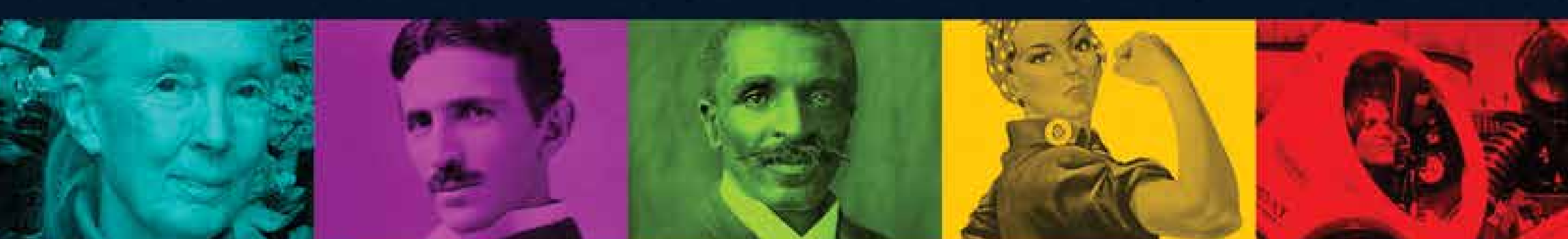
EUREKA!

GRADE 3–5 SCIENCE ACTIVITIES AND STORIES

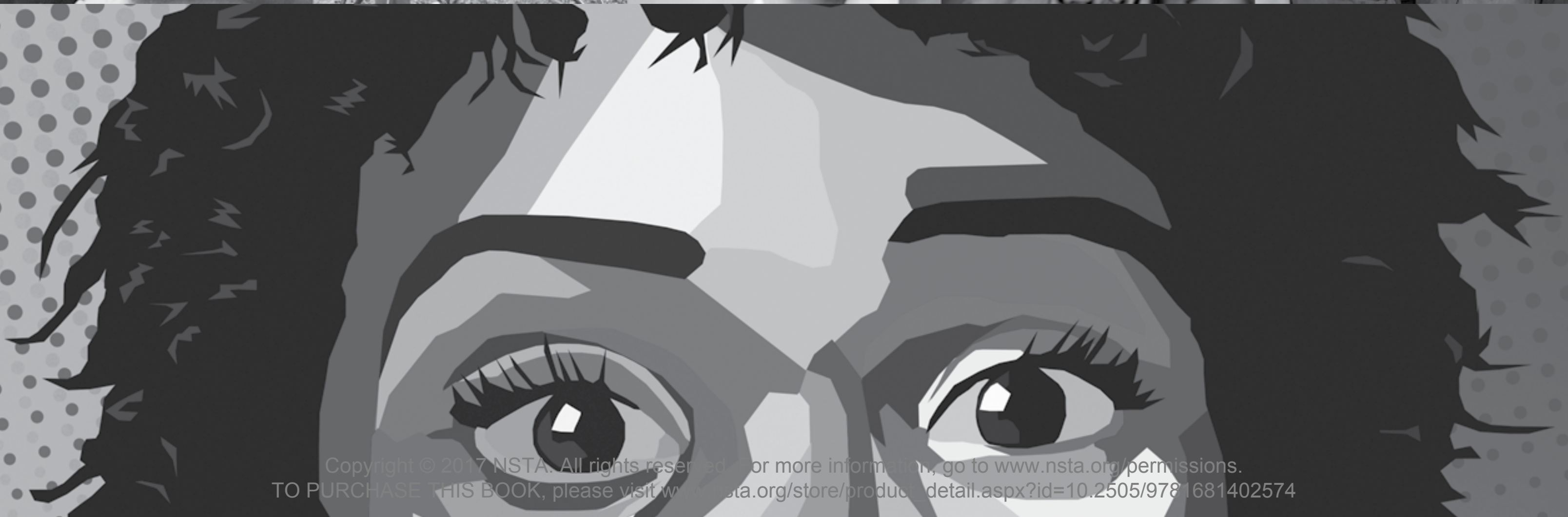


DONNA FARLAND-SMITH
JULIE THOMAS

NSTApress
National Science Teachers Association

EUREKA!

GRADE 3–5 **SCIENCE ACTIVITIES AND STORIES**



EUREKA!

GRADE 3–5 SCIENCE ACTIVITIES AND STORIES

DONNA FARLAND-SMITH
JULIE THOMAS

NSTApress
National Science Teachers Association
Arlington, Virginia

NSTA press®
National Science Teachers Association

Claire Reinburg, Director
Rachel Ledbetter, Managing Editor
Deborah Siegel, Associate Editor
Amanda Van Beuren, Associate Editor
Donna Yudkin, Book Acquisitions Manager

Art and Design
Will Thomas Jr., Director
Joe Butera, Senior Graphic Designer, cover and interior design

Printing and Production
Catherine Lorrain, Director

National Science Teachers Association
David L. Evans, Executive Director
David Beacom, Publisher

1840 Wilson Blvd., Arlington, VA 22201
www.nsta.org/store
For customer service inquiries, please call 800-277-5300.

20 19 18 17 4 3 2 1

NSTA is committed to publishing material that promotes the best in inquiry-based science education. However, conditions of actual use may vary, and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors do not warrant or represent that the procedures and practices in this book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book, including any of the recommendations, instructions, or materials contained therein.

Cataloging-in-Publication Data

Names: Farland-Smith, Donna, author. | Thomas, Julie, 1947- author.
Title: Eureka! grades 3-5 science activities and stories / Donna Farland-Smith, Julie Thomas.
Description: Arlington, VA : National Science Teachers Association, [2017] | Includes bibliographical references and index.
Identifiers: LCCN 2017021228 | ISBN 9781681402574 (print)
Subjects: LCSH: Science--Study and teaching (Elementary)--Activity programs--United States.
Classification: LCC LB1585.3 .F37 2017 | DDC 372.35/044--dc23 LC record available at *https://lccn.loc.gov/2017021228*

e-ISBN: 9781681402581

CONTENTS

FOREWORD ix

DEDICATION xvii

ACKNOWLEDGMENTS xvii

ABOUT THE AUTHORS xvii

1 INTRODUCTION: WHAT WE DID IN THIS BOOK AND WHY 1

2 ASKING QUESTIONS AND DEFINING PROBLEMS 9

Recommended Science Teaching Strategy: Designating Makerspaces 9

Scientists and Engineers Are THINKERS—Learning About Philo Farnsworth 11
The Boy Who Invented TV: The Story of Philo Farnsworth by Kathleen Krull

Scientists and Engineers Are INSPIRED—Learning About Thomas Edison 22
Young Thomas Edison by Michael Dooling

Scientists and Engineers Are DILIGENT—Learning About George Washington Carver 35
A Picture Book of George Washington Carver by David A. Adler

3 DEVELOPING AND USING MODELS 47

Recommended Science Teaching Strategy: Graphic Organizers as Models 47

Scientists and Engineers Are IMAGINATIVE—Learning About Annie Jump Cannon 49
Annie Jump Cannon, Astronomer by Carole Gerber

Scientists and Engineers Are VISIONARY—Learning About George Washington Ferris Jr. 60
Mr. Ferris and His Wheel by Kathryn Gibbs Davis

Scientists and Engineers Are PATIENT—Learning About Gregor Mendel 69
Gregor Mendel: The Friar Who Grew Peas by Cheryl Bardoe

CONTENTS

4 **PLANNING AND CARRYING OUT INVESTIGATIONS** **81**

Recommended Science Teaching Strategy: Effective Questioning 81

Scientists and Engineers Are OBSERVANT—Learning About Jane Goodall 83
The Watcher: Jane Goodall's Life With the Chimps by Jeanette Winter

Scientists and Engineers Are PUZZLERS—Learning About Charles Darwin 93
Darwin: With Glimpses Into His Private Journal and Letters by Alice B. McGinty

Scientists and Engineers Are INTUITIVE—Learning About Barnum Brown 104
Barnum's Bones: How Barnum Brown Discovered the Most Famous Dinosaur in the World by Tracey Fern

5 **ANALYZING AND INTERPRETING DATA** **119**

Recommended Science Teaching Strategy: Integration of Science and Mathematics 119

Scientists and Engineers Are DEDICATED—Learning About Wilson Bentley 121
Snowflake Bentley by Jacqueline Briggs Martin

Scientists and Engineers Are DREAMERS—Learning About Luke Howard 131
The Man Who Named the Clouds by Julie Hannah and Joan Holub

Scientists and Engineers Are CURIOUS—Learning About John James Audubon 141
The Boy Who Drew Birds: A Story of John James Audubon by Jacqueline Davies

6 **USING MATHEMATICS AND COMPUTATIONAL THINKING** **157**

Recommended Science Teaching Strategy: Probeware and Digital Media 157

Scientists and Engineers Are INNOVATIVE—Learning About Ada Byron Lovelace 159
Ada Byron Lovelace and the Thinking Machine by Laurie Wallmark

Scientists and Engineers Are COURAGEOUS—Learning About Galileo Galilei 173
Starry Messenger by Peter Sís

Scientists and Engineers Are CONFIDENT—Learning About Jacques Cousteau 182
Manfish: A Story of Jacques Cousteau by Jennifer Berne

CONTENTS

7 **CONSTRUCTING EXPLANATIONS (SCIENCE) AND DESIGNING SOLUTIONS (ENGINEERING)** **193**

Recommended Science Teaching Strategy: KLEW Charts 193

Scientists and Engineers Are CLEVER—Learning About Elijah McCoy 195
The Real McCoy: The Life of an African-American Inventor by Wendy Towle

Scientists and Engineers Are PERSISTENT—Learning About John Roebling 208
The Brooklyn Bridge: The Story of the World's Most Famous Bridge and the Remarkable Family That Built It by Elizabeth Mann

Scientists and Engineers Are INVENTIVE—Learning About William Kamkwamba 218
The Boy Who Harnessed the Wind by William Kamkwamba and Bryan Mealer

8 **ENGAGING IN ARGUMENT FROM EVIDENCE** **235**

Recommended Science Teaching Strategy: Science Talk 235

Scientists and Engineers Are RISK TAKERS—Learning About Nikola Tesla 237
Electrical Wizard: How Nikola Tesla Lit Up the World by Elizabeth Rusch

Scientists and Engineers Are FEARLESS—Learning About Sylvia Earle 249
Life in the Ocean: The Story of Oceanographer Sylvia Earle by Claire A. Nivola

Scientists and Engineers Are CREATIVE—Learning About Waterhouse Hawkins 260
The Dinosaurs of Waterhouse Hawkins by Barbara Kerley

9 **OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION** **273**

Recommended Science Teaching Strategy: Citizen Science 273

Scientists and Engineers Are PERSUASIVE—Learning About Rachel Carson 276
Rachel Carson and Her Book That Changed the World by Laurie Lawlor

Scientists and Engineers Are PASSIONATE—Learning About Wangari Maathai 286
Seeds of Change: Wangari's Gift to the World by Jen Cullerton Johnson

Scientists and Engineers Are INQUISITIVE—Learning About Carl Sagan 296
Star Stuff: Carl Sagan and the Mysteries of the Cosmos by Stephanie Roth Sisson

CONTENTS

10 BEYOND *EUREKA!* TEACHING HOW SCIENTISTS AND ENGINEERS WORK 309

Recommended Science Teaching Strategy: Concept Mapping 310

Scientists and Engineers Use MODIFICATION 311
Papa's Mechanical Fish by Candace Fleming

Scientists and Engineers Use IDEA DEVELOPMENT 321
What Do You Do With an Idea? by Kobi Yamada

Scientists and Engineers Use DESIGN PROCESS 327
Rosie Revere, Engineer by Andrea Beaty

LESSON GUIDELINES 335

Appendix A: Overview of Featured Books 339

Appendix B: Timeline of Featured Scientists and Engineers 342

Appendix C: Lesson Connections to the *NGSS* and the Nature of Science, Grades 3–5 343

Appendix D: Glossary of Character Traits 350

Appendix E: Recommended Science Teaching Strategies 351

Index 363

FOREWORD

Kevin D. Finson

Elementary teachers know the challenges of balancing literacy instruction with high-stakes testing and content area instruction. One way to do this is by incorporating literature relating to the content area into the lessons of that content area. In the case of science, the use of trade books to integrate literacy into science instruction is commonly used as a means of maximizing students' understanding of specific content-related concepts. Some educators, however, have expressed concern that not all books containing science information meet a suitable standard for both science and literature content. Perhaps more troublesome, some studies have demonstrated that science literature books can actually create or increase misconceptions about the content they include (Trundle, Troland, and Pritchard 2008). Should these concerns derail elementary teachers' selection and use of science trade books in their classrooms? Certainly, the answer is *no*. However, these concerns do heighten the need for teachers to have a clear understanding of the quality of science trade book content that appropriately conveys the desired information and concepts. Included with such considerations is the need to make trade book selections with very clear and purposeful rationales, having a definite sense for how a book's content can be used to address specific science messages to students while at the same time providing support for high-quality literacy instruction.

A perusal of many science trade books might quickly reveal that the science content targeted in them can range from concepts (such as lightning, magnets, or volcanoes) to gizmos (such as science equipment and devices) to history (such as science during a specific era) or to other aspects of the discipline. One aspect of science that is sometimes difficult to tease out of trade books is the nature and work of scientists. What are scientists like? What do they do? How do they do it? Who can be a scientist? These are among the questions that arise when a teacher wishes to find a trade book that focuses on scientists. A trade book whose primary focus is on gizmos might mention scientists in passing but is likely going to do a poor job of addressing the actual nature of scientists. In short, it might be difficult for teachers to find high-quality science trade books that focus on the nature and work of scientists. The authors of this book have undertaken the task of helping elementary teachers with this problem. They have carefully identified key elements about the nature and work of scientists that should be considered in trade book selection and then developed and followed a process for assessing trade books to derive a set of books that could best meet the need.

Among those key features about the nature and work of scientists that are included in the authors' selection process are (1) personal stories about scientists' lives (who scientists are), (2) portrayal of science as a human endeavor (what inspires scientists' work), (3) features of the processes scientists use (what we know as the science process skills describing how scientists do what they do), and (4) illustrations of scientists (how they are depicted) within the books. For many elementary teachers, locating personal stories (who scientists are) is likely to be the easiest of these three things to accomplish. Finding the science processes (how scientists do their work) within the pages of these same books might be a little more difficult but still relatively easy. However, finding trade books that clearly identify science as a human endeavor is more difficult but certainly possible in trade books (Segun 1988; Tapscott 2009). Let's look briefly at aspects of these last three elements the authors dealt with in this book.

Science Process Skills

How do scientists actually do science? Shortly after the launching of the satellite *Sputnik* by the Soviet Union on October 4, 1957, this became a key question for American education to answer. It was important because leaders in our nation realized we needed to do a better job of helping future citizens not only understand science but also how to actually do science. Congress provided millions of dollars in funding to various agencies and universities to develop science curricula that could help teachers accomplish this task. The three major elementary curriculum projects that emerged were Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), and Science: A Process Approach (SAPA) (Shymansky 1989). Each of these curricula had at its heart the most significant science concepts and science process skills. The process skills were derived from observations and interviews with actual practicing scientists to assess the procedures they followed when doing their work (i.e., process skills). Hence, one of the aspects of the nature of scientists is the process skills scientists choose to use and how they employ them.

The set of science process skills derived varies depending on the source one reads, but all sets include essentially the same process skills. These skills can be categorized as either basic process skills or integrated process skills. The basic science process skills are the foundational skills upon which all other skills are based. The integrated science process skills are those that can be seen as integrated combinations of two or more of the basic science process skills. Although educators often view the basic science process skills as being taught only at the elementary level, many of them need to be revisited during later grades and at higher levels of sophistication. The essentials about the science process skills are described below.

Basic Science Process Skills

Observing

Observing is using the senses (or extensions of them) to gather information about an object or event. An example is watching and describing an ice cube as it melts.

Inferring

Inferring is making a conclusion or interpretation based on observations, whether observed by oneself or others, using reasoning to explain data or information. An example is concluding that the lid of a container filled with water was pushed off the container by the expansion of water as it turned to ice.

Measuring

Measuring is using both standard and nonstandard measures or estimates to describe dimensions of objects or events in quantitative ways. An example is using a metric ruler to measure the length and width of an ice cube in centimeters.

Communicating

Communicating is sharing or transferring ideas through spoken, written, graphic, or pictoral form. An example is using graphs to show the relationship of an ice cube's melting to time exposed to the air.

Using Numbers

Using numbers is applying mathematical rules and/or formulas to calculate quantities or determine relationships. An example is calculating the average time for an ice cube to melt in 25 ml of room-temperature water.

Manipulating Materials

Manipulating materials is handling or treating materials and equipment skillfully and effectively. An example is pouring a liquid from a graduated cylinder into another container when making ice.

Classifying

Classifying is grouping, ordering, or arranging objects, events, or information into groups or categories based on their properties or the criteria specified in some method or system. An example is placing ice crystals in groups based on their shape.

Predicting

Predicting is stating an outcome for a future event or condition one expects to exist based on a pattern of evidence derived from observations and measurements. An example is stating that an ice cube will melt within a specified amount of time.

Developing Vocabulary

Developing vocabulary is using and understanding terminology, specific and unique to uses of words in a discipline, in ways that have meaning. An example is applying working definitions of science concepts in verbal discussions, such as *melting* or *heat exchange* for an ice cube.

Integrated Science Process Skills

Questioning

Questioning is using questions to focus inquiry or to determine prior knowledge and establish purposes or expectations for an investigation. An example is formulating a question about how an ice cube wrapped in newspaper will melt.

Identifying and Controlling Variables

Identifying and controlling variables is identifying and describing the factors that are thought to be constant or changing under differing conditions that can affect the outcome of an experiment, keeping all of them constant except for the one being investigated. An example is identifying the factors that might affect the melting of an ice cube and keeping all of them the same except for the amount of light that shines on the ice cube.

Defining Operationally

Defining operationally is stating how to measure a variable or stating what a phenomenon is according to the actions or operations to be performed on it. An example is stating that an ice cube has "melted" when there is no solid material left in the cup where the ice cube was kept.

Recording Data

Recording data is setting down data in writing or some other permanent form (e.g., taking notes, making lists, and entering in data tables) in an organized manner to facilitate analysis to determine whether patterns or relationships exist in the data. An example is recording data about the mass of the ice remaining in an ice cube compared with the time it has been in a cup on the table.

Formulating Models

Formulating a model is creating a mental or physical model or representation of a process, object, or event. An example is making a three-dimensional model of the molecules in an ice cube.

Hypothesizing

Hypothesizing is stating or constructing a statement that is tentative and testable about what is thought to be the expected outcome of the interaction of two or more variables. An example is stating that if one ice cube is placed in water and another is left in an open container, the one in the water will melt more quickly.

Experimenting

Experimenting is conducting procedural steps to test a hypothesis, including asking appropriate questions, stating the hypothesis, identifying and controlling variables, operationally defining variables, designing a "fair test," and interpreting and then communicating the results. An example is investigating whether hot water or cold water freezes more quickly in a freezer.

Making Decisions

Making decisions is drawing conclusions based on the results of experiments or collections of data, including identifying alternatives and choosing a course of action from among them based on the judgment for the selection with justifiable reasons. An example is identifying alternative ways to store ice cubes to avoid causing some of them to melt within a specific amount of time.

Science as a Human Endeavor

Science as a human endeavor is a significant component of both the American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* (Project 2061) (*AAAS Benchmarks*; 1993), the *National Science Education Standards* (*NSES;* NRC 1996), and *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (*Framework*; NRC 2012), which delineated how science as a human endeavor is evidenced by the following: (1) being people engaged in science and technology for a long time, (2) those who have contributed throughout history to the knowledge base have been both men and women and of various ethnicities—some of whom make careers in the sciences, and (3) science is an ongoing endeavor that does not end. It would seem logical that educators interested in teaching science would therefore look for ways to help students see science as a human endeavor.

A very human aspect of doing science is engaging in scientific inquiry (Akerson and Hanuscin 2005). Scientific inquiry consists of posing questions and then conducting investigations in attempts to find evidence-based answers to them. This is central to the scientific enterprise and necessitates the appropriate development of scientific habits of mind and thinking. Seeing science as a human endeavor helps students develop an image of science going beyond familiar bodies of knowledge, helps them perceive science as something they can engage in successfully, and becomes something to them that is clearly a human endeavor. Abd-El-Khalick, Bell, and Lederman (1998) and Lederman (2007) emphasized that science as a human enterprise is practiced within the context of the culture in which it is situated. Hence, how science and scientists are portrayed in trade books can help contextualize students' views and understanding about science as a human endeavor.

Illustrations of Scientists

Good picture books include colorful images students will want to look at and be able to refer to over and again (House and Rule 2005; Verhallen and Bus 2011; Xiung 2009). Analysis of images differentiates between photographs and other types of illustrations and considers their attributes, qualities, and appropriateness for use with targeted student age groups. The differentiation between photographs and illustrations is an important consideration because students' preferences—and subsequent attentiveness to the images in a book—help them comprehend the content being presented (Fang 1996; Glenberg and Langston 1992).

Included in the extant research regarding the impact of illustrations and images on elementary students were examinations of image attributes of color (bold and bright versus muted and pastels), realistic versus conventionalized presentation, sharp versus rounded lines, line drawings versus drawn images, and drawings or paintings versus photographs. Rationales for considering the importance of such elements encompass improvement of reader comprehension and development of specific language. The overall design of visual features and illustrations typically guides the reader in comprehending and linking elements of stories (Andrews, Scharff, and Moses 2002; Wolfenbarger and Sipe 2007). Appropriate and well-done illustrations help children develop a language of science (beyond simple vocabulary) extending to the language of inquiry: observation, logically derived hypothesizing, question posing, and examination of evidence (Pappas 2006). So, it is important to select trade books that have appropriately designed illustrations of scientists that are constructed in ways students prefer. Students' preferences include such qualities as:

- being realistic and life-like (Rudisill 1952), with life-like realism being more important than color when those aspects are considered separately (King 1967);
- photographs, particularly in color, over drawings and paintings (Rudisill 1952; Simcock and DeLoache 2006);
- being simplified and less complex (French 1952), although they accept more complexity increases with each grade level; and
- being more realistically colored over those either using no color or including colors too bold and not seen in the "real" things represented in the images (Rudisill 1952; Welling 1931). Younger children prefer bright primary colors, while older children tend to prefer softer colors (Andrews, Scharff, and Moses 2002; Stewig 1972). Freeman and Freeman (1933) noted that preschool-age children favored bolder and more life-like colors.

Illustrations in nonfiction picture books play an integral role in how the reader understands the content. They "serve a special comprehension function in that these [visual] elements help readers link information-containing portions of the text" (Donovan and Smolkin 2002, p. 510). Thus, illustrations are an essential component in not only understanding science content but also aiding students' understanding of science as a human endeavor or something they themselves could engage in.

Illustrations can go a long way in influencing students not only with respect to understanding where scientists work and what they do but also with regard to instilling interest and later engagement in actual career choices (Archer et al. 2010; Shope 2006). Children are very likely to formulate much of their perceptions about scientists from what they see in the illustrations in books. This factor can have a number of implications teachers may not readily consider. For example, the perceptions students hold about scientists may relate to their attitudes toward science and scientists (Finson 2003; Fung 2002). Finson (2003) found that students having more negative attitudes toward science tended to have more stereotypical perceptions of scientists, which in turn led to a reduced desire to pursue science as a vocation later in life.

Another component influencing student interest and choice is self-efficacy. O'Brien, Kopala, and Martinez-Pons (1999) linked self-efficacy (with respect to a given field) to the probability of an individual choosing a career in that field. Individuals who perceive themselves as being successful or potentially successful engaging in science are those who will have higher science self-efficacy. From this finding, one could reasonably conclude that individuals holding negative perceptions of science or scientists may be less interested in science and less likely to select science courses or pursue science as a career.

The specifics with respect to the *NSES* (NRC 1996) are as follows:

Standard Statement 1: "The long-term and ongoing practice of science and technology is done by many people" (NRC 1996, p. 141).

- The practice of science must include students' practice and learning. The content of a trade book must be both age- and developmentally appropriate for its intended audience so readers can cognitively connect with what is presented. An example of a book that meets these criteria is *Gregor Mendel: The Friar Who Grew Peas* by Cheryl Bardoe (2006), which tells how Mendel had paired different species of plants to see what offspring (hybrids) would result and then would count the numbers of specific traits that exhibited themselves in each hybrid to determine whether a mathematical pattern would emerge.
- The storytelling aspect of the book is more likely to reflect science as a human endeavor than are presentations of sets of facts. As an example, in *Rachel Carson: Preserving a Sense of Wonder*, Locker and Bruchac (2004) wrote about Carson hearing stories of robin deaths linked to pesticides, leading her to write a story in which the songbirds of the world had disappeared. Carson followed that up with *Silent Spring* in which she explained how every strand within the web of life is connected to the other strands and how the collapse of one endangers all the others.

Standard Statement 2: "Both men and women have made significant contributions to science and technology throughout history" (NRC 1996, p. 141).

- A trade book should include images of both males and females inasmuch as this is historically appropriate. In addition, the images of persons included within a trade book should be as nonstereotypical as possible (Farland 2006a; Farland 2006b).

Standard Statement 3: "By its nature, science will never be finished. Although much has been learned through inquiry about phenomena, objects, and events, there remains ever more to be discovered and learned" (NRC 1996, p. 141).

- Two things need consideration: (1) accuracy of the science information (Rice and Snipes 1997) and (2) attributes of the processes of science as delineated by the *NSES* and National Science Teachers Association documents on scientific literacy (Showalter et al. 1974). An example of a trade book that meets the requisites for accuracy of science information is Dan Yaccarino's (2009) *The Fantastic Undersea Life of Jacques Cousteau*, in which he describes how Cousteau conducted life inventories of sea flora and fauna in books and documentaries and how that inventory information changed over decades of study.

Standard Statement 4: "Many men and women choose science as a vocation and devote their lives to studying it. Many also derive great pleasure from doing so" (NRC 1996, p. 141).

- The story presented in a trade book should illustrate the roles of people engaging in the scientific enterprise. A good example is Jacqueline Briggs Martin's (1998) *Snowflake Bentley,* in which she describes how a farmer became interested in and persisted in photographing snowflakes over many years until he was able to publish a book about them at the age of 66—and even then he continued his work about them.

Conclusion

In writing this book, the authors have been diligent and deliberate in selecting the science trade books that serve as the anchors for each of the chapters. Through careful examination of each of those books, the authors identified the science process skills that were attendant to the work of the person at the focus of each book and then matched those process skills to suggested activities that clearly lead children in their learning of how to apply those essential skills for investigations in science.

Elementary teachers who read and use this book will benefit from the extensive work already completed by the authors. Teachers can be confident that the trade books used as the focus within the chapters are high quality and meet well-established standards for both literacy and science with respect to the nature of scientists. Making use of this book will help teachers save precious time, will help them make science more personable to their students, and will guide them in how to connect the science process skills central to excellent science activities they can select to accompany literature that truly engages students.

References

Abd-El-Khalick, F., R. L. Bell, and N. G. Lederman. 1998. The nature of science and instructional practice: Making the unnatural natural. *Science Education* 82: 417–436.

Akerson, V. L. , and D. L. Hanuscin. 2007. Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching* 44 (5): 653–680.

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy: Project 2061.* New York: Oxford University Press.

Andrews, J., L. Scharff, and L. Moses. 2002. The influence of illustrations in children's storybooks. *Reading Psychology* 23 (4): 3223–3339.

Archer, L., J. Dewitt, J. Osborne, J. Dillon, B. Willis, and B. Wong. 2010. Construction of science through the lens of identity. *Science Education* 94 (4): 617–639.

Bardoe, C. 2006. *Gregor Mendel: The friar who grew peas.* New York: Harry N. Abrams.

Briggs Martin, J. 1998. *Snowflake Bentley.* New York: Houghton Mifflin.

Donovan, C. A., and L. B. Smolkin. 2002. Considering genre, content, and visual features in the selection of trade books for science instruction. *The Reading Teacher* 55: 502–520.

Fang, Z. 1996. Illustrations, text, and the child reader: What are pictures in children's storybooks for? *Reading Horizons* 37 (2): 130–142.

Farland, D. 2003. "The effect of historical non-fiction trade books on students' perceptions of scientists." PhD diss., University of Massachusetts: Lowell.

Farland, D. 2006a. The effect of historical, nonfiction trade books on elementary students' perceptions of scientists. *Journal of Elementary Science Education* 18 (2): 31–48.

Farland, D. 2006b. Trade books and the human endeavor of science. *Science and Children* 44: 35–37.

Finson, K. D. 2003. Applicability of the DAST-C to the images of scientists drawn by students of different racial groups. *Journal of Elementary Science Education* 15 (1): 15–26.

Freeman, L., and R. S. Freeman. 1933. Selecting books for the nursery child. *Childhood Education* 10: 68–72.

French, J. E. 1952. Children's preference for pictures of varied complexity of pictorial pattern. *Elementary School Journal* 53: 90–95.

Fung, Y. 2002. A comparative study of primary and secondary school students' images of scientists. *Research in Science and Technological Education* 20 (2): 199–213.

Glenberg, A. M., and W. E. Langston. 1992. Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language* 31: 129–151.

House, C. A., and A. C. Rule. 2005. Preschoolers' ideas of what makes a picture book illustration beautiful. *Early Childhood Education Journal* 32 (5): 283–290.

King, E. M. 1967. Critical appraisal of research on children's reading interests, preferences, and habits. C*anadian Educational Research Digest* 7: 312–326.

Lederman, N. G. 2007. Nature of science: Past, present, and future. In *Handbook of research on science education,* ed. S. K. Abel and N. G. Lederman, 831–877. New York: Routledge.

Locker, T., and J. Bruchac. 2004. *Rachel Carson: Preserving a sense of wonder.* Golden, CO: Fulcrum Publishing.

National Research Council (NRC). 1996. *National Science Education Standards.* Washington, DC: National Academies Press.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

O'Brien, V., M. Kopala, and M. Matrinez-Pons. 1999. Mathematics self-efficacy, ethnic identity, gender, and career interests related to mathematics and science. *Journal of Educational Research* 92: 231–235.

Pappas, C. C. 2006. The information books genre: Its role in integrated science literacy research and practice. *Reading Research Quarterly* 41: 226–250.

Rice, D. C., and C. Snipes. 1997. Children's tradebooks: Do they affect the development of science concepts? Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Rudisill, M. 1952. Children's preferences for color versus other qualities in illustrations. *The Elementary School Journal* 52 (8): 444–451.

Segun, M. 1988. The importance of illustrations in children's books. In *Illustrating for Children,* ed. M. Segun, 25–27. Ibadan: CLAN.

Shope III, R. E. 2006. The Ed3U science model: Teaching science for conceptual change. Retrieved from *http://theaste.org/publications/proceedings/2006proceedings/shope.html.*

Showalter, V., D. Cox, P. Holobinko, B. Thomson, and M. Orledo. 1974. *What is unified science education? (Part 5) Program objectives and scientific literacy, Prism II.* Arlington, VA: National Science Teachers Association.

Shymansky, J. A. 1989. What research says about ESS, SCIS, and SAPPA. *Science and Children,* 26 (7): 33–35.

Simcock, G., and J. DeLoache. 2006. Get the picture? The effects of iconicity on toddlers' reenactment from picture books. *Developmental Psychology* 42: 1352–1357.

Stewig, J. W. 1972. Children's preference in picture book illustration. *Educational Leadership* 30 (3): 273–277.

Tapscott, D. 2009. *Grown up digital. How the net generation is changing your world.* New York: McGraw-Hill.

Trundle, K., T. Troland, and T. Pritchard. 2008. Representations of the moon in children's literature: An analysis of written and visual text. *Journal of Elementary Science Education* 20 (1): 17–28.

Verhallen, M. J. A. J., and A. G. Bus. 2011. Young second language learners' visual attention to illustrations in storybooks. *Journal of Early Childhood Literacy* 11 (4): 480–500.

Welling, J. B. 1931. Illustrated books for the four- to eight-year-old. *Childhood Education* 8: 132–138.

Wolfenbarger, C. D., and L. R. Sipe. 2007. A unique visual and literary art form: Recent research on picturebooks. *Language Arts* 84 (3): 273–280.

Xiung, Y. 2009. Levels of meaning and children: An exploratory study of picture books' illustrations. *Library and Information Science Research* 31: 240–246.

Yaccarino, D. 2009. *The fantastic undersea life of Jacques Cousteau.* New York: Knopf.

Dedication

This book is dedicated to the best science teacher I know, who teaches at Eastford Elementary School in Connecticut.
—Donna Farland-Smith

This book is dedicated to my most supportive husband, who has helped me brainstorm, craft, and edit these ideas and lessons from the very beginning.
—Julie Thomas

Acknowledgments

We would like to thank NSTA Press for the opportunity to publish this work. Special thanks to Amanda Van Beuren for her editorial expertise.

We're especially grateful to the many teachers at Alton Darby Elementary, Ridgewood Elementary, and Darby Creek Elementary in the Hilliard City School District (Columbus, Ohio) and to Alexandria Walenz at Roper Elementary in the Lincoln Public School District (Lincoln, Nebraska) for their willingness to participate in the development of many of these lessons. Thank you also to their administrators—Herb Higginbotham, Tara Grove, and Cindy Teske—for their support. Thanks to the amazing Andrew Queler for sharing photographs of his unique sawfish nostrums for use in this book. And thanks to Susie Scott, whose passion for teaching science is unmatched!

About the Authors

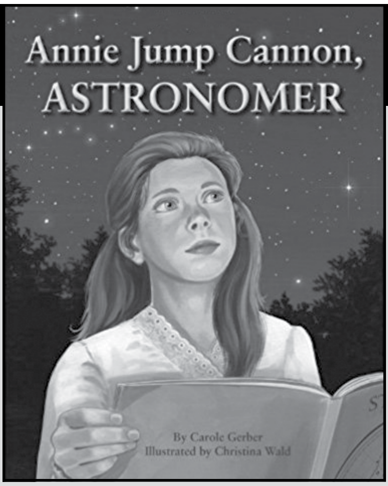
Donna Farland-Smith has over a decade of experience in the classroom and previously taught science in all grades K–12. She currently serves as an associate professor of science education in The School of Teaching and Learning at The Ohio State University-Mansfield. Her areas of expertise include teacher education, students' perceptions of science and scientists, and encouraging girls to explore science and engineering fields. Along with several book chapters and many articles about science education, Farland-Smith has written and published four books that inspire children to understand and appreciate scientists and their work: *Jungle Jane* (Authentic Perceptions Press, 2002), *It Takes Two: The Story of the Watson and Crick Team* (Authentic Perceptions Press, 2002), and *The Simple Truth About Scientists* (Authentic Perceptions Press, 2002). Farland-Smith received a BA in elementary education, a BA in natural science, an MA in science education, and an EdD in mathematics and science education from the University of Massachusetts-Lowell. In 2017, she published the book *Many Hands, One Vision: 20 Principles That Built a Children's Museum and Revitalized a Downtown Community* (CreateSpace), which tells about her experience in founding The Little Buckeye Children's Museum in Mansfield, Ohio.

Julie Thomas is an experienced elementary classroom teacher and elementary gifted-program coordinator. Now a research professor of science education in the College of Education and Human Sciences at the University of Nebraska-Lincoln, Thomas focuses her efforts on elementary science—for teachers and their students. She has led both state-funded and federally funded projects and has published research about children's science learning and teacher professional development. Thomas's accomplishments include collaborative efforts such as No Duck Left Behind, a partnership with waterfowl biologists to promote wetland education efforts; and Engineering Is Everywhere (E2), a partnership with a materials engineer to develop a time-efficient model for STEM career education. Throughout her teaching career, Thomas has been active in professional associations such as the School Science and Mathematics Association, for which she is a past executive director; the National Science Teachers Association, for which she has authored articles in the journal *Science and Children* and has served on the Awards Committee and Nominations Committee; and the Council for Elementary Children International, for which she is a past president.

SCIENTISTS AND ENGINEERS ARE

IMAGINATIVE

Learning About Annie Jump Cannon



Imaginative (adj.): creative or having the ability to think of unique ideas

Lesson: Starlight—Light From the Sun

Description

In this lesson, students will learn about how scientist Annie Jump Cannon observed variations in the brightness of stars and explored behaviors of light from the Sun.

Objectives

Students will consider how the character trait of *being imaginative* helped Annie Jump Cannon develop a classification system for stars and explore the nature of reflected light.

- Before starting the lesson, students will make a two-dimensional (2-D) foldable model of their place in the solar system.
- As a class, students will make a model to show the position of Earth and the solar system within the Milky Way galaxy.
- Students will hear the story *Annie Jump Cannon, Astronomer* by Carole Gerber and discuss how it relates to the word *imaginative*.
- Students will explore the behaviors and benefits of luminous and reflected light.
- To conclude the lesson, students will engage in a light-tag activity to further explore the behavior of reflected light.

Learning Outcomes

Students will (1) make a science notebook entry to explain what it means to be imaginative and why being imaginative is an important trait for scientists and engineers and (2) demonstrate their understanding of the behavior and benefits of reflected light.

Connections to the *NGSS* and the Nature of Science, Grades 3–5

Disciplinary Core Ideas

ESS1.A: THE UNIVERSE AND ITS STARS

- The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.

PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- Light also transfers energy from place to place.

PS4.B: ELECTROMAGNETIC RADIATION

- An object can be seen when light reflected from its surface enters the eyes.

Science and Engineering Practices

Asking Questions and Defining Problems: A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested. Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships.

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- 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.

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 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.

- Develop and/or use models to describe and/or predict phenomena.
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

Crosscutting Concepts

Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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 can be used as evidence to support an explanation.

Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- 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.

Nature of Science Connections

SCIENTIFIC INVESTIGATIONS USE A VARIETY OF METHODS

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

SCIENCE KNOWLEDGE IS BASED ON EMPIRICAL EVIDENCE

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

SCIENCE IS A WAY OF KNOWING

- Science is both a body of knowledge and processes that add new knowledge.

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.
- Creativity and imagination are important to science.

SCIENCE ADDRESSES QUESTIONS ABOUT THE NATURAL AND MATERIAL WORLD

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

Source: NGSS Lead States 2013.

Overview

In this lesson, students learn how Annie Jump Cannon invented a model for classifying stars based on the stars' temperatures and shared her classification system with others in her science community. This challenged the way people thought about female astronomers. Through the featured book, students learn that men and women from all backgrounds choose careers as scientists and engineers. The character trait *imaginative* references Cannon's meticulous and creative attempts to organize the starlight behaviors she observed. Students also share ideas about women being scientists. In the hands-on exploration, students explore the nature of reflected light.

Materials

You will need supply of 9 in. × 14 in. or 8.5 in. × 11 in. colored paper in seven colors, enough for one color set for each student; and one copy of the featured book, *Annie Jump Cannon, Astronomer,* by Carole Gerber (ISBN 978-1589809116). Each group of students will need one rock, a cup of water, a piece of aluminum foil, a piece of white paper, and a small plastic bag. Each student will need a set of colored papers prepared ahead by the teacher, a glue stick, his or her science notebook, a flashlight, safety glasses or goggles, and a small acrylic mirror (e.g., 3 in. × 5 in.). *Note:* Acrylic mirrors minimize the safety risks of glass mirrors. Sheets of mirrored acrylic are available online and in most building supply stores and can be cut to any size.

Safety Notes

(1) Personal protective equipment should be worn during the setup, hands-on, and takedown segments of the activity. (2) Immediately wipe up spilled water—it creates a slip-and-fall hazard. (3) Wash hands with soap and water upon completing this activity.

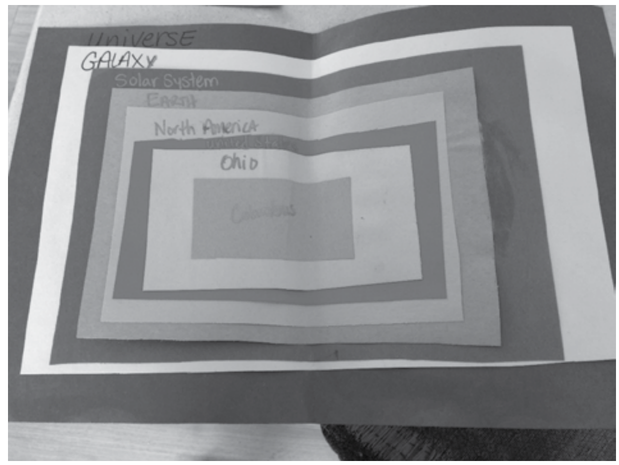
Setting the Context

Engage

Ask students whether they have ever wondered how humans fit in the universe; that is, where we are relative to galaxies, the universe, and the solar system. Ask, "Which is larger, a galaxy, the universe, or a solar system?" Help students build a model of the universe so they appreciate how they actually fit into the big picture.

Figure 3.1

Example of a Student's Stacked-Paper Model of the Universe



This model helps students conceptualize the relative sizes of the various parts of the universe and their location within it. See Zike 2004 for more information.

1. Before class, prepare the colored paper sets for students, planning for all students to create their stacks in the same color sequence. Leave the sheets of the first color of paper whole. For each subsequent color, cut the sheet to be 1 in. shorter and 1 in. narrower than for the previous color.

2. Provide each student with one set of precut colored paper and a glue stick. Have students stack the seven paper sheets by descending size (see Figure 3.1) and glue them in place.

3. Help students label their models. First, have them label the bottommost paper "Universe" (the outermost location in the universe model) and the topmost paper "Home" (the innermost location in the universe model). *Students might instead use the city name and/or street addresses for the innermost label.* Involve students in a conversation about which colors in this model represent the Milky Way galaxy, the solar system, Earth, North America, the United States, and their state. Prompt students with questions about relative size; for example, ask, "If the universe is the biggest, what fits inside it?" It is sometimes easier to begin with the home city and expand outward. You might use the book *My Place in Space* by Robin and Sally Hirst to help your students think about the smaller and larger components of this model.

4. Prompt students to connect their models to the classification of the stars by asking, "Where would the stars be found?" and "How might scientists find out the temperature of a star?" Guide the discussion to the idea that collecting data about space is challenging because stars are far away.

Guided Reading

Inform students that by reading *Annie Jump Cannon, Astronomer,* they will be learning about how stars are classified and about the work of Annie Jump Cannon, a scientist who was especially imaginative. Introduce the book by asking, "Can you describe the person on the front cover? What seems to be happening on the front cover?" Read the story aloud. Encourage students to notice and think about the challenges Cannon faced as a female astronomer. The questions below may be used to guide students' attention to detail as you read. (Page numbers reference unnumbered book pages, beginning with the title page as page 1.)

1. **Pages 3–5:** When she was young, Annie Jump Cannon enjoyed stargazing with her mother. How did Cannon and her mother know what stars they were looking at? *Cannon and her mother climbed onto the roof of their house and matched their view of the night sky to her mother's school star charts. This was how Cannon learned the names of the visible constellations.*

2. **Pages 6–10:** Cannon enrolled in a nearby boys' school after they began admitting girls and graduated at the top of her class. How did Cannon happen to then enroll in Wellesley College? *Annie's father had toured Wellesley on a business trip and was impressed that Wellesley, a women's college, offered the same courses as all-male universities.*

3. **Pages 12–15:** Cannon loved attending Wellesley College, especially the laboratory experiments in her science classes. What challenges did she encounter as a student? *During her sophomore year, Cannon had scarlet fever and developed an ear infection that left her partially deaf. Despite that, she graduated with her class.*

4. **Pages 16–18:** After her mother died, Cannon remembered how much she had enjoyed studying the stars with her mother, so she returned to Wellesley to study astronomy. How did Cannon's astronomy studies set the course for her career? *While at Wellesley, Cannon arranged a way to use the telescope at the Harvard College Observatory.*

5. **Pages 19–21:** The director of Harvard College Observatory hired Cannon to help photograph and classify all the stars in the sky; however, Cannon soon learned that she would not actually be photographing stars. How did astronomers take photographs of the stars? Why did Cannon not photograph stars? *Astronomers used a special system to photograph the stars. They attached prisms to telescopes that separated the light from each star into different wavelengths, similarly to how raindrops separate sunlight into a rainbow. Cannon did not take photographs of the stars because only the male astronomers were allowed to. Women could only be assistants who worked as "human*

Annie Jump Cannon

computers" to examine the photographic plates (spectrographs) to analyze the type of light from each star. Women were paid one-fourth the amount that men were paid.

6. **Pages 24–28:** Cannon had sharp eyes and a good memory and soon became the fastest computer—she could classify three stars per minute. How did she identify a problem with the classification system? *The computers used magnifying glasses to examine the spectrographs. They used the dark lines on the spectrographs to determine what the star was made of and how hot it was and then ranked the stars (named according to letters of the alphabet) on the basis of their spectral characteristics. Cannon noticed, for example, that the O stars (the brightest) were the hottest and the A stars were the third hottest. So, she developed a shorter, more accurate star classification system that organized the classes of stars from hottest to coolest—O, B, A, F, G, K, M. Her system is still used today and is remembered by the mnemonic "Oh Be A Fine Guy/Girl, Kiss Me."*

7. **Pages 26–29:** Introduce a discussion of the importance of Cannon's model for classifying stars in ranked order from hottest to coolest by asking the following questions. How did Cannon become known as "the census taker of the stars"? Why is this system needed, and why is it important to science? How does this science activity of re-creating Cannon's classification system on a model help you think about Cannon's imaginative model for classifying the stars? *This is a complex model, and students are expected to understand only that she saw patterns in both the spectra and the temperatures of stars and that she reorganized the alphabetical lettering system (OBAFGKM) to classify stars from hottest (O) to coolest (M).*

Making Sense

Explore

Begin by holding a discussion about rainbows to help students recall their knowledge of refraction—the bending and separating of light into a spectrum of colors. Although refraction is not the lesson focus, this discussion will help students connect the lesson to Annie Jump Cannon's interest in and research about stars. Initiate the discussion by asking, "When do we see rainbows?" "What are the colors of the rainbow?" and "What causes rainbows?" *Rainbows appear when rain and sunlight interact in a specific manner. When sunlight passes through water droplets, the droplets act like prisms and refract (bend) the various wavelengths of light that make up white light, which we then see as a spectrum of colors—red, orange, yellow, green, blue, indigo, and violet (ROYGBIV). Cannon worked with images collected through telescopes equipped with prisms and recognized that the different classes of stars emitted light composed of particular wavelengths, which could be distinguished by their refraction through the prisms.*

Extend the discussion to students' experience of light from the Sun and other stars. Ask, "What do we know about the light that comes from the Sun, which is one of the largest stars in our galaxy?" Encourage students to share personal experiences and observations of the nature of light from the Sun (e.g., what sunlight feels like on their skin, that sunlight passes through clouds and windows, and that blocking sunlight produces shadows). Then, inform students that they will conduct an exploration of how the Sun's light behaves when it strikes various objects. *This exploration focuses on reflection, the bouncing of light rays off an object, which allows us to see the object. It is organized in two parts and will work best in a darkened classroom with the lights off and the shades drawn.* The steps of the exploration are as follows:

1. Organize students into table groups and provide each group with a rock, a cup of water, a piece of aluminum foil, a piece of white paper, and a small plastic bag. Each student will need a flashlight. Invite students to examine each item and predict what will happen when they shine a flashlight on it. Encourage students to think of the flashlight as the Sun. Guide their thinking

by asking, "What will happen to the light when it hits this object?" "Where will the light go?" and "Will the light rays pass through, be blocked, or be reflected?" Have students record their predictions in their science notebooks; encourage them to create a chart so they can record both their predictions and their test results. Then, allow some time for students to use their flashlights to test their predictions. *Students should find that the opaque objects (rock and paper) will block some light and cast a shadow; the shiny object (aluminum foil) will reflect or redirect some of the light; and the clear objects (water and plastic bag) will allow most or all of the light to pass through. Note that all the objects actually reflect some light, although this will not be obvious to your students. This fine point may become clear in the "Extend" and "Explain" sections that follow.*

2. Have students work in pairs. Provide each pair with a flashlight and a small acrylic mirror. Begin with the guiding question, "What happens when the Sun's light reflects off a mirror?" Prompt students to think of their flashlight as the Sun, and invite them to work together to observe what happens when they shine their flashlight on the mirror. They should easily observe a reflected light beam if they lay the flashlight on the table and shine it into a mirror held perpendicular to the table so that some of the light spills onto the table. Once they recognize the line of reflected light, ask, "How can you change the line of reflected light?" Challenge students to record their data by creating three diagrams in their science notebooks. Each diagram should include an arrow to show the direction of the reflected (outgoing) light. *Students may need to adjust the angle of the mirror and the distance between the flashlight and the mirror. Once students have completed their three diagrams, ask, "What pattern do you see?" Students should be able to explain that light reflecting from the mirrors travels in a straight line and that the angle of reflection changes when the position of the mirror changes.*

Explain

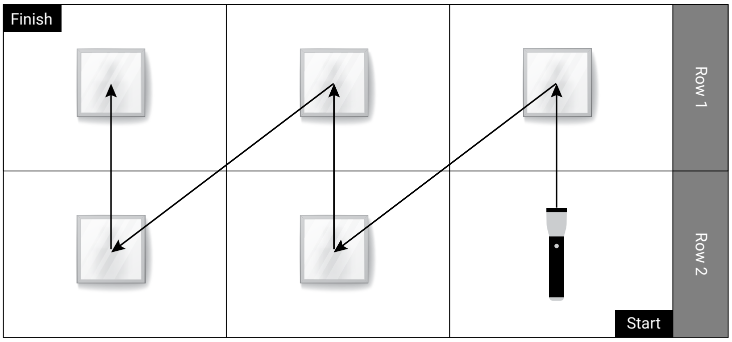
Encourage students to summarize their understanding of the different ways the Sun's light (modeled by the flashlight) behaved when it struck opaque, shiny, and clear objects and the relationship between the angle of the mirror and the line of reflection. *Note: There is a rule for mirror reflections—that the angle of the incidence equals the angle of the reflection—but this is not the point in this lesson. Rather, this lesson introduces the concept of a definite line of light that reflects from the mirror.*

Extend

Organize a light-tag activity. Darken the classroom (turn the lights off and draw the shades) and seat students in two facing rows. Each pair of facing rows is a group. Give a flashlight to a student seated at the end of a row and give small acrylic mirrors to the other students. The goal is for the group members with mirrors to adjust

Figure 3.2

One Way to Organize Students in Rows for Light Tag



them so that the light from the flashlight reflects off each mirror in turn until the light reaches the last person in the group (see Figure 3.2). Then, ask each group to explain what they learned about how to position the mirrors.

Evaluate

Summative evaluation of this lesson will include assessment of students' understanding of (1) what it means to be imaginative and how scientists and engineers might benefit from the character trait of being imaginative and (2) the behavior of light when it hits an object and the benefits of reflected light.

CHARACTER TRAIT

Encourage students to answer the following questions:

1. If Annie Jump Cannon had not designed the starlight classification system, do you think someone else would have? *Although others might eventually have thought of these ideas, Cannon was imaginative and saw a relationship between the heat of the stars and the light being emitted.*
2. Why is being imaginative an important attribute for scientists to have and how was Cannon imaginative? *Imaginative people are clever and often see things that others overlook. In Cannon's case, she perceived the relationship between a star's spectra and its temperature (i.e., she recognized that hotter stars are bluer and cooler stars are redder). From that, she developed a shorter, more accurate system for classifying stars than any astronomer before or since her time.*
3. Brainstorm with a partner about a time when you were (or wished you were) imaginative and/or to think of someone else you consider to be imaginative, such as a family member or neighbor.

CONTENT

You will want to assess students' understanding about how the Sun's light behaves when it strikes opaque, shiny, and clear objects and how light is reflected in a mirror. Table 3.1 is a rubric you might use to evaluate their science notebook entries.

Table 3.1

Rubric for Assessing Student Science Notebook Entries for Starlight—Light From the Sun

Content	Not Yet	Beginning	Developing	Secure
Opaque Objects	Student did not include information about the rock and paper blocking some light and casting a shadow.	Student included some information about the rock and paper blocking some light and casting a shadow.	Student included much information about the rock and paper blocking some light and casting a shadow.	Student included much information about the rock and paper blocking some light and casting a shadow and a clear explanation for that phenomenon.
Shiny Objects	Student did not include information about the aluminum foil reflecting or redirecting some light.	Student included some information about the aluminum foil reflecting or redirecting some light.	Student included much information about the aluminum foil reflecting or redirecting some light.	Student included much information about the aluminum foil reflecting or redirecting some light and a clear explanation for that phenomenon.
Clear Objects	Student did not include information about the water and plastic bag allowing the light to pass through them.	Student included some information about the water and plastic bag allowing the light to pass through them.	Student included much information about the water and plastic bag allowing the light to pass through them.	Student included much information about the water and plastic bag allowing the light to pass through them and a clear explanation for that phenomenon.
Mirror	Student did not produce three diagrams with an arrow showing the direction of the reflected (outgoing) light.	Student produced three diagrams but they did not all have an arrow showing the direction of the reflected (outgoing) light.	Student produced three diagrams and all had an arrow showing the direction of the reflected (outgoing) light.	Has three diagrams that include an arrow to show the direction of the reflected (outgoing) light. Highlights the relationship between the angle of incidence and the angle of reflection.

Index

Page numbers printed in **bold** type indicate tables, figures, or illustrations.

A

Ada Byron Lovelace and the Thinking Machine (Wallmark), 159, 163–166, **340**
Ada Lovelace Day website, 170
age-appropriate content, trade book selection, 336
Airboat Race lesson, 159–172
  description and overview, 159, 163
  learning outcomes, 159
  making sense, 166–171, **172**
    evaluate, 170–171, **172**
    explain, 168, 170
    explore, 166–168, **167**, **169**
    extend, 170, **171**
  materials, 163
  NGSS and Nature of Science connections, 160–162
  objectives, 159
  safety notes, 163
  setting the context, 163–166
    engage, 163
    guided reading, 163–166
analyzing and interpreting data
  about, 119
  integration of science and mathematics, 119–120, 356–357
  See also Sandhill Crane Migration lesson; Sizing Up Snowflakes lesson; Water Cycle in a Bag lesson
Annie Jump Cannon, Astronomer (Gerber), 49, 52, 54–56, **339**
Aqua Lung, 182, 187–188
Arbor Day and Earth Day lesson, 286–295
  description and overview, 286, 289
  learning outcomes, 287
  making sense, 292–295
    evaluate, 294–295, **295**
    explain, 294
    explore, 292, **293**
    extend, 294
  materials, 289
  NGSS and Nature of Science connections, 287–289
  objectives, 286
  setting the context, 289–292
    engage, 289–290
    guided reading, 290–292
argument from evidence. *See* engaging in argument from evidence
asking questions and defining problems
  about, 9
  designating makerspaces, 9–10, 352–353, **354**, 355
  See also Edison's Three Questions lesson; How Are Fruits and Vegetables Different? lesson; Thinking and Tinkering lesson
assessment rubrics
  Airboat Race lesson, **172**
  Arbor Day and Earth Day lesson, **295**
  Building Dinosaurs lesson, **271**
  Chirping Crickets lesson, **92**
  Digging Up Dinosaurs lesson, **117**
  Edison's Three Questions lesson, **34**
  Electric Action lesson, **248**
  Exploring Suspension Bridges lesson, **217**
  Food Delivery Design Challenge, **320**
  Gravity Versus Microgravity lesson, **307**
  How Are Fruits and Vegetable Different? lesson, **45**
  How Do Submersibles Work? lesson, **191**
  Inventing a Solution lesson, **232**
  M is for Motion lesson, **181**
  Mysterious Sawfish lesson, **259**
  New Uses lesson, **285**
  Pass It Along lesson, **78**
  Puzzling Potatoes lesson, **103**
  Racing Against Friction lesson, **207**
  Rosie Revere, Engineer lesson, **333**
  Round and Round We Go! lesson, **68**

Sandhill Crane Migration lesson, **155**
Sizing Up Snowflakes lesson, **130**
Starlight—Light From the Sun lesson, **59**
Thinking and Tinkering lesson, **21**
Water Cycle in a Bag lesson, **140**
What Do You Do With an Idea? lesson, **326**
Audubon, John James, 141, 145, 146–148, **147**, 152, 153–154, 342
See also Sandhill Crane Migration lesson

B

Babbage, Charles, 164–166
Ballard, Bob, 258
Barnum's Bones (Fern), 104, 108–110, **339**
Bentley, Wilson, 121, 124, 125–126, *127*, 128–129, 342
See also Sizing Up Snowflakes lesson
Big Beast Book (Booth), 269
bioinspiration, 229
bird banding, 145–146
book overview
5E learning-cycle format, 5
chapters and lessons structure, 2, 7–8
character traits of featured scientists, 3
children's views of scientists, 6–7, **7**
Eureka! title, 1–2
NGSS connections, 2–3
recommended science teaching strategies, 3–4
safety considerations, 5–6
The Boy Who Drew Birds (Davies), 141, 145, 146–148, **340**
The Boy Who Harnessed the Wind (Kamkwamba and Mealer), 218, 222, 223–225, **340**
The Boy Who Invented TV (Krull), 11, 13, **339**
brainstorming. *See* What Do You Do With an Idea? lesson
bridges. *See* Exploring Suspension Bridges lesson
The Brooklyn Bridge (Mann), 208, 211, 212–214, **212**, **340**
Brown, Barnum, 104, 107, 108–110, **109**, 116, 342
See also Digging Up Dinosaurs lesson
Building Dinosaurs lesson, 260–272
description and overview, 260, 264
learning outcomes, 260
making sense, 267–270, **271**
evaluate, 270, **271**
explain, 267, 269
explore, 267, **268**, **269**
extend, 269–270
materials, 264
NGSS and Nature of Science connections, 261–263
objectives, 260
safety notes, 264
setting the context, 264–267
engage, 264
guided reading, 264–267

C

Calypso (research vessel), 186, 187
Cannon, Annie Jump, 49, 52, 54–56, **55**, 58, 342
See also Starlight—Light From the Sun lesson
Carson, Rachel, 276, 279, 280–281, **281**, 283, 284, 342
See also New Uses lesson
Carver, George Washington, 35, 37, 38–39, **40**, 44, 342
See also How Are Fruits and Vegetable Different? lesson
CER (claim, evidence, and reasoning), 235–236, 237, 247–248, 249, 250, 258, 259, 270, 359
character traits
clever (Racing Against Friction lesson), 195, 196, 198, 199, 205–206
confident (How Do Submersibles Work? lesson), 182, 186, 191
courageous (*M* is for Motion lesson), 173, 176, 177, 180–181
creative (Building Dinosaurs lesson), 260, 264, 269, 270
curiosity (Sandhill Crane Migration lesson), 141, 142, 145, 146, 153–154
dedication (Sizing Up Snowflakes lesson), 121, 122, 124, 125–126, 128, 129
diligence (How Are Fruits and Vegetables Different? lesson), 35, 44
dreamer (Water Cycle in a Bag lesson), 131, 132, 135, 139–140
fearless (Mysterious Sawfish lesson), 249, 250, 253, 254, 258
glossary of, 350
imaginative (Starlight—Light From the Sun lesson), 49, 50, 52, 58
innovative (Airboat Race lesson), 159, 163, 170–171
inquisitive (Gravity Versus Microgravity lesson), 296, 297, 300, 302, 305–306
inspired (Edison's Three Questions lesson), 22–23, 33–34
intuitive (Digging Up Dinosaurs lesson), 104, 105, 108, 115, 116
inventive (Inventing a Solution lesson), 218, 219, 222, 224, 230
observant (Chirping Crickets lesson), 83, 85, 90, 91
passionate (Arbor Day and Earth Day lesson), 286, 287, 289, 290, 292, 294
patience (Pass It Along lesson), 69, 71, 72, 77–78

persistent (Exploring Suspension Bridges lesson), 208, 209, 211, 216
persuasive (New Uses lesson), 276, 277, 279, 280, 284
puzzler (Puzzling Potatoes lesson), 93–94, 96, 102
risk taker (Electric Action lesson), 237, 240, 243, 247
thinker (Thinking and Tinkering lesson), 11, 13, 19–20
visionary (Round and Round We Go! lesson), 60, 63, 67
Chemistry Matters (AIMS Education Foundation), 120
Chirping Crickets (Berger), 90
Chirping Crickets lesson, 83–92
description and overview, 83, 84
learning outcomes, 83
making sense, 88–91, **92**
evaluate, 90–91, **91**, **92**
explain, 89
explore, 88, **89**, 90
extend, 90
materials, 86, **86**
NGSS and Nature of Science connections, 84–85
objectives, 83
safety notes, 86
setting the context, 86–88
engage, 86
guided reading, 86–88
citizen science, 273–275, 359–360
clever (character trait), 195, 196, 198, 199, 205–206
clouds. *See* Water Cycle in a Bag lesson
concept mapping, 310, 327, 329, **331**, 332, **333**, 360, **361**
confident (character trait), 182, 186, 191
constructing explanations (science) and designing solutions (engineering)
about, 193
KLEW charts, 193–194, 199, 211, 223, 358, **359**. *See also* Exploring Suspension Bridges lesson; Inventing a Solution lesson; Racing Against Friction lesson content
content
Airboat Race lesson, 171, **172**
Arbor Day and Earth Day lesson295, **295**
Building Dinosaurs lesson, 270, **271**
Chirping Crickets lesson, 91, **92**
Edison's Three Questions lesson, 34, **34**
Electric Action lesson, 247–248, **248**
Exploring Suspension Bridges lesson, 216, **217**
Gravity Versus Microgravity lesson, 306, **307**
How Are Fruits and Vegetables Different? lesson, 44, **45**
Inventing a Solution lesson, 230–231, **231**, **232**
M is for Motion lesson, 181, **181**
Mysterious Sawfish lesson, 259, **259**
New Uses lesson, 284, **285**
Pass It Along lesson, 78, **78**
Puzzling Potatoes lesson, 102, **103**
Racing Against Friction lesson, 206–207, **207**
Round and Round We Go! lesson, 68, **68**
Sandhill Crane Migration lesson, 154, **155**
Sizing Up Snowflakes lesson, 130, **130**
Starlight—Light From the Sun lesson, 58, **59**
Thinking and Tinkering lesson, 20, **20**, **21**
Water Cycle in a Bag lesson, 140, **140**
courageous (character trait), 173, 176, 177, 180–181
Cousteau, Jacques, 182, 186, 187–188, **188**, 191, 342
See also How Do Submersibles Work? lesson
Creating Snowflakes activity, 125, 128
creative (character trait), 260, 264, 269, 270
Crime Scene Investigations (Walker and Wood), 77
crosscutting concepts
Airboat Race lesson, 162
Arbor Day and Earth Day lesson, 288
Building Dinosaurs lesson, 262
Chirping Crickets lesson, 84
Digging Up Dinosaurs lesson, 106
Edison's Three Questions lesson, 24
Electric Action lesson, 239
Exploring Suspension Bridges lesson, 210
Gravity Versus Microgravity lesson, 299
How Are Fruits and Vegetables Different? lesson, 36
How Do Submersibles Work? lesson, 184
Inventing a Solution lesson, 221
M is for Motion lesson, 175
Mysterious Sawfish lesson, 251
New Uses lesson, 278
Pass It Along lesson, 70
Puzzling Potatoes lesson, 95
Racing Against Friction lesson, 197
Rosie Revere, Engineer lesson, 329
Round and Round We Go! lesson, 62
Sandhill Crane Migration lesson, 143
Sizing Up Snowflakes lesson, 123
Starlight—Light From the Sun lesson, 51
summary table, **347–348**
Thinking and Tinkering lesson, 12
Water Cycle in a Bag lesson, 133
What Do You Do With an Idea? lesson, 322
curiosity (character trait), 141, 142, 145, 146, 153–154

D

Darwin, Charles, 93, 96, 98–99, **98**, 100–101, 102, 342
    See also Puzzling Potatoes lesson
Darwin (McGinty), 93, 96, 98–99, **339**
DDT insecticide, 279
dedication (character trait), 121, 122, 124, 125–126, 128, 129
design
    engineering design process, 17–18, **17**
    See also Food Delivery Design Challenge; Rosie Revere, Engineer lesson; What Do You Do With an Idea? lesson
designating makerspaces, 9–10, 352–353, **354**, 355
Design for a Livable Planet (Naar), 283
Desmos graphing tool, 157–158, 170, **171**
developing and using models
    about, 47
    Ferris wheel model, 65–66, **66**, **68**
    graphic organizers as models, 47–48, 355, **355**
    stacked-paper model of the universe, 53, **53**
    See also Building Dinosaurs lesson; Pass It Along lesson; Round and Round We Go! lesson; Starlight—Light From the Sun lesson
Digging Up Dinosaurs lesson, 104–117
    description and overview, 104, 108
    learning outcomes, 105
    making sense, 110–116, **117**
        evaluate, 115–116, **117**
        explain, 114–115
        explore, 110, **111–112**, **113**, **114**
        extend, 115
    materials, 108
    NGSS and Nature of Science connections, 105–107
    objectives, 104
    setting the context, 108–110
        engage, 108
        guided reading, 108–110
diligence (character trait), 35, 44
dinosaurs. *See* Building Dinosaurs lesson; Digging Up Dinosaurs lesson
The Dinosaurs of Waterhouse Hawkins (Kerley), 260, 264–267, **340**
disciplinary core ideas
    Airboat Race lesson, 160
    Arbor Day and Earth Day lesson, 287
    Building Dinosaurs lesson, 261
    Chirping Crickets lesson, 84
    Digging Up Dinosaurs lesson, 106
    Edison's Three Questions lesson, 23
    Electric Action lesson, 238
    Exploring Suspension Bridges lesson, 209
    Food Delivery Design Challenge, 312
    Gravity Versus Microgravity lesson, 297
    How Are Fruits and Vegetables Different? lesson, 36
    How Do Submersibles Work? lesson, 183
    Inventing a Solution lesson, 219–220
    M is for Motion lesson, 174
    Mysterious Sawfish lesson, 250–251
    New Uses lesson, 277
    Pass It Along lesson, 70
    Puzzling Potatoes lesson, 94
    Racing Against Friction lesson, 196
    Rosie Revere, Engineer lesson, 328
    Round and Round We Go! lesson, 61
    Sandhill Crane Migration lesson, 142
    Sizing Up Snowflakes lesson, 122
    Starlight—Light From the Sun lesson, 50
    summary table, **343–346**
    Thinking and Tinkering lesson, 12
    Water Cycle in a Bag lesson, 132
    What Do You Do With an Idea? lesson, 321–322
dreamer (character trait), 131, 132, 135, 139–140

E

Earle, Sylvia, 182, 190, 249, 253–254, **255**, 258–259, 342
    See also Mysterious Sawfish lesson
Earth Day. *See* Arbor Day and Earth Day lesson
The Edge of the Sea (Carson), 281
edible plant parts diagram, **39**, 40, 42
Edison's Three Questions lesson, 22–34
    description and overview, 22, 25
    learning outcomes, 23
    making sense, 29–34
        evaluate, 33–34, **34**
        explain, 29, **30**, 32, **32**
        explore, 29, **30**, **31**
        extend, 32–33
    materials, 25–26
    NGSS and Nature of Science connections, 23–24
    objectives, 22
    safety notes, 25
    setting the context, 26–28
        engage, 26–27, **27**
        guided reading, 27–28
Edison, Thomas, 22, 25, *25*, 27–28, 33, 242, 342
    See also Edison's Three Questions lesson
effective questioning, 81–82, 355–356, **356**
egg-drop challenge, 193

Electric Action lesson, 237–248
  description and overview, 237, 240
  learning outcomes, 237
  making sense, 243–248
    evaluate, 247–248, **248**
    explain, 244
    explore, 243–244, **243**, **244**
    extend, 245–246, **245**
  materials, 240
  NGSS and Nature of Science connections, 237–239
  objectives, 237
  safety notes, 240
  setting the context, 241–243
    engage, 241–242
    guided reading, 242–243
Electrical Wizard (Rusch), 237, 240, 242–243, 244, **340**
energy phase demonstration, 26–27, **27**
engaging in argument from evidence
  about, 235
  science talk, 235–236, 359
  See also Building Dinosaurs lesson; Electric Action lesson; Mysterious Sawfish lesson
engineering design process (EDP)
  process chart, 17–18, **17**
  See also Food Delivery Design Challenge; Rosie Revere, Engineer lesson; What Do You Do With an idea? lesson
environment. *See* Arbor Day and Earth Day lesson; Gravity Versus Microgravity lesson; New Uses lesson
evidence. *See* engaging in argument from evidence
explicit questioning, 9
Exploring Suspension Bridges lesson, 208–217
  description and overview, 208, 211
  learning outcomes, 209
  making sense, 214–216, **217**
    evaluate, 216, **217**
    explain, 214–215
    explore, 214, **215**
    extend, 215
  materials, 211
  NGSS and Nature of Science connections, 209–210
  objectives, 208
  safety notes, 211
  setting the context, 211–214
    engage, 211
    guided reading, 212–214

F

Farnsworth, Philo, 11, 13, 15–17, **15**, 19–20, 342
  See also Thinking and Tinkering lesson
fearless (character trait), 249, 250, 253, 254, 258
Ferris, Jr., George Washington, 60, 63–65, **65**, 67, 342
  See also Round and Round We Go! lesson
Food Delivery Design Challenge, 311–320
  description and overview, 311, 315
  learning outcomes, 311
  making sense, 317–320
    evaluate, 320, **320**
    explain, 319, **319**
    explore, 317–318, **317**, **318**
    extend, 319–320, **320**
  materials, 315
  NGSS and Nature of Science connections, 312–314
  objectives, 311
  safety notes, 315
  setting the context, 315–316
    engage, 315
    guided reading, 315–316
force-fitting, 229–230
Ford, Henry, 33
fossils. *See* Digging Up Dinosaurs lesson
friction. *See* Racing Against Friction lesson

G

Galilei, Galileo, 173, 176–177, **178**, 180, 342
  See also M is for Motion lesson
Genetic Science Learning Center website, 72
genetic traits, 77
Goodall, Jane, 83, 85, 86–88, *87*, 90, 91, 342
  See also Chirping Crickets lesson
graphic organizers as models, 47–48, 355, **355**
Gravity Versus Microgravity lesson, 296–308
  description and overview, 296, 300
  learning outcomes, 297
  making sense, 303–306, **307**
    evaluate, 305–306, **307**
    explain, 303, 305
    explore, 303, **304**, **305**
    extend, 305
  materials, 300
  NGSS and Nature of Science connections, 297–299
  objectives, 296
  safety notes, 300
  setting the context, 301–302
    engage, 301–302

guided reading, 302
The Green Consumer (Makower), 283
green improvements, 283
Gregor Mendel (Bardoe), 69, 72–74, 336, **339**
guided reading
Airboat Race lesson, 163–166
Arbor Day and Earth Day lesson, 290–292
Building Dinosaurs lesson, 264–267
Chirping Crickets lesson, 86–88
Digging Up Dinosaurs lesson, 108–110
Edison's Three Questions lesson, 27–28
Electric Action lesson, 242–243
Exploring Suspension Bridges lesson, 212–214
Food Delivery Design Challenge, 315–316
Gravity Versus Microgravity lesson, 302
How Are Fruits and Vegetables Different? lesson, 38–39
How Do Submersibles Work? lesson, 187–188
Inventing a Solution lesson, 223–225
M is for Motion lesson, 177
Mysterious Sawfish lesson, 253–255
New Uses lesson, 280–281, 283
Pass It Along lesson, 72–74
Puzzling Potatoes lesson, 98–99
Racing Against Friction lesson, 199–201
Rosie Revere, Engineer lesson, 330–331
Round and Round We Go! lesson, 64–65
Sandhill Crane Migration lesson, 146–148
Sizing Up Snowflakes lesson, 125–126
Starlight—Light From the Sun lesson, 54–56
Thinking and Tinkering lesson, 15–17
Water Cycle in a Bag lesson, 135–136
What Do You Do With an Idea? lesson, 323–324

H
Harlen, Wynne, 10
Have You Seen Mary? (Kurrus), 152
Hawkins, Waterhouse, 260, 264–267, **265**, 270, 342
See also Building Dinosaurs lesson
Heloise's Hints for a Healthy Planet (Heloise), 283
Howard, Luke, 131, 135, 136, **137**, 140, 342
See also Water Cycle in a Bag lesson
How Are Fruits and Vegetables Different? lesson, 35–46
description and overview, 35, 37
learning outcomes, 36
making sense, 40–46
evaluate, 44, **45**
explain, 42–43, **43**
explore, **39**, 40–42, **41**, **42**
extend, 43
materials, 37
NGSS and Nature of Science connections, 36–37
objectives, 35
safety notes, 37
setting the context, 38–39
engage, 38
guided reading, 38–39
How the Dinosaur Got to the Museum (Hartland), 115
How Do Birds Find Their Way? (Gans), 148
How Do Submersibles Work? lesson, 182–192
description and overview, 182, 186
learning outcomes, 182
making sense, 188–191
evaluate, 191, **191**
explain, 190
explore, 188–190, **189**
extend, 190
materials, 186
NGSS and Nature of Science connections, 183–185
objectives, 182
safety notes, 186
setting the context, 186–188
engage, 186–187
guided reading, 187–188

I
illustrations, trade book selection, 336, 337
imaginative (character trait), 49, 50, 52, 58
implicit questioning, 9
"In-Flight Education Downlinks," 305
information. *See* obtaining, evaluating, and communicating information
inheritance. *See* Pass It Along lesson
innovative (character trait), 159, 163, 170–171
inquisitive (character trait), 296, 297, 300, 302, 305–306
inspired (character trait), 22–23, 33–34
integration of science and mathematics, 119–120, 356–357
intuitive (character trait), 104, 105, 108, 115, 116
Inventing a Solution lesson, 218–233
description and overview, 218, 222
learning outcomes, 219
making sense, 225–231, **232**
evaluate, 230–231, **230**, **231**
explain, 229
explore, 225–226, **226**, **227**, 228–229, **228**, **229**
extend, 229–230
materials, 222

NGSS and Nature of Science connections, 219–222
objectives, 218
safety notes, 222
setting the context, 223–225
engage, 223
guided reading, 223–225
inventive (character trait), 218, 219, 222, 224, 230
The Inventor's Secret (Slade), 22, 33
It Looked Like Spilt Milk (Shaw), 139

J
Jericho Historical Society, 129

K
Kamkwamba, William, 218, 222, 223–225, **225**, 230, 342
See also Inventing a Solution lesson
Kid Wind Project, 230
KLEW charts, 193–194, 199, 211, 223, 358, **359**

L
lesson guidelines
planning your own lessons, 337
trade book selection, 335–337
Life in the Ocean (Nivola), 249, 253–254, **340**
light beam experiment, 29, 32, **32**
lima bean plant embryo, 42–43, **43**
Lovelace, Ada Byron, 159, 163–166, **165**, 170, 342
See also Airboat Race lesson

M
Maathai, Wangari, 286, 289, 290–292, **291**, 294, 342
See also Arbor Day and Earth Day lesson
makerspaces, designating makerspaces, 9–10
Manfish (Berne), 182, 186, 187–188, 336, **340**
The Man Who Named the Clouds (Hannah and Holub), 131, 135–136, **339**
"Mass vs. Weight: Stretching Mass" lesson, 303, **304**, 305, **305**
mathematics. *See* using mathematics and computational thinking
McCoy, Elijah, 195, 196, 198, 199–201, **200**, 204–206, 342
See also Racing Against Friction lesson
McCoy, Mary, 201
Mendel, Gregor, 69, 72–74, **74**, 342
See also Pass It Along lesson
Merlin Bird ID app, 152
migration. *See* Sandhill Crane Migration lesson
M is for Motion lesson, 173–181
description and overview, 173, 176
learning outcomes, 173
making sense, 177–181
evaluate, 180–181, **181**
explain, 179–180
explore, 177–179, **179**, **180**
extend, 180, **181**
materials, 176
NGSS and Nature of Science connections, 174–175
objectives, 173
setting the context, 176–177
engage, 176
guided reading, 177
Mistakes That Worked (Jones), 18
models. *See* developing and using models
Mr. Ferris and His Wheel (Davis), 60, 63, 64–65, **339**
My Place in Space (Hirst and Hirst), 53
Mysterious Sawfish lesson, 249–259
description and overview, 249, 253
learning outcomes, 250
making sense, 255–259
evaluate, 258–259, **259**
explain, **256**, 257–258, **257**
explore, 255–257, **256**, **257**
extend, 258
materials, 253
NGSS and Nature of Science connections, 250–252
objectives, 249
setting the context, 253–255
engage, 253
guided reading, 253–255
Mystery Tube activity, 245–246, **245**

N
NASA (National Aeronautics and Space Administration), 300, 301, 303, 305
Nashua River, 284
National Council of Teachers of English (NCTE), 335
National Science Teachers Association (NSTA), 335
Nation of Makers website, 10
Nature of Science connections
Airboat Race lesson, 162
Arbor Day and Earth Day lesson, 288–289
Building Dinosaurs lesson, 262–263
Chirping Crickets lesson, 85
Digging Up Dinosaurs lesson, 107
Edison's Three Questions lesson, 24
Electric Action lesson, 239

Exploring Suspension Bridges lesson, 210
Food Delivery Design Challenge, 314
Gravity Versus Microgravity lesson, 299
How Are Fruits and Vegetables Different? lesson, 37
How Do Submersibles Work? lesson, 185
Inventing a Solution lesson, 221–222
M is for Motion lesson, 175
Mysterious Sawfish lesson, 252
New Uses lesson, 279
Pass It Along lesson, 71
Puzzling Potatoes lesson, 95–96
Racing Against Friction lesson, 197–198
Rosie Revere, Engineer lesson, 329
Round and Round We Go! lesson, 62
Sandhill Crane Migration lesson, 144
Sizing Up Snowflakes lesson, 123–124
Starlight—Light From the Sun lesson, 51–52
summary table, **348–349**
Thinking and Tinkering lesson, 13
Water Cycle in a Bag lesson, 134
What Do You Do With an Idea? lesson, 322

The New 50 Simple Things I Can Do to Save the Earth (Earthworks Group), 283

New Uses lesson, 276–285
description and overview, 276, 279
learning outcomes, 277
making sense, **282**, 283–284, **285**
evaluate, 284, **285**
explain, 283
explore, **282**, 283
extend, 284
materials, 279
NGSS and Nature of Science connections, 277–279
objectives, 276
setting the context, 280–283
engage, 280
guided reading, 280–281, 283

NGSS (Next Generation Science Standards) connections
Airboat Race lesson, 160–162
analyzing and interpreting data, 119
Arbor Day and Earth Day lesson, 287–288
asking questions and defining problems, 9
book overview, 2–3
Building Dinosaurs lesson, 261–262
Chirping Crickets lesson, 84
constructing explanations (science) and designing solutions (engineering), 193
developing and using models, 47
Digging Up Dinosaurs lesson, 105–106
Edison's Three Questions lesson, 23–24
Electric Action lesson, 238–239
engaging in argument from evidence, 235
Exploring Suspension Bridges lesson, 209–210
Food Delivery Design Challenge, 312–314
Gravity Versus Microgravity lesson, 297–299
How Are Fruits and Vegetables Different? lesson, 36–37
How Do Submersibles Work? lesson, 183–184
Inventing a Solution lesson, 219–221
M is for Motion lesson, 174–175
Mysterious Sawfish lesson, 250–251
New Uses lesson, 277–278
obtaining, evaluating, and communicating information, 273
planning and carrying out investigations, 81
Puzzling Potatoes lesson, 94–95
Racing Against Friction lesson, 196–197
Rosie Revere, Engineer lesson, 328–329
Sandhill Crane Migration lesson, 142–143
Sizing Up Snowflakes lesson, 122–123
Starlight—Light From the Sun lesson, 50–51
summary table, **343–348**
teaching how scientists and engineers work, 309
Thinking and Tinkering lesson, 12
trade book selection, 336
using mathematics and computational thinking, 157–158
Water Cycle in a Bag lesson, 132–133
What Do You Do With an Idea? lesson, 321–322

NOAA website, 190
nostrums. *See* Mysterious Sawfish lesson

O

observant (character trait), 83, 85, 90, 91
Observing Snow Crystals activity, 124, 126–127
obtaining, evaluating, and communicating information
about, 273
citizen science, 273–275, 359–360
See also Arbor Day and Earth Day lesson; Gravity Versus Microgravity lesson; New Uses lesson
Ocean Floor Mapping activity, 188–190, **189**
Ocean (Woodward), 258
On the Wing (Lerner), 148

P

paleontologists, 108
Papa's Mechanical Fish (Fleming), 309, 311, 315–316, **341**
passionate (character trait), 286, 287, 289, 290, 292, 294

Pass It Along lesson, 69–79
description and overview, 69, 72
learning outcomes, 69
making sense, 75–79
evaluate, 77–78, **79**
explain, 76
explore, 75, **76**
extend, 76
materials, 72
NGSS and Nature of Science connections, 70–71
objectives, 69
safety notes, 72
setting the context, 72–74
engage, 72
guided reading, 72–74
patent, 199
patience (character trait), 69, 71, 72, 77–78
pendulums. *See M* is for Motion lesson
persistent (character trait), 208, 209, 211, 216
persuasive (character trait), 276, 277, 279, 280, 284
A Picture Book of George Washington Carver, 35, **35**, 37, 38–39, **339**
planning and carrying out investigations
about, 81
effective questioning, 81–82, 355–356, **356**
See also Chirping Crickets lesson; Digging Up Dinosaurs lesson; Puzzling Potatoes lesson
Platte River, 150, **150**, 152
Preserving Snow Crystals activity, 125, 127–128
probeware and digital media, 157–158, 177–180, **179**, **180**, 182, 188–190, **189**, 357–358
problems. *See* asking questions and defining problems
Project Budburst, 274–275
Project FeederWatch, 274
puzzler (character trait), 93–94, 96, 102
Puzzling Potatoes lesson, 93–103
description and overview, 93, 96
learning outcomes, 94
making sense, 100–102, **103**
evaluate, 102, **103**
explain, 101
explore, 100, **100**
extend, 101
materials, 96
NGSS and Nature of Science connections, 94–96
objectives, 93
safety notes, 96–97
setting the context, 97–99
engage, 97, **97**
guided reading, 98–99

Q

questions. *See* asking questions and defining problems

R

Rachel Carson and Her Book That Changed the World (Lawlor), 276, 279, 280–281, 283, 335, **341**
Racing Against Friction lesson, 195–207
description and overview, 195, 198
learning outcomes, 196
making sense, 201–207
evaluate, 205–207, **207**
explain, 204–205
explore, 201, **201**, **202**, 203–204, **203**
extend, 205
materials, 198–199
NGSS and Nature of Science connections, 196–198
objectives, 195–196
safety notes, 199
setting the context, 199–201
engage, 199
guided reading, 199–201
rainbows, 56
The Real McCoy (Towle), 195, 198, 199–201, **340**
Rearing Horse (sculpture), 269–270
refraction of light, 29, 32, **32**
ringing (bird banding), 145–146
risk taker (character trait), 237, 240, 243, 247
A River Ran Wild (Cherry), 284
Roebling, Emily, 211, 212, 213, 216
Roebling, John, 208, 211, 212–214, **213**, 215, 216, 342
See also Exploring Suspension Bridges lesson
Roebling, Washington, 211, 212–214, 216
Rosie Revere, Engineer (Beaty), 309–310, 327, 329, 330–331, **341**
Rosie Revere, Engineer lesson, 327–333
description and overview, 327, 330
learning outcomes, 327
making sense, **331**, 332, **333**
evaluate, 332, **333**
explain, 332
explore, **331**, 332
extend, 332
materials, 329

NGSS and Nature of Science connections, 328–329
objectives, 327
setting the context, 329–331
engage, 329–330, **330**
guided reading, 330–331
Round and Round We Go! lesson, 60–68
description and overview, 60, 63
learning outcomes, 60
making sense, 65–68
evaluate, 67–68, **68**
explain, 67
explore, 65–66, **66**
extend, 67
materials, 63
NGSS and Nature of Science connections, 61–62
objectives, 60
safety notes, 63
setting the context, 63–65
engage, 63–64
guided reading, 64–65
Rowe Sanctuary website, 148, 150

S

Sagan, Carl, 296, 300, **301**, 302, 306, 342
See also Gravity Versus Microgravity lesson
Sandhill Crane Migration lesson, 141–156
description and overview, 141, 145
learning outcomes, 142
making sense, 148–154, **155**
evaluate, 153–154, **155**
explain, 149–153, **149**, **150**, **151**
explore, 148
extend, 153, **153**
materials, 145
NGSS and Nature of Science connections, 142–144
objectives, 141
safety notes, 145
setting the context, 145–148
engage, 145–146
guided reading, 146–148
science
citizen science, 273–275
as human endeavor, xii
science process skills, x–xii
science talk, 235–236, 359
science teaching and science literature, ix–x, xv
See also Nature of Science connections; science and engineering practices; science notebooks; science teaching strategies; teaching how scientists and engineers work
science and engineering practices
Airboat Race lesson, 160–161
Arbor Day and Earth Day lesson, 287–288
Building Dinosaurs lesson, 261–262
Chirping Crickets lesson, 84
Digging Up Dinosaurs lesson, 105–106
Edison's Three Questions lesson, 23
Electric Action lesson, 238
Exploring Suspension Bridges lesson, 209
Food Delivery Design Challenge, 312–314
Gravity Versus Microgravity lesson, 297–298
How Are Fruits and Vegetables Different? lesson, 36
How Do Submersibles Work? lesson, 183–184
Inventing a Solution lesson, 220–221
M is for Motion lesson, 174–175
Mysterious Sawfish lesson, 251
New Uses lesson, 277–278
Pass It Along lesson, 70
Puzzling Potatoes lesson, 94
Racing Against Friction lesson, 197
Rosie Revere, Engineer lesson, 328
Round and Round We Go! lesson, 61
Sandhill Crane Migration lesson, 142–143
Sizing Up Snowflakes lesson, 122–123
Starlight—Light From the Sun lesson, 50–51
summary table, **346–347**
Thinking and Tinkering lesson, 12
Water Cycle in a Bag lesson, 132–133
What Do You Do With an Idea? lesson, 322
science notebooks
Airboat Race lesson, 159
Chirping Crickets lesson, 88, **88**, 90, 91
Digging Up Dinosaurs lesson, 114
Edison's Three Questions lesson, 28, **28**
Food Delivery Design Challenge, 318, **318**, 320, **320**
How Are Fruits and Vegetables Different? lesson, **45**
Inventing a Solution lesson, 219, 223, 228–229, **229**, 230–231, **231**
M is for Motion lesson, 173, 179, 181
Mysterious Sawfish lesson, 250, 259
Pass It Along lesson, 72
Puzzling Potatoes lesson, 94, 100, **100**
Racing Against Friction lesson, 196, 204
Rosie Revere, Engineer lesson, 332
Sizing Up Snowflakes lesson, 128, 129–130
Starlight—Light From the Sun lesson, 58, **59**

Water Cycle in a Bag lesson, 138
science teaching strategies
about, 3–4, 351–352, **352**, **353**
citizen science, 273–275, 359–360
concept mapping, 310, 327, 329, **331**, 332, **333**, 360, **361**
designating makerspaces, 9–10, 352–353, **354**, 355
effective questioning, 81–82, 355–356, **356**
graphic organizers as models, 47–48, 355, **355**
integration of science and mathematics, 119–120, 356–357
KLEW charts, 193–194, 199, 211, 223, 358, **359**
probeware and digital media, 157–158, 177–180, **179**, **180**, 182, 188–190, **189**, 357–358
science talk, 235–236, 359
"Science Trade Book Evaluation Rubric," 335
scientists
children's views of, 6–7, **7**
illustrations of, xii–xv
SCUMPS (size, color, use, material, parts, and shape), 256, 257–258, **257**
The Sea Around Us (Carson), 281
Seeds of Change (Johnson), 286, 289, 290–292, **341**
self-assessment, Thinking and Tinkering lesson, **20**
Seven Blind Mice (Young), 115
"Shark Tank" (television show), 199, 205
Silent Spring (Carson), xiv, 335
Sizing Up Snowflakes lesson, 121–130
description and overview, 121, 124
learning outcomes, 122
making sense, 126–130, **130**
evaluate, 129–130, **130**
explain, 128
explore, 126–128
extend, 129
materials, 124–125
NGSS and Nature of Science connections, 122–124
objectives, 121
safety notes, 125
setting the context, 125–126
engage, 125
guided reading, 125–126
Snowcrystals website, 125
Snowflake Bentley (Martin), 121, 124, 125–126, 336, **339**
Snowflake Bentley website, 129
soda bottle bird feeder, 153, **153**
stacked-paper model of the universe, 53, **53**
star classification, 55–56
Starlight—Light From the Sun lesson, 49–59
description and overview, 49, 52
learning outcomes, 50
making sense, 56–59
evaluate, 58, **59**
explain, 57
explore, 56–57
extend, 57–58, **58**
materials, 52
NGSS and Nature of Science connections, 50–52
objectives, 49
safety notes, 52
setting the context, 53–56
engage, 53, **53**
guided reading, 54–56
Starry Messenger (S¡s), 173, 176, 177, 180, **340**
Star Stuff (Sisson), 296, 300, 302, **341**
STEAM education model, and maker thinking, 10
Steven Caney's Invention Book (Caney), 18
The Story of Snow (Cassino and Nelson), 129
student-created cloud formations, 139, **139**
student evaluation. *See* content
student inventions, 18–19, **19**
sunlight, 56–57
Survivor Tree, 294
suspension bridges. *See* Exploring Suspension Bridges lesson
symmetry. *See* Sizing Up Snowflakes lesson

T

teaching how scientists and engineers work
about, 309–310
concept mapping, 310, 327, 329, **331**, 332, **333**, 360, **361**
See also Food Delivery Design Challenge; Rosie Revere, Engineer lesson; What Do You Do With an Idea? lesson
Tesla, Nikola, 237, 240, **241**, 242–243, 247, 342
See also Electric Action lesson
thinker (character trait), 11, 13, 19–20
Thinking and Tinkering lesson, 11–21
description and overview, 11, 13
learning outcomes, 11
making sense, 17–21
assessment rubric, **21**
evaluate, 19–20, **19**
explain, 18
explore, 17–18, **17**
extend, 18–19
self-assessment, **20**

materials, 13–14
NGSS and Nature of Science connections, 12–13
objectives, 11
safety notes, 14
setting the context, 14–17
engage, 14–15
guided reading, 15–17
Trout in the Classroom program, 273–274

U

Under the Sea-Wind (Carson), 281
using mathematics and computational thinking
about, 157
probeware and digital media, 157–158, 177–180, **179**, **180**, 182, 188–190, **189**, 357–358
See also Airboat Race lesson; How Do Submersibles Work? lesson; *M* is for Motion lesson

V

Venn diagrams, 244, **244**, 286, 289, 292, **293**, 294, 295
visionary (character trait), 60, 63, 67

W

The Watcher (Winter), 83, 86–88, 336, **339**
Water Cycle in a Bag lesson, 131–140
description and overview, 131, 135
learning outcomes, 132
making sense, 136–140, **140**
evaluate, 139–140, **140**
explain, 138
explore, 136–138, **138**
extend, 138–139, **139**
materials, 135
NGSS and Nature of Science connections, 132–134
objectives, 131
safety notes, 135
setting the context, 135–136
engage, 135
guided reading, 135–136
weather. *See* Water Cycle in a Bag lesson
What Do You Do With an Idea? lesson, 321–326
description and overview, 321, 323
learning outcomes, 321
making sense, 324–326
evaluate, 325–326, **326**
explain, 325, **325**
explore, 324–325, **324**
extend, 325
materials, 323
NGSS and Nature of Science connections, 321–322
objectives, 321
setting the context, 323–324
engage, 323
guided reading, 323–324
What Do You Do With an Idea? (Yamada), 309, 321, 323–324, **341**
Williams, Sunita, 302
windmills. *See* Inventing a Solution lesson
World's Fair in Chicago, 63–64

Y

Young Birder's Guide to Birds of North America (Thompson), 152
Young Thomas Edison (Dooling), 22, 25, 27–28, **339**

EUREKA!

GRADE 3–5 SCIENCE ACTIVITIES AND STORIES

"Our goal is that these will be the lessons you cannot wait to teach every year with a new group of students."

—Authors Donna Farland-Smith and Julie Thomas

With *Eureka! Grade 3–5 Science Activities and Stories*, you've found a fresh, versatile way to put a human face on science and engineering! The title evokes Archimedes's famous cry because the book's lessons help your students make discoveries about who scientists and engineers are and what they do.

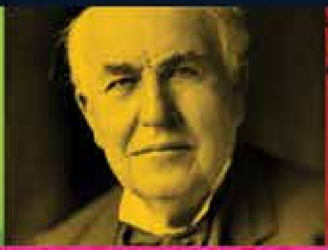
Eureka's appeal comes from its engaging lessons, which are built around 24 children's trade-book biographies of scientists and engineers. Some of these are well known, such as Galileo Galilei, George Washington Carver, and Jane Goodall. Others are not, such as astronomer Annie Jump Cannon, oceanographer Sylvia Earle, and engineer William Kamkwamba. But all of their stories will help your students see scientists and engineers not as stereotypes wearing goggles and lab coats, but as real women and men whose work and success stem from their life experiences and characters.

Each chapter is designed to do the following:

- **Focus on science and engineering practices.** These include asking questions and defining problems, planning and carrying out investigations, and analyzing and interpreting data.
- **Bring these practices to life** through the trade books and related lessons, which introduce a skill-building, inquiry-based investigation while highlighting the scientists' and engineers' work and the character traits that helped each succeed. You can teach one lesson or all three from each chapter—whatever will enrich your curriculum the most.
- **Be easy to use.** In addition to supporting the *Next Generation Science Standards*, each chapter recommends a teaching strategy and uses a learning-cycle format.

Authors Donna Farland-Smith and Julie Thomas point out one other big benefit that makes *Eureka!* a resource you'll turn to again and again. "We like to think of this book as a way to invite scientists and engineers into your classroom," they write, "without the hassle of finding and scheduling guest speakers."




Grades 3–5

NSTA press
National Science Teachers Association

PB423X1
ISBN: 978-1-68140-257-4
9 781681 402574