement activity. Pause before reading the last paragraph. Ask students what kinds of critters they could expect to find in a creek ecosystem. (*frogs*, *salamanders*, *birds*, *dragonflies*, *other bugs*, *etc*.)
- The origin of the word *ecosystem* comes from the Greek words *oikos*, meaning "home," and *systema*, meaning "system."
- Lead a discussion about what it means to be a scientist. Talk about how scientists ask questions about the natural world, make observations, record data, form hypotheses, test their hypotheses, and do experiments, to name a few! Ask students whether or not they think going to a creek to check the water quality counts as being a scientist. (*Answers may vary*, *but help students understand why this is an example of acting like a scientist*.)

  SUPPORT—It can be helpful to show students pH strips in the classroom while reading this story so they can better understand the investigation.

Page 3

- Focus on the terms *alkaline* and *acidic*. Discuss what makes a substance a base (**alkaline**) or an acid (**acidic**).
- As a class, make a prediction. Do students think the creek water will be more acidic or alkaline? Keep reading to find out if the students are right.

  CHALLENGE—Challenge students to name examples of common, everyday alkaline substances (e.g., baking soda, toothpaste, bleach, soap). Then challenge them to name examples of common, everyday acidic substances (e.g., vinegar, lemon juice, soda, citrus fruits, apple cider, tomatoes, sour milk).

Page 4

- What does Rowan's friend Mia mean when she says "This place is alive!"? (*That there is a lot of animal and plant activity by the creek. She is specifically talking about all the bugs*.)
- Ask students if they have tested the pH of a substance before. Was it interesting to watch the pH strip change color?

  SUPPORT—Some students may not understand what the colors on a pH strip mean. Refer back to the previous page for the image of the pH strip with color reference. Discuss how the pH strip changes color to indicate whether a substance is more acidic, neutral, or alkaline. Draw attention to how the colors on the pH scale move from reds on the acidic side to blues on the alkaline side.

Page 5

- Scientists use lots of tools when studying nature. Tools can be highly complex, but they can also be very basic. Some basic tools can include things like pH strips or even paper and pencils. Using something like a pH strip is an important way scientists learn more about the natural environment. (See **Know the Standards.**)
- Why is it important for the water in the creek to have a neutral pH? (*That is the pH needed for the living things in and around the creek*.)
- Talk about the importance of repeating tests in science. Sometimes repeating a test multiple times can help get more accurate answers.

Page 6

- What information could the students learn by timing how fast the water is moving? (*They could find out if the water is moving fast enough to stay clean for the organisms living there*.)

  EXTEND—Have students research and share information about an ecosystem in which organisms began to disappear, indicating that the ecosystem was in trouble. Examples may include the Great Barrier Reef (decline of coral cover), the Chesapeake Bay (decline of the oyster and crab populations), the Amazon rainforest (decline of certain animal species like jaguars and insects), or kelp forests in California (decline of sea otters, which affected the urchin population).

Page 7

- What might happen if the water is moving too fast? (*If the water is moving too fast, dirt could wash up or plants could get damaged*.)

Page 8

- Why would Rowan want to check the creek over a few school years? (*to see if the conditions were the same every year*)

  EXTEND—Professional Profile! Have students research what kind of environmental team in your city or county can help if a creek in your area is polluted. Find out if the environmental team is made up of scientists, and what kind. What else do these workers do besides help maintain water quality? Do they also work to prevent wildfires? Do they conduct special studies of the soil? Perhaps they study air quality in your area.

Page 9

- Who had an important impact on Rowan's interest in chemistry in high school? (*her AP Chemistry teacher, Dr. Boyette*)
- Why did Rowan look up to Dr. Boyette so much? (*Dr. Boyette was a smart and strong woman. She was a black belt in karate. She challenged the students but also gave them a lot of support*.)

  EXTEND—Professional Profile! Have students find out what it takes to be a high school chemistry teacher. What subjects do they need to study or master in college? What skills do they need to have? Are certifications required?

Know the Standards

NOS2. Scientific Knowledge Is Based on Empirical Evidence There are many tools that scientists use to make observations and take measurements. Some tools that students might use as they begin exploring the world include timers, rulers or metersticks, measuring tapes, graphs, charts, calculators, magnifying glasses, microscopes, pH strips, and drawing paper and utensils.

Page 10

- What excited Rowan about going into the field of chemical engineering? (*being able to make a positive impact on the environment*)

  CHALLENGE—Have students think about what they would want to focus on if they became a chemical engineer and share their ideas with the class. Create an anchor chart to record the ideas. See how many similar interests there are within the class and talk about it.

Page 11

- What did Rowan do to help her decide what to study in college? (*She made a chart of pros and cons.*)
- What things did Rowan want to make sure she got to do in college? (*be creative*, *use chemistry*, *help the world*, *get to use math*)
- What is an ecosystem that you could explore at school or in your backyard? (*garden*, *small patch of grass*, *compost pile*, *trees*, *flower bed*)

3. Connect to lived experience.

Invite students to share any details from the chapter that resemble someone or something familiar to them. Perhaps they know someone who has helped rescue an animal in the wilderness, or perhaps they feel a connection to the critters in creeks. 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.

Remind the class that everyone has experience with ecosystems; this is a universal thing that all people share. We all live within an ecosystem. Ask students if they have ever paid attention to the critters in a creek or other ecosystem, like Rowan did in the story. Do they find any particular part of the ecosystem interesting?

Relate the concept of polluted water to any **pollution** events that have happened in your area. Perhaps your area has occasional air pollution, or maybe local bodies of water have been found with litter in them. Talk about how this can affect life for all organisms on the planet.

LESSON 2

Rowan Smith: Engineering a Greener Future

At a Glance

Learning Objectives

- ✓ Define *chemical engineer*.
- ✓ Differentiate between chemists and chemical engineers.
- ✓ Explain how math and computers are used in chemical engineering.

Instructional Activities

- teacher Read Aloud
- class discussion
- vocabulary reinforcement
- class demonstration

NGSS and CCSS References

NOS5. Science Is a Way of Knowing: Science is a way of knowing that is used by many people.

NOS7. Science Is a Human Endeavor: Science affects everyday life.

RI.5.1. Key Ideas and Details: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

L.5.4.a. Vocabulary Acquisition and Use: Use context . . . as a clue to the meaning of a word or phrase.

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biodiesel fuel **chemical engineer** **chemist** **coding**
reaction **renewable**

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influence

Instructional Resources

Reader

Ch. 2

Reader, Chapter 2
"Rowan Smith: Engineering a Greener Future"

Activity Page

AP 1

Activity Page
pH Mystery Challenge (AP 1)

Materials and Equipment

Collect or prepare the following items:

- reference books and other research materials
- internet access and the means to project images/video for whole-class viewing
- vegetable oil
- water
- food coloring
- baking soda (or table salt)
- clear jar or bottle (for mixing)
- spoon or stick (for stirring)

Advance Preparation:

Set up a table with the ingredients to make the pretend biodiesel fuel.

THE CORE LESSON

1. Focus attention on the lesson purpose.

Do a demonstration where you simulate how to make **biodiesel fuel**. Explain to the class that biodiesel fuel is a type of **renewable** fuel made from natural, plant-based oils, like avocadoes, or animal fats. It is better for the environment when people use biodiesel fuel as opposed to regular gasoline and oil.

Draw students' attention to the station you have already prepared. Explain that you're going to make a safe, pretend version of biodiesel fuel. Point out that real biodiesel production uses chemicals that can be dangerous, so this is a way to learn how it is made without the risks.

Review the ingredients that you have, and explain what they simulate from a real recipe for making biodiesel fuel.

- Pour a small amount of vegetable oil into the clear jar. Explain that this represents the oil used in real biodiesel production.
- Next, add a few drops of colored water to act as "methanol." Explain that when making real biodiesel, methanol helps convert the oil into fuel.
- Sprinkle a little bit of baking soda or salt into the jar. Explain that this is pretending to be the "lye," which in real life helps the **reaction** happen.

- Stir the ingredients together. Explain that in real biodiesel production, this is when a chemical reaction would happen to create biodiesel.
- Let the mixture sit for a few minutes. The oil and water will naturally separate, forming two layers. Explain that in real biodiesel production, this separation represents biodiesel (the top layer) and glycerin (the bottom layer).

Point out how the two layers formed, just like in real biodiesel production where biodiesel separates from glycerin.

Talk about how this process shows that mixing the right ingredients can create new products and that biodiesel is a cleaner, renewable fuel that can be made from oils. In this new chapter that students will read, they will learn about a young scientist who is learning how to develop products like this biodiesel fuel to help the environment.

2. Read and discuss: "Rowan Smith: Engineering a Greener Future"

Reader

Ch. 2

Prepare to read together, or have students read independently, Chapter 2 "Rowan Smith: Engineering a Greener Future." 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

- What is Rowan studying in school? (***chemical engineering***)
- What does a **chemist** do? (*studies chemicals and substances and their reactions or interactions with other things*)

  SUPPORT—Make sure students understand what a reaction is. You can explain that a reaction is what happens when two or more substances mix together and change into something new. Reactions can change the color, temperature, or even smell, but they always make something different from what you started with.

  CHALLENGE—Have students give examples of reactions, such as mixing baking soda and vinegar to make bubbles because a new gas is being created.

- Do you think a chemical engineer is the same thing as a chemist? Why or why not? (*Accept any answer.*) Explain that they will learn about what a chemical engineer does on the next page.

Page 13

- What is the difference between a chemist and a chemical engineer? (*A chemist works with substances on a small scale. A chemical engineer works with what chemists have discovered and makes more of it.*)
- What does *mass production* mean? (*making a lot of something*)

  SUPPORT—An engineer is someone who finds solutions to problems. A chemical engineer is an engineer who finds solutions to problems related to chemistry.

Page 14

- What is biodiesel fuel? (*a kind of fuel that is better for the environment and made from vegetable oils*) What kind of vegetable oil did Rowan use in her school project to make biodiesel fuel? (*avocado oil*)
- What were the drawbacks Rowan experienced when it came to making the biodiesel fuel in huge amounts? (*It would be more complicated, have more safety risks, and require more money.*)

Page 15

- What is an advantage of biodiesel fuel? (*it is made from materials that would otherwise end up in a landfill.*)
- What is a disadvantage of biodiesel fuel? (*Some engines need to be modified to run on biodiesel fuel.*)

EXTEND—Have students research different types of biodiesel fuel that are currently being used. Ask them to describe the types of vehicles or machines using the fuel.

Page 16

- Draw student attention to the phrase "scaling up" in the second paragraph. Ask: what do you think this phrase means? (*It means that a chemical process needs to produce more or be bigger.*)

SUPPORT—Students may think that *scale* relates to the tool. Explain that in science and math, *scale* can also mean to make something bigger or smaller while keeping the same proportions. For example, if you're building a model of a mountain, you might make it on a smaller scale so it fits on a table, but all the parts would still look like the real thing.

CHALLENGE—Challenge students to come up with an example of making something on a bigger scale while keeping the same proportion. For example, drawing a close-up of a tiny insect requires us to make it on a bigger scale so we can see all the details.

Page 17

- Draw student attention to the word *plant* in the first paragraph on the page. Explain that here, the word *plant* does not refer to something that grows. It is describing a place where things are made, like a factory.
- What was Rowan's plant designed to produce? (*ammonium nitrate/fertilizer*)

Page 18

- What did Rowan and her team use to design the fertilizer plant? (*a software/computer program*)
- Ask students if they think Rowan and her teammates were acting like scientists by designing things in a computer software program. Have students expand on their answers. (See **Know the Standards**.)

Know the Standards

NOS5. Science Is a Way of Knowing Science is used by many people, even if they do not realize they are using science or intending to act like a scientist. When you use calculations to find the height of a building or when you try to find the speed of a roller coaster or when you draw designs in a computer program, that can be an example of how science is used in everyday life.

SUPPORT—If necessary, differentiate computers and software. Make sure students do not think these things are interchangeable.

EXTEND—If you have any students in the class who use design software programs or want to try drawing some freehand, have them try drawing the plans to something simple, like a closed circuit.

Page 19

- Hold a discussion about the different ways you can use computers in science. (*researching new information*, *making graphs for data*, *recording data*, *drawing simulations*, *printing pictures of nature*)
- Ask students if they know what **coding** is. (*Coding is like giving instructions to a computer to tell it what to do. It's a way of writing a set of steps, using a special language, so that the computer can follow them.*)
- Why is it important for engineers to know math? (*It can help them better understand the results of a test or better design effective solutions.*)

EXTEND—Have students do a simple coding activity. Use a free online coding tool or download a free coding worksheet and provide it to students to work on.

Page 20

- What exciting research project is Rowan working on at school? (*using* E. coli *to produce eco-friendly dyes*)
- How does Rowan overcome the unequal gender ratio of men to women at her university? (*She focuses on her studies and passion for the industry and surrounds herself with a supportive community.*)

Page 21

- How is Rowan hoping to balance her concerns about the environment with a job as a chemical engineer? (*By developing safer fertilizers and pesticides, she hopes to reduce damage chemicals do to the environment.*)

Page 22

- What kind of scientist was Marie Curie? (*physicist and chemist*)
- How did Marie Curie contribute to the world of science? (*She discovered radioactivity, including the elements polonium and radium.*)

Page 23

- What notable achievement is Marie Curie known for? (*She was the first woman to ever win a Nobel Prize. She won two Nobel Prizes in her lifetime.*)
- How were Marie Curie's discoveries used during wartime? (*Doctors used X-ray machines to help wounded soldiers.*)

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. Lead a discussion about the idea of inspiration. Ask students to share what inspires them. Some kids may be inspired by their own dreams or goals. Others might be inspired by someone they know. Have they had someone in their life (e.g., a family member, teacher, friend, gym coach, etc.) that inspired them in some way?

Ask students to tell details about the chapter or about Rowan's life that interested them most. Invite students to ask questions about details that might not have been clear to them.

Use Experience A to reinforce students' reflections on the chapter.

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

EXPERIENCE A

pH Mystery Challenge

At a Glance

Learning Objectives

- ✓ Describe the pH scale.
- ✓ Explain why pH level is important.
- ✓ Identify the pH of multiple substances.

Instructional Activities

- video clip
- hands-on activity
- discussion
- vocabulary instruction

NGSS and CCSS References

NOS5. Science Is a Way of Knowing: Science is a way of knowing that is used by many people.

NOS7. Science Is a Human Endeavor: Science affects everyday life.

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ecosystem **pH**

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Instructional Resource

Activity Page

AP 1

Activity Page
pH Mystery Challenge (AP 1)

Materials and Equipment

Collect or prepare the following items:

- reference books and other research materials
- internet access and the means to project images/video for whole-class viewing
- 1 fluid oz each of everyday liquids (3–4 samples), such as lemon juice, vinegar, tap water, and baking soda solution, per group
- small cups (or containers), 1 for each liquid sample, per group
- pH test strips (litmus strips), 1 per cup, per group
- 1 marker per group

Advance Preparation:

Decide in advance which 3–4 liquids you will use for this activity. Have them ready to pour into clear cups, or pour the liquids into the cups ahead of time. If preferred, you can use the marker to label the cups in advance, naming them "Sample A," "Sample B," etc. (You will need to remember which liquid was put into which cup.) Make sure the students do not know what the liquids are . . . this is part of the mystery!

The Core Lesson

1. Focus attention and preview the investigation.

Remind students that they read about a young girl who felt a connection to the **ecosystem** at a creek. Then they read about a real-life girl named Rowan Smith who is getting a degree in chemical engineering.

Lead a short discussion on the **pH** scale. Remind students that the pH scale is something many scientists, including chemical engineers, use as a way to measure how acidic or basic (alkaline) a liquid is. It has the numbers 0 to 14. If something has a pH of 7, it's neutral, like pure water. If the pH is less than 7, it's acidic, and if it's more than 7, it's basic. The lower the number, the stronger the acid. The higher the number, the stronger the base.

Online Resources

Show students the video of a scientist detective who needs to solve a mystery using pH scales. While they are watching, encourage students to think about why knowing the pH level of a liquid substance, like public drinking water, is important. (See the Online Resources Guide for a link to a recommended video.)

Tell students that in this experience, they will get to act like scientist detectives and test the pH levels of mystery substances to find out whether the substances are acids or bases.

2. Facilitate the investigation.

Activity Page

AP 1

Divide the class into small groups, not larger than five students to a group. Distribute the following materials to each group: cups, pH litmus paper, marker, and the everyday liquids that will be poured into the cups (if they are not pre-poured).

Review with students the materials they have. Explain that they will act like scientists. Each group will work together to identify the mystery samples of liquids based on their pH. (See **Know the Standards**)

Distribute AP 1. Review the pH scale picture on AP 1 with students. Make sure students understand which objects correlate to the different numbers on the scale.

Go over the directions for this hands-on activity and how to use the activity page. First, groups will pour each mystery liquid into its own cup. They must use the marker to label the cups "Sample A," "Sample B," etc., if the cups are not labeled already. Then, students will place the litmus paper into the liquids and use the pH scale to tell whether the liquids are bases or acids.

Finally, students will use the information they observe and record to identify which liquid is the lemon juice, the vinegar, and the baking soda (or whichever other liquids you select to use for this experience).

Circulate the room as students work on the activity.

> **SUPPORT**—Remind students that acting like a scientist means using special skills in the lab. For example, scientists use caution when handling unknown substances. They activate their senses, being aware of what they see, hear, and smell. Remind students that they must report spills right away to avoid anyone slipping.

Know the Standards

NOS7. Science Is a Human Endeavor Whether we realize it or not, pH is a part of science that affects everyday life. It helps keep our environment and bodies in balance. For example, plants need the right pH in the soil to grow properly, and fish need the right pH in the water to stay healthy. Our bodies also rely on a balanced pH, like in our stomachs, where acid helps us digest food. If the pH is too high or too low, it can make it hard for living things to survive, so monitoring pH levels is crucial for keeping ecosystems and our health in check.

As students complete the pH tests, encourage them to have patience if they do not notice the paper changing color right away.

For filling out the first table on AP 1, students should write down the color of the litmus papers. For the second table on AP 1, students should put a check mark or an X in the box if the sample is a base, a neutral, or an acid. It is also acceptable for students to write the words *yes* or *no* in the table.

SUPPORT—If necessary, help students complete the second table for AP 1. Explain that the columns are separated by sample. Each sample will be put in a category depending on whether it is an acid, a base, or neutral.

CHALLENGE—To make this activity more challenging, offer more mystery samples for students to test.

EXTEND—Have students explore the pH in their kitchens at home. They can find 3–4 different liquids from the kitchen (with parent permission) to test their pH. Examples could include juice, milk, dish soap, or soda. They can use pH strips or a homemade pH indicator (such as red cabbage juice) to test each liquid. Then, have students answer the following question: How might the pH of these liquids affect how they are used for cleaning/drinking/cooking?

3. Summarize and discuss.

As each team completes recording their observations, hold a brief discussion at the end. Ask volunteers to summarize their findings.

CHALLENGE—Challenge students to guess which mystery solution was the lemon juice and which was the vinegar, etc. Repeat this for each of the samples used in the experience.

Ask guiding questions to help link details in the findings back to the story they read about Rowan and the pH of the creek. For example, what do you think would happen if nobody ever checked the pH of a body of water? (*The animals and plants that live in that ecosystem could suffer because no one would know if the water could sustain a healthy life for organisms.*)

Have students make a connection back to what they read about Rowan Smith. For example, why might a chemical engineer need to know about pH levels? (*Chemical engineers need to know about pH levels because it affects chemical reactions, product quality, and safety. In industries like water treatment, food production, and manufacturing, controlling pH ensures processes run efficiently and products meet safety standards.*)

4. Check for understanding.

Activity Page

AP 1

- Have students summarize what they learned about pH levels.
- Have students summarize what they learned about chemical engineers.
- Review students' tables on pH Mystery Challenge (AP 1) to determine students' understanding of the following concepts:
  - Everything has a pH.
  - Substances are classified as either a base, a neutral, or an acid.

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

LESSON 3

Gianna's Path

At a Glance

Learning Objectives

✓ Identify the needs of living things.

✓ Explain how science is used when caring for animals.

✓ Describe problems and solutions.

Instructional Activities

- teacher Read Aloud
- class discussion
- vocabulary reinforcement

NGSS and CCSS References

NOS1. Scientific Investigations Use a Variety of Methods: Science investigations use a variety of methods, tools, and techniques.

NOS2. Scientific Knowledge Is Based on Empirical Evidence: Scientists use tools and technologies to make accurate measurements and observations.

NOS5. Science Is a Way of Knowing: Science is a way of knowing that is used by many people.

NOS6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems: Science assumes consistent patterns in natural systems.

RI.5.4. Craft and Structure: Determine the meaning of words and phrases as they are used in a text, including figurative language such as metaphors and similes.

L.5.4. Vocabulary Acquisition and Use: Determine or clarify the meaning of unknown and multiple-meaning words and phrases

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data **evidence** **habitat** **prediction** **veterinarian**

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problem **solution**

Instructional Resource

Reader

Ch. 3

Reader, Chapter 3
"Gianna's Path"

Materials and Equipment

Collect or prepare the following items:

- reference books and other research materials
- large sheets of paper
- markers, crayons, colored pencils
- pictures or cutouts of animals (or magazines to cut from)
- glue
- scissors

The Core Lesson

1. Focus attention on the lesson purpose.

Have students work in small groups to design a **habitat** of their choosing. Each student group should pick an animal they want to create a habitat for. It could be a pet (like a dog or cat), a farm animal, or a wild animal (like a bird or rabbit).

Have students spend a few minutes talking in their groups about what the animal needs to survive. Prompt them to think about what kind of food, shelter, and space the animal needs. Ask them to think about what things the animal might need to avoid that could harm it.

Tell students to use a large sheet of paper to draw or paste together with pictures a habitat for their animal. They can add food sources, water, places to hide or rest, and any toys or enrichment items that would make the animal comfortable.

Spend a few minutes having each group share their habitat with the class, explaining the choices they made and why each part of the habitat is important for the animal's health and happiness.

Discuss why it is important to take care of animals. Talk about how people take care of animals, whether they are pets, zoo animals, or wild animals.

2. Read and discuss: "Gianna's Path."

Reader

Ch. 3

Prepare to read together, or have students read independently, Chapter 3 "Gianna's Path." 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 did Gianna's mom do as a profession? (***veterinarian***) Ask students if they think veterinarians use science in their careers.
- What did Gianna help her mother with? (*medical tests and vaccines*)
- What did Gianna have to have done before she could go with her mom? (*piano practice*)

Page 25

- What was Gianna fascinated with? (*bodies, anatomy, and how organs worked*)
- What did Gianna learn from raising butterflies? (*She learned that small actions can make a big difference in the lives of living things.*)

  CHALLENGE—Initiate a think-share-pair activity. Have students think of something they are interested in. Encourage them to identify what might have gotten them interested and how they might purse their interest further.

Page 26

- How were Gianna's birthday parties special? (*She had health and science activities to do as part of the fun.*)
- What sort of sports did Gianna play? (*She played lacrosse and practiced karate.*)
- What did Gianna learn from these activities? (*She learned to stay calm and push her limits.*)

Page 27

- After the piano, what musical instruments did Gianna learn to play? (*She learned how to play the oboe and English horn.*)
- How is engineering like making music? (*A piece of music is made up of notes, chords, and verses. In engineering, the thing being engineered is also made up of parts and pieces. When a band plays, they have to alter what they are doing much like an engineer does when they change their design.*)

EXTEND—Post a graphic of the engineering design process so students can use it as a reference. Have students determine where the steps of the engineering design process are similar to and different from playing a piece of music. Consider listing each step in a column at the front of the class and have students write down how a step of the engineering process might be related to a piece of music and the band playing the music.

Page 28

- What responsibilities did Gianna have as the drum major of her high school's marching band? (*She had to signal the band when to play, when to stop*, and *when to march. She also had to use her mace to give directions and keep time.*)
- Why would a drum major need to be skilled at playing music? (*being skilled at playing music will help them help the musicians in each section*) What skill would being a drum major help people learn? (*how to lead people*)

Page 29

- What are the parts of a marching band? (*the instruments, the people that play them, the section leaders, and the drum major*)
- How is a marching band like a machine? (*The marching band is like a machine in that all the parts have to work together.*)
- Describe the parts of the band between the instruments and the drum major. (*The individual band members play their instruments. They report to the section leaders. The section leaders report to the drum major.*)

Page 30

- What subjects was Gianna good in? (*math and music*)
- How would you describe Gianna's challenges in deciding what to do in college? (*Gianna had a lot of choices. She could do something with math, such as an engineering program, or something with music.*)
- How would you describe Gianna's dad? (*tough but understanding of what Gianna wanted to do*)

Page 31

- What type of engineering sounded interesting to Gianna? (*She thought biomedical engineering was interesting.*)
- Why was biomedical engineering interesting to Gianna? (*Biomedical engineering would incorporate her interests in biology with math and engineering.*)

Page 32

- How would you describe Gianna's mom? (*curious and supportive of what Gianna wanted to do*)
- What kinds of programs would a college need to attract Gianna's attention? (*The school needs engineering programs and a music program.*)

EXTEND—Have students make a list of jobs they would be interested in doing. Then have them make a list of subjects that teach elements of that job, such as math for engineering. Then have them make a list of programs a college would need to have to meet their interests.

Page 33

- What were some advantages of the school in New York? (*Gianna's grandparents liked the school, Gianna liked the students and staff there, Gianna liked the programs.*)
- What was a disadvantage? (*It could be snowy and cold.*)
- Was the weather a factor in deciding to go to the college? (*No. Gianna liked so much about the school that the weather was not a deciding factor.*)

3. Connect to lived experience.

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. Invite students to ask questions about details that might not have been clear to them. Ask students if they find any particular part of fostering animals interesting?

LESSON 4

Gianna Scire: Journey to Engineering

At a Glance

Learning Objectives

- ✓ Define what a biomedical engineer is.
- ✓ Identify skills needed to be a biomedical engineer.
- ✓ Describe the importance of robotics.
- ✓ Explain real-world problems and how robots could solve them.

Instructional Activities

- video clip
- teacher Read Aloud
- class discussion
- vocabulary reinforcement

NGSS and CCSS References

NOS1. Scientific Investigations Use a Variety of Methods: Science investigations use a variety of methods, tools, and techniques.

NOS2. Scientific Knowledge Is Based on Empirical Evidence: Scientists use tools and technologies to make accurate measurements and observations.

RI.5.1. Key Ideas and Details: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

L.5.4.a Vocabulary Acquisition and Use: Use sentence-level context as a clue to the meaning of a word or phrase.

L.5.4.b. Vocabulary Acquisition and Use: Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word.

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.

algorithm **anatomy** **biology** **biomedical engineering** **robotics**

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.

internship

Instructional Resource

Reader

Ch. 4

Reader, Chapter 4
"Gianna Scire: Journey to Engineering"

Activity Page

AP 2.1

Activity Page
Helping Hands (AP 2.1)

Materials and Equipment

Collect or prepare the following items:

- reference books and other research materials
- internet access and the means to project images/video for whole-class viewing

The Core Lesson

1. Focus attention on the lesson purpose.

Talk to students about robots. Ask students if they have robots at home, and ask if they have ever used a robot. Maybe you have a robot in your classroom or at your school! Many students may not realize that something as common as a remote-controlled car is a type of robot.

People use robots for so many different things. Watch a short video on different types of robots and how they are used. While students are watching, encourage them to think about why robots are important. How have robots helped society?

Are there any drawbacks to using robots? (See the Online Resources Guide for a link to a recommended video: **www.coreknowledge.org/cksci-online-resources**.)

If time permits, have students pair up and draw a design of a future robot that they would make if they could. Have students share with the class what their robot would be called, what function it would do, and how it would help society.

Explain that they will read about an engineering student who works with robots in the medical field.

2. Read and discuss: "Gianna Scire: Journey to Engineering"

Reader

Ch. 4

Prepare to read together, or have students read independently, Chapter 4 "Gianna Scire: Journey to Engineering." 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

- What are some of the things that Gianna did in her life that shaped her journey into **biomedical engineering**? (*dissecting sheep hearts, working at a medical company, and playing oboe*)
- Ask students what they think *biomedical* means. As a class, break down the word *biomedical*. "Bio"—this part comes from the Greek word *bios*, meaning "life." It refers to anything related to living organisms. "Medical"—this comes from the Latin word *medicus*, meaning "physician" or "related to the practice of medicine." It refers to the science and practice of diagnosing, treating, and preventing diseases. (See **Know the Standards**.)
- What do you think biomedical engineers do in their profession? (*solve problems and design solutions related to living things*)

Page 35

- Lead a discussion about how precision, rhythm, and coordination used in playing music could sharpen Gianna's skills in engineering. (*Precision is important because in engineering, exact measurements and careful calculations are critical. Rhythm in music helps musicians understand timing, patterns, and flow, which are essential in engineering for things like project planning and workflow management. Music requires coordination between hands, fingers, feet, and mouths, which can enhance an engineer's ability to multitask, particularly in mechanical or electrical engineering.*)

Know the Standards

L.5.4.b. Vocabulary Acquisition and Use: Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word. Break the term *biomedical* into two parts. *Bio* means living things and *medical* is the study of medicine.

EXTENSION—Give students the names of famous engineers who were also musicians, such as Leonardo da Vinci, Herbert von Karajan, Nikola Tesla, Brian May, Tom Scholz, and Alexander Graham Bell. Allow students to choose one engineer/musician to focus on. Have them write a brief report about their experience with engineering and music and discuss how the two areas of study complement each other.

Page 36

- Why might there be so many different colleges for engineering studies? (*There are many different types of engineering. As a result, there are many different engineering programs.*)

  SUPPORT—Explain to students that different engineering colleges will often have specialties within their engineering programs. CalTech does more cutting-edge and theoretical physics and engineering. MIT does a lot of work with energy and defense projects for the federal government. Georgia Tech is helping engineer the world's transition to information, and Purdue is known for electrical, mechanical, and industrial engineering.

Page 37

- How would liking problem-solving relate to being a biomedical engineer? (*A biomedical engineer needs to be able to develop a solution to a biomedical problem.*)

  CHALLENGE—Call on students to give examples of human **anatomy**, animal anatomy, and plant anatomy.

- Ask: How is studying caterpillars and their transformation into butterflies a way to study anatomy? (*It shows how the body of a living creature can completely change and adapt. This transformation, called metamorphosis, lets scientists observe how different body parts develop and serve new purposes as the animal grows.*)

Page 38

- What causes a concussion? (*the brain moving and hitting the inside of the skull*)
- What can cause brain damage from a concussion? (*Brain damage can happen when the brain starts swelling inside the skull.*)
- What confirmed Gianna's passion for the field of biomedical engineering? (*working at a research lab where they developed materials to help with spinal cord recovery*)

Page 39

- How did Gianna's internship show her the practical side of being a biomedical engineer? (*Her grandfather received a heart valve replacement from the company where she had worked.*)

  EXTENSION—Explain that there are many professions that help save the lives of others or even save the lives of animals or plants. The people who do these jobs are everyday heroes! Assign students to research a variety of different professions. Make sure to include some science and engineering careers. Example professions include firefighters, marine biologists, mechanical engineers, nurses, lifeguards, and humanitarian aid workers. Have students write a report about what a day in the life of the profession is like. Do students consider a person in this profession to be an everyday hero? Why or why not?

Page 40

- Read the first sentence on the page and pause. Focus on the term *internship*. Ask students what they think an *internship* is. (*It is a temporary job or work experience that helps people learn about a career or field.*)
- Ask students what they think robotics is. (*when a robot does the work of a human*)
- Have a discussion about robotics and the industries that use robots. Explain that robots are used in the medical profession to help do surgeries. They are also used in manufacturing industries to help build things.

  SUPPORT—Robots used for doing surgeries—or any work—are built and programmed by humans. They understand how to carry out specific commands because they have a computer inside of them. The computer is programmed with a set of steps for the robot to carry out.

  Focus student attention on the term **algorithm**. Have students talk about algorithms if they are already familiar with them. If not, see the SUPPORT below. Ask: What do you think it means that the algorithms that Gianna designed are "advanced"? (*It means that they are complex or able to handle more difficult problems or steps.*)

  SUPPORT—An algorithm is a defined way to solve a problem. It involves a series of steps. Have students think about a simple maze. An effective way to get through a simple maze is called the "right hand rule." It goes like this: If you keep your right hand out to touch the wall throughout the whole maze, you will get to the end of the maze. This is a type of algorithm for getting out of a maze.

Page 41

- How is being able to replace a bad joint an advancement in medical care? (*Someone with a replaced joint like a hip can walk better again.*)
- What are some common themes in the work Gianna has done as a young engineer? (*the work solved problems*, *the work was related to medical issues*, *the solutions often were put inside a body to help someone get better*)
- Why would it be important for a biomedical engineer to have a good understanding of patient care? (*Understanding patient care is important because it helps engineers design and create medical devices or solutions that meet the needs of the patients who use them.*)

Page 42

- Why would it be good for Gianna to share her experiences with engineering as part of the Engineering Ambassadors program? (*By sharing her experiences, she might help younger students discover if they want to be engineers.*)
- Talk about technical skills. Have students give examples of technical skills that they think might relate to engineering. (*coding*, *programming*, *writing*, *web design*, *using photo editing tools*, *etc.*)

Page 43

- Review what STEM stands for. (*science*, *technology*, *engineering*, *and math*)
- Why is working as a STEM outreach Engineering Ambassador important? (*It inspires younger students to explore the world of STEM.*)

Page 44

- Who was Gianna inspired by? (*Hedy Lamarr*)
- What was Hedy Lamarr famous for? (*Hollywood actress*)

Page 45

- What notable contributions did Hedy Lamarr make to science? (*She co-invented frequency hopping. She laid the foundation for modern wireless communication.*)
- How was Lamarr's technology initially used? (*to prevent enemy forces from jamming radio-controlled torpedoes*)

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. Perhaps they know someone in their life who had a surgery that used robotics, such as a knee replacement. Or maybe they know an engineer, even if the engineer works in a completely different field.

Ask students to tell details about the chapter that interested them most. Was there anything about Gianna that they could relate to? Remind students that she does more than just study robotics for surgeries. Gianna tries to help better the lives of people.

Invite students to ask questions about details that might not have been clear to them.

Use Experience B to reinforce students' reflections on the chapter.

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

EXPERIENCE B

Helping Hands

At a Glance

Learning Objectives

- ✓ Design and build a robotic hand.
- ✓ Explain why robotics is an important field in biomedical engineering.

Instructional Activities

- video clip
- hands-on activity
- discussion
- vocabulary instruction

NGSS and CCSS References

NOS5. Science Is a Way of Knowing: Science is a way of knowing that is used by many people.

NOS7. Science Is a Human Endeavor: Science affects everyday life.

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

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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.

robotics **robots**

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.

Instructional Resources

Activity Pages

AP 2.1
AP 2.2

Activity Page
Helping Hands (AP 2.1)
Hand Blackline (AP 2.2)

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images/video for whole-class viewing
- cardstock paper
- ruler
- string or yarn
- straws
- double-sided tape or glue
- scissors

Advance Preparation:

Print the hand blackline on AP 2.2. You will need enough copies for each student. Print on cardstock paper.

Make your own robotic hand to show the class as a model.

The Core Lesson

1. Focus attention and preview the investigation.

Online Resources

Remind students that they read about a real-life girl named Gianna Scire who is getting a degree in biomedical engineering.

Lead a short discussion on the area of **robotics**, which is the field of studying and designing robots. This is something Gianna does for her biomedical engineering degree. Remind students that **robots** are machines that can do tasks on their own or be controlled by a person.

Watch this video of an important robot in development that will one day go to Mars! As students watch, encourage them to think about how this robot is helping humankind. Ask them to write down any unfamiliar words they hear in the video, such as *code* or *artificial intelligence*. Hold a discussion to answer any questions students have after the video.

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

Tell students that in this experience, they will get to act like engineers by making their own simple robotic hand. (See **Know the Standards**.)

2. Facilitate the investigation.

Activity Page

AP 2.1

Divide the class into small groups, not larger than five students to a group. Distribute the following materials to each group: printed hand, ruler, string or yarn, straws, double-sided tape or glue, and scissors.

Review with students the materials they have. Explain that they will act like biomedical engineers. Each group will work on building their own robotic hands. Clarify that although students are working in groups, each student will make their own hand.

Distribute AP 2.1. Go over the directions for this hands-on activity and how to use the activity page. Quickly review the steps. Then, show students the model robotic hand that you made in advance. Allow students to see you pulling on the string to bend the fingers and make the hand move.

Circulate the room as students work on the activity. Provide assistance where needed.

> **SUPPORT**—Make sure students are completing the steps in the correct order, and ensure no steps have been skipped, or else this activity will not work.

Explain how the fingers in a real hand have bones, joints, and tendons to help them bend and move.

As students get to the part where they make the fingers bendable, remind them that the straws act like the bones, creating joints that let the fingers bend.

Ask students: What do you think the string represents on a real finger? (*tendons*) Tendons pull on the bones in a real hand, making the fingers move.

Encourage teamwork by suggesting that the groups of students complete the steps together. Even if one person finishes a step quicker than the other students in the group, that person can wait for the rest to catch up before they all move on to the next step.

Know the Standards

NOS7. Science Is a Human Endeavor Whether we realize it or not, robotics is a part of science that affects everyday life. This is because robots are used in many areas that make our lives easier, safer, and more efficient. In medicine, robots help doctors perform precise surgeries and deliver medicines in hospitals. In manufacturing, robots build cars, electronics, and other products quickly and accurately so we have the things we need. At home, robotic vacuum cleaners can help clean floors, while robots in agriculture help grow and harvest food. Robotics also helps in areas like space exploration, where robots go to places too dangerous for humans, like Mars.

CHALLENGE—To make this activity more challenging, give students the materials to make the robotic hand, but do not give them for the design for it. Have students come up with their own design for the robotic hand using the same materials.

EXTEND—Have students explore and make note of the various kinds of robots they encounter for one week, including at home, at school, or out in the community.

3. Summarize and discuss.

Activity Page

AP 2.1

As each team completes their robotic hand, hold a brief discussion at the end. Ask classmates to summarize their findings.

Ask students to think about how their robotic hand works compared to a real hand.

- What parts were easy to design?
- What parts were challenging?

Discuss how biomedical engineers must consider things like comfort, flexibility, and ease of use when designing prosthetic limbs for people.

4. Check for understanding.

Activity Page

AP 2.1

- Have students summarize what they learned about what biomedical engineers do.
- Have students explain why robotics is important.
- Review students' robotic hands to determine students' understanding of the design.

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

Teacher Resources

Activity Pages

- pH Mystery Challenge (AP 1) 47
- Helping Hands (AP 2.1) 49
- Hand Blackline (AP 2.2) 51

Activity Pages Answer Key 52

Name ______________________________ Date ____________________

pH Mystery Challenge

With your team, test the pH of each sample substance. Then, use the pH scale to determine what each mystery sample is.

What color did the pH paper turn from each sample?

	Color
Mystery Sample A	
Mystery Sample B	
Mystery Sample C	
Mystery Sample D	

Name ______________________________ Date ____________________

pH Mystery Challenge

How would you classify each of the mystery samples? Place an X in the box that applies.

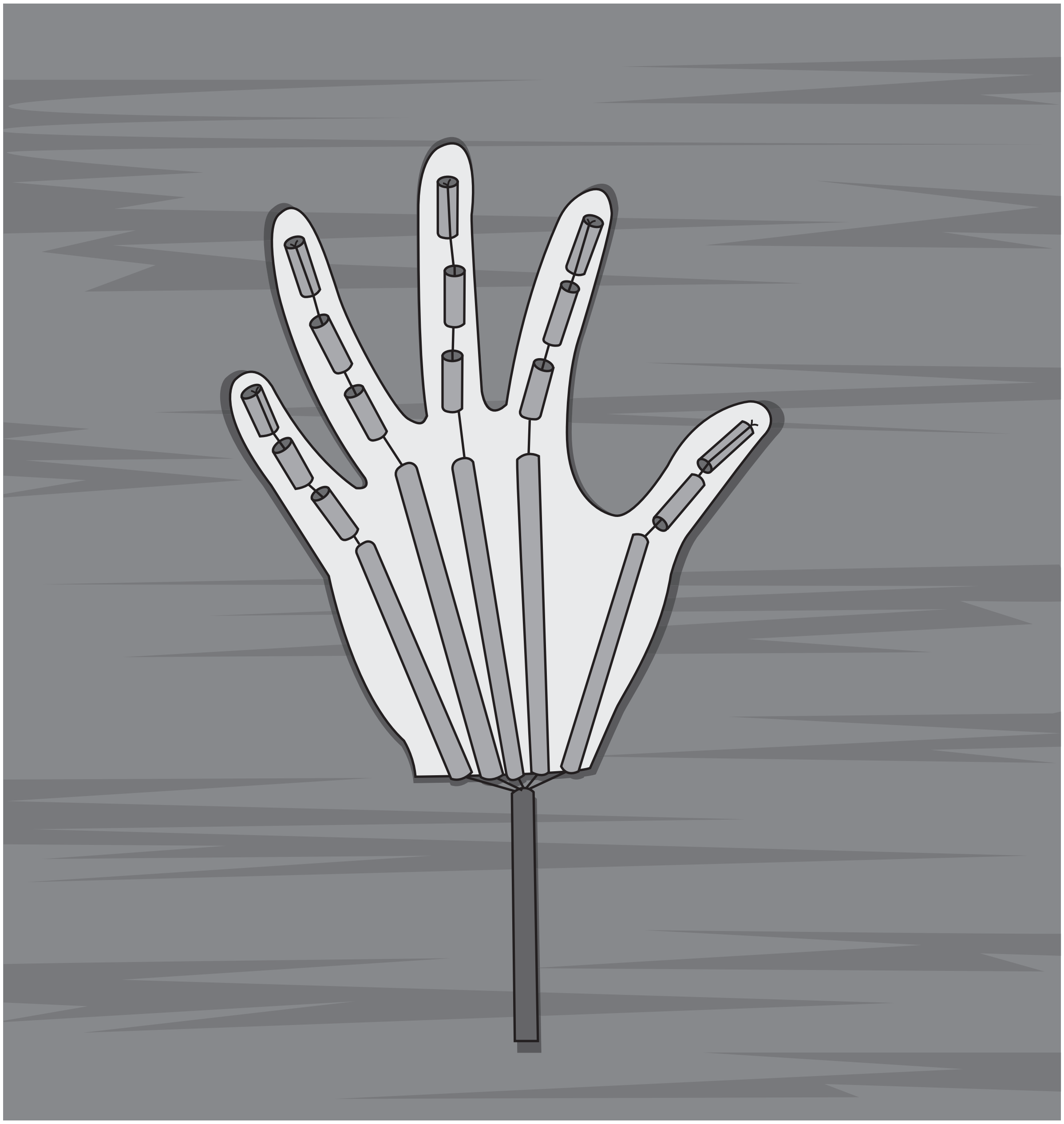
	Acid	Neutral	Base
Mystery Sample A			
Mystery Sample B			
Mystery Sample C			
Mystery Sample D			

Name ________________________________ Date ____________________

Activity Page 2.1 Use with Experience B

Helping Hands

Build a simple model of a robotic hand that moves when you control it.



Instructions

Design the Hand:

1. Cut out the shape of the hand.

Helping Hands

Make the Fingers Bendable:

1. Cut fourteen small pieces of straws, about 1.5 cm each.
2. Tape/glue the cut straws to each finger on the paper hand, placing them where the joints would be.
3. Cut three pieces of straws, about 9 cm each.
4. Tape/glue the 9 cm straws to the bottom of the hand, under the first, second, and third fingers.
5. Cut two pieces of straws, about 7 cm each.
6. Tape/glue the 7 cm straws beneath the thumb and the pinky finger.

Add Tendons:

1. Thread the string/yarn through the straw pieces. Start at the top of one finger. Tie the string to the straw. Make a knot so the string cannot fall out.
2. Now, thread the string down and through the rest of the straws for that finger.
3. Thread the string through the longer straw on the hand beneath that finger.
4. Leave the bottom end of the string loose at the bottom of the hand.
5. Repeat this step for each finger, with a new piece of string.

Test the Robotic Hand:

1. Test your robotic hand. Pull on the strings at the bottom of the hand. When you pull the strings, the fingers should bend.
2. Experiment with moving each finger, one at a time. Then experiment with pulling on multiple strings to make the hand "grab" something.
3. At this point, go back and fix anything that does not work.

Questions

1. What parts were easy to design? ____

   ____

2. What parts were challenging? ____

   ____

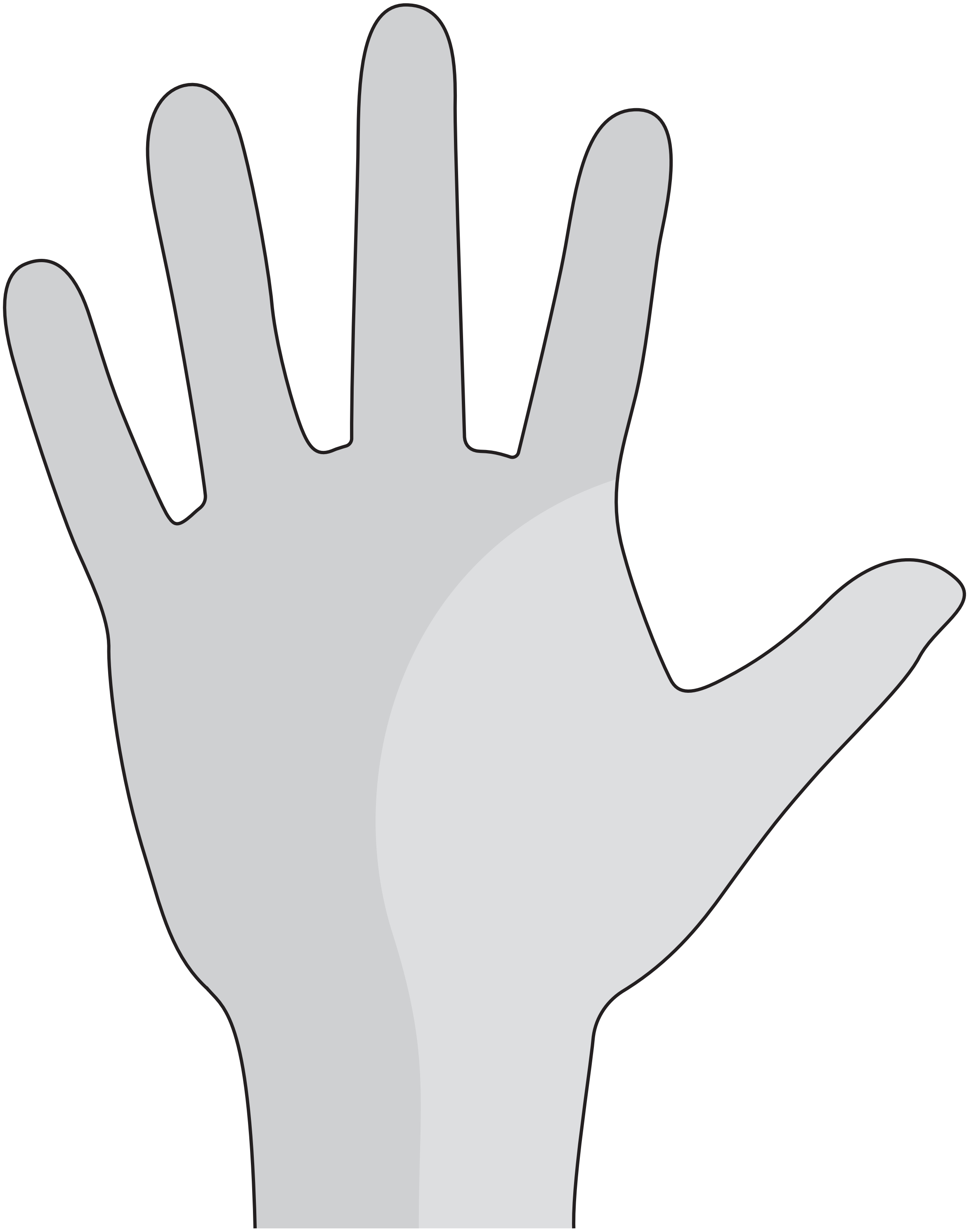
Name ______________________________ Date ____________________

Activity Page 2.2

Use with Experience B

Hand Blackline

Print on cardstock or heavy duty paper. Print enough copies for each student to have one hand.



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.

pH Mystery Challenge (AP 1)
(pages 47–48)

Sample answers will vary depending on the liquids tested. Common substances: toothpaste, 7 (green) to 10 (blue); baking soda, 9 (blue to blue-green); milk or water, 7 (green); coffee, 5 (green to yellow); vinegar, 2 to 3 (yellow to orange); and lemon juice, 2 to 3 (yellow to orange).

Helping Hands (AP 2.1)
(pages 49–50)

Sample answers: The longer bones that did not move were easier to design. The joints that have to bend were challenging to design.

Appendix A

Glossary

Green words and phrases are Core Vocabulary in the lessons, though the terms are not called out with color or bold treatment on the Reader pages. **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 Reader. Vocabulary words are not intended for use in isolated drill or memorization.

A

acidic, adj. having a pH below 7

algorithm, n. a step-by-step list, or directions, on how to solve a problem or perform a task

alkaline, adj. having a pH greater than 7

anatomy, n. the body structures of living things

B

biodiesel fuel, n. fuel made from biodegradable products

biology, n. the study of living organisms

biomedical engineering, n. the application of engineering to solve medical and biological problems

C

chemical engineer, n. an engineer who uses their knowledge of chemistry and engineering to develop methods to turn raw materials into usable products

chemist, n. a person who studies chemicals and how they react with each other

coding, n. the practice of writing instructions for computer programs

D

data, n. details of information collected by observation or measurement

E

ecosystem, n. all the living and nonliving things that interact in a given area

evidence, n. a detail that supports a claim or helps prove an idea is true

H

habitat, n. the environment where organisms usually live

I

influence, v. to affect an outcome

internship, n. a student or trainee in an organization who works to gain experience or requirements to qualify for a job

investigate , v. to observe and study something to collect information

N

native, adj. belonging to a place from birth

P

pH, n. "potential of hydrogen"; the scale used to measure how acidic or basic a solution is

pollution, n. the act of leaving harmful things in a natural environment

prediction, n. a declaration in advance of what one thinks will happen

problem, n. a condition that falls short of satisfying a want or a need

R

reaction, n. a response to a stimulus

renewable, adj. capable of being naturally replaced as quickly as it is used

robotics, n. the branch of engineering that deals with the development and application of robots

robots, n. machines developed to carry out a set of instructions automatically, often with the use of a computer

runoff, n. water and substances in the water that drains away from another area

S

solution, n. a design that meets a need or solves a problem

V

veterinarian, n. a doctor trained to treat animals

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.

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Core Knowledge Science™

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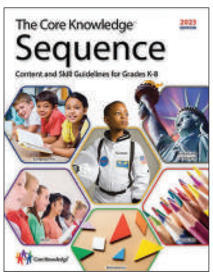
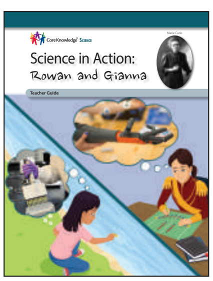


What is the Core Knowledge Sequence?
The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, computer science, and the fine arts. In the domain of computer science, the *Core Knowledge Sequence* 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 Grade 5 and is part of a series of **Core Knowledge SCIENCE** units of study.

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