



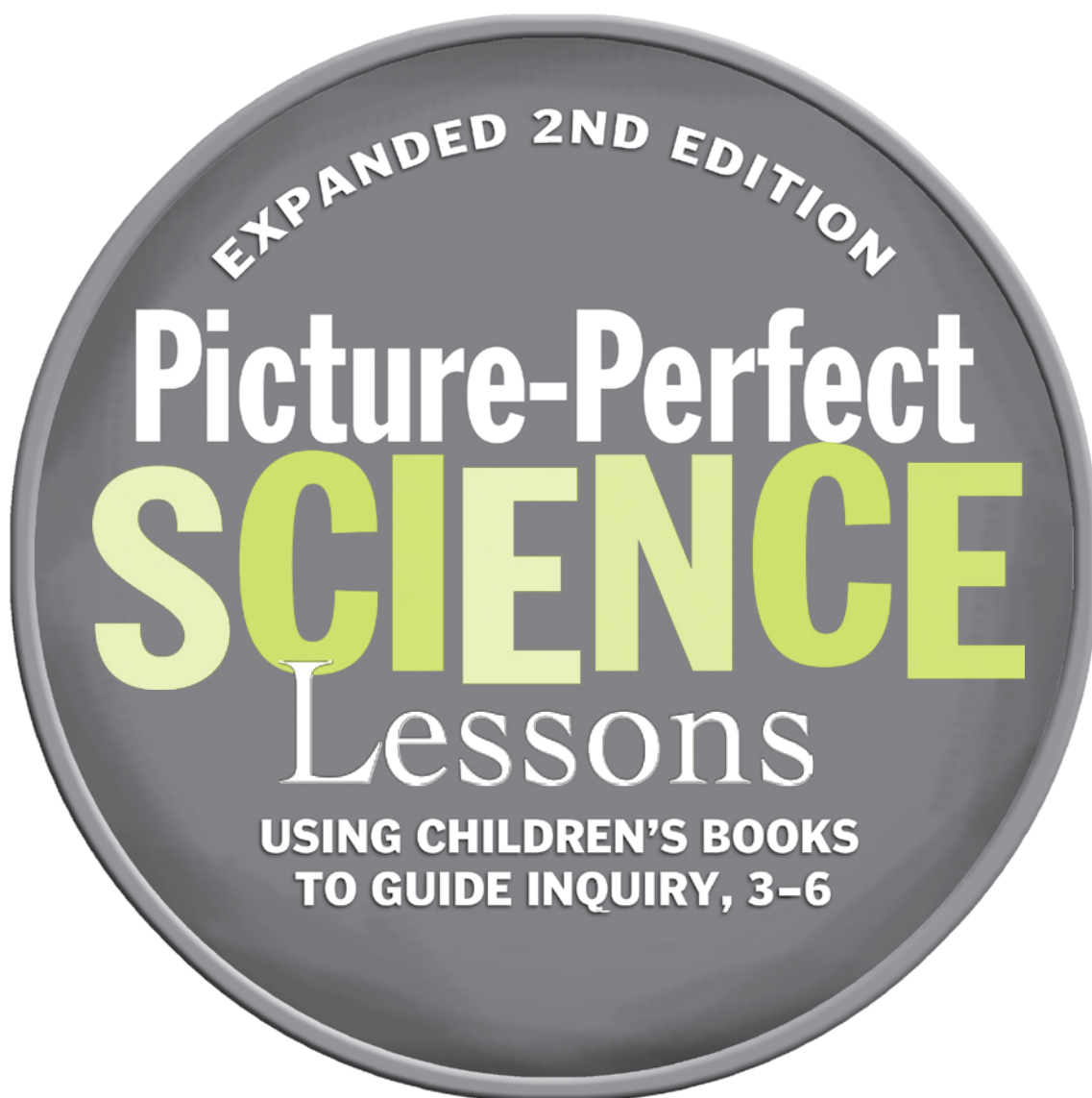
EXPANDED 2ND EDITION

Picture-Perfect SCIENCE Lessons

USING CHILDREN'S BOOKS
TO GUIDE INQUIRY, 3-6

by Karen Ansberry
and Emily Morgan

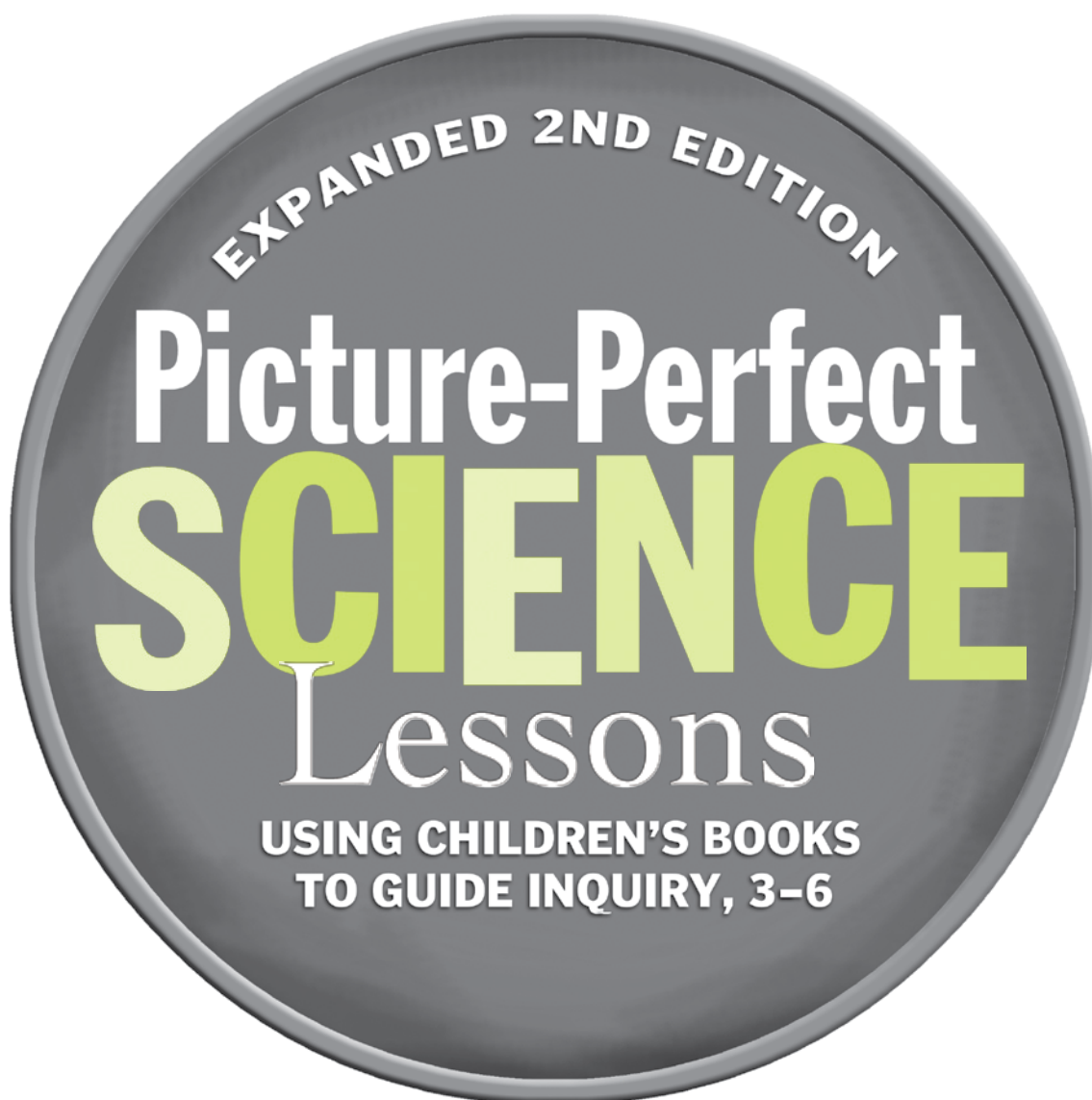
NTApress
National Science Teachers Association



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NSTApress
National Science Teachers Association
Arlington, Virginia



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Contents

Foreword.....	ix
Preface.....	xi
Acknowledgments.....	xiii
About the Authors.....	xv
About the Picture-Perfect Science Program.....	xvi
Lessons by Grade.....	xvii
1 Why Read Picture Books in Science Class?.....	1
2 Reading Aloud.....	9
3 Teaching Science Through Inquiry.....	17
4 BSCS 5E Instructional Model.....	27
5 National Science Education Standards.....	33
6 Earthlets.....	37
<i>Dr. Xargle's Book of Earthlets and Seven Blind Mice</i>	
7 Name That Shell!.....	55
<i>Seashells by the Seashore and A House for Hermit Crab</i>	
8 Rice Is Life.....	71
<i>Rice Is Life and Rice</i>	

9	What's Poppin'?	95
	<i>Popcorn!</i>	
10	Mystery Pellets	119
	<i>White Owl, Barn Owl and Butternut Hollow Pond</i>	
11	Close Encounters of the Symbiotic Kind	137
	<i>What's Eating You? Parasites—The Inside Story and Weird Friends: Unlikely Allies in the Animal Kingdom</i>	
12	Turtle Hurdles	161
	<i>Turtle Watch and Turtle, Turtle, Watch Out!</i>	
13	Oil Spill!	177
	<i>Prince William and Oil Spill!</i>	
14	Sheep in a Jeep	191
	<i>Sheep in a Jeep</i>	
15	Sounds of Science	217
	<i>Sound and The Remarkable Farkle McBride</i>	
16	Chemical Change Café	227
	<i>Pancakes, Pancakes!</i>	
17	The Changing Moon	247
	<i>Rise the Moon; The Moon Book; and Papa, Please Get the Moon for Me</i>	
18	Day and Night	263
	<i>Somewhere in the World Right Now</i>	
19	Grand Canyon	277
	<i>Erosion and Grand Canyon: A Trail Through Time</i>	
20	Brainstorms: From Idea to Invention	291
	<i>Imaginative Inventions and Girls Think of Everything: Stories of Ingenious Inventions by Women</i>	

21	Bugs!307 <i>The Perfect Pet; Bugs Are Insects; Ant, Ant, Ant! (An Insect Chant)</i>
22	Batteries Included 325 <i>Electrical Circuits and Too Many Toys</i>
23	The Secrets of Flight345 <i>How People Learned to Fly and Kids' Paper Airplane Book</i>
24	Down the Drain361 <i>Down the Drain: Conserving Water and A Cool Drink of Water</i>
25	If I Built a Car373 <i>If I Built a Car and Inventing the Automobile</i>
	Glossary 393
	Index 399

Foreword

I had the good fortune to meet the authors of *Picture-Perfect Science Lessons*, Karen Ansberry and Emily Morgan, in the fall of 2003 at a workshop I facilitated on inquiry-based science. At that event, we had a lively discussion about the nature of science and how the teachers in attendance might impart their love of science to elementary-age children. The authors then took me aside and told me of their plans to write a book for teachers (and parents, too) using children’s literature to engage children in scientific inquiry. I have always believed that children in the elementary grades would experience more science if elementary teachers were provided with better ways to integrate literacy and science. So, of course, I was intrigued.

As I reviewed this manuscript, I was reminded of one of my favorite “picture books” as an adult—*The Sense of Wonder*, by Rachel Carson. In that book, Ms. Carson expresses her love of learning and how she helped her young nephew discover the wonders of nature. As she expressed,

I sincerely believe that for the child, and for the parent seeking to guide him, it is not half so important to know as to feel. If facts are the seeds that later produce knowledge and wisdom, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow. The years of early childhood are the time to prepare the soil. Once the emotions have been aroused—a sense of the beautiful, the excitement of the new and the unknown, a feeling of sympathy,

pity, admiration or love—then we wish for knowledge about the object of our emotional response. Once found, it has lasting meaning. It is more important to pave the way for the child to want to know than to put him on a diet of facts he is not ready to assimilate.
(Carson 1956)

Rachel Carson used the natural environment to instill in her nephew the wonders of nature and scientific inquiry, but I believe, along with the authors, that picture books can have a similar emotional effect on children and inspire their wonder and their curiosity. Then, when teachers and parents couple scientific inquiry experiences with the content of the picture books, science really comes to life for children. *Picture-Perfect Science Lessons* provides an ideal framework that encourages children to read first; explore objects, organisms, and events related to what they’ve read; discern relationships, patterns, and explanations in the world around them; and then read more to gather more information, which will lead to new questions worth investigating.

In addition, *Picture-Perfect Science Lessons* is the perfect antidote to leaving science behind in the elementary classroom. As elementary teachers struggle to increase the basic literacy of all students, they often cannot find the time to include science in the curriculum, or they are discouraged from teaching science when literacy scores decline. Teachers need resources such as *Picture-Perfect Science Lessons* to genuinely integrate science and literacy. There is no doubt that inquiry-based science experiences

motivate children to learn. Through this book, teachers have the best of both worlds—they will have the resources to motivate children to read and to “do science.” What could be better?

As one of the developers of the BSCS 5E Instructional Model, I was gratified to learn that the authors intended to use the “5Es” to structure their learning experiences for children and teachers. These authors, as with many teachers across the country, had become acquainted with the 5Es and used the model extensively to promote learning in their own classrooms; however, they did not know the origin of the model until we had a conversation about BSCS and the 5Es. This book helps set the record straight—the 5E Instructional Model was indeed developed at BSCS in the late 1980s in conjunction with an elementary curriculum project and thus is appropriately titled “The BSCS 5E Instructional Model” in this book. The authors’ iterative use of the BSCS 5Es is appropriate because the model is meant to be fluid, where one exploration leads to a partial explanation that invites further exploration before a child has a grasp of a complete scientific explanation for a phenomenon. As the authors mention, the final E—evaluate—is applied more formally at the end of a unit of study, but the BSCS 5E model by no means

implies that teachers and students do not evaluate, or assess, student learning as the students progress through the model. Ongoing assessment is an integral part of the philosophy of the BSCS 5Es and the authors appropriately weave formative assessment into each lesson.

Once you place your toe into the waters of this book, I guarantee that you will dive right in! Whether you are a teacher, a parent, or both, you will enjoy this inviting approach to inquiry-based science. If you follow the methods outlined in *Picture-Perfect Science Lessons*, you and the children with whom you interact will have no choice but to learn science concepts through reading and scientific inquiry.

I don’t know about you, but I’m rather curious about those sheep in a jeep. Enjoy!

Nancy M. Landes
Senior Science Educator
Center for Professional Development
Biological Sciences Curriculum Study

Reference

Carson, R. 1956. *The sense of wonder*. Berkeley, CA: The Nature Company. (Copyright renewed 1984 by Roger Christie. Text copyright 1956 by Rachel Carson.)

Preface

A class of fifth-grade students laughs as their teacher reads Jeanne Willis's *Dr. Xargle's Book of Earthlets*. Students are listening to the alien professor, Dr. Xargle, teach his pupils about Earthlets (human babies): "Earthlets are born without fangs. At first, they drink only milk, through a hole in their faces called a mouth. When they finish the milk, they are patted and squeezed so they won't explode." The fifth-grade class giggles at this outrageous lesson as Dr. Xargle continues to lecture. Students then begin sorting cards containing some of the alien professor's "observations" of Earthlets. The teacher asks her students, "Which of Dr. Xargle's comments are truly observations?" Students review their cards and realize that many of his comments are not observations but rather hilariously incorrect inferences. They re-sort their cards into two groups: observations and inferences. This amusing picture book and word sorting activity guide students into hands-on inquiry where they make observations about sealed mystery samples Dr. Xargle collected from Earth. Eventually students develop inferences about what the mystery samples might be. Through this exciting lesson, students construct their own understanding of the difference between an observation and an inference, how scientists use observations and inferences, and how to make good observations and inferences.

What Is Picture-Perfect Science?

This scenario describes how a children's picture book can help guide students through an engaging, hands-on inquiry lesson. *Picture-Perfect*

Science Lessons contains 20 science lessons for students in grades 3 through 6, with embedded reading comprehension strategies to help them learn to read and read to learn while engaged in inquiry-based science. To help you teach according to the National Science Education Standards, the lessons are written in an easy-to-follow format for teaching inquiry-based science: the Biological Sciences Curriculum Study 5E Instructional Model (Bybee 1997, used with permission from BSCS). This learning cycle model allows students to construct their own understanding of scientific concepts as they cycle through the following phases: Engage, Explore, Explain, Elaborate, and Evaluate. Although *Picture-Perfect Science Lessons* is primarily a book for teaching science, reading comprehension strategies are embedded in each lesson. These essential strategies can be modeled throughout while keeping the focus of the lessons on science.

Use This Book Within Your Science Curriculum

We wrote *Picture-Perfect Science Lessons* to supplement, not replace, an existing science program. Although each lesson stands alone as a carefully planned learning cycle based on clearly defined science objectives, the lessons are intended to be integrated into a more complete unit of instruction in which concepts can be more fully developed. The lessons are not designed to be taught sequentially. We want you to use *Picture-Perfect Science Lessons* where appropriate within your school's current science curriculum to support, enrich, and extend it. And we want you to adapt the lessons to fit


your school's curriculum, your students' needs, and your own teaching style.

Special Features

1. Ready-to-Use Lessons With Assessments

Each lesson contains engagement activities, hands-on explorations, student pages, suggestions for student and teacher explanations, opportunities for elaboration, assessment suggestions, and annotated bibliographies of more books to read on the topic. Assessments range from poster sessions with rubrics to teacher checkpoint labs to formal multiple choice and extended response quizzes.

2. Reading Comprehension Strategies


Reading comprehension strategies based on the book *Strategies That Work* (Harvey and Goudvis 2000) and specific activities to enhance comprehension are embedded throughout the lessons and clearly marked with an icon . Chapter 2 describes how to model these strategies while reading aloud to students.

3. Standards-Based Objectives

All lesson objectives were adapted from *National Science Education Standards* (NRC 1996) and are clearly identified at the beginning of each lesson. Because we wrote *Picture-Perfect Science Lessons* for students in grades 3 through 6, we used two grade ranges of the Standards:

K–4 and 5–8. Chapter 5 outlines the National Science Education Standards for those grade ranges and shows the correlation between the lessons and the Standards.

4. Science as Inquiry

As we said, the lessons in *Picture-Perfect Science Lessons* are structured as guided inquiries following the 5E Model. Guiding questions are embedded throughout each lesson and marked with an icon . The questioning process is the cornerstone of good teaching. A teacher who asks thoughtful questions arouses students' curiosity, promotes critical-thinking skills, creates links between ideas, provides challenges, gets immediate feedback on student learning, and helps guide students through the inquiry process. Each lesson includes an "Inquiry Place," a section at the end of the lesson that suggests ideas for developing open inquiries. Chapters 3 and 4 explore science as inquiry and the BSCS 5E Instructional Model.

References

- Bybee, R. W. 1997. *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.
- Harvey, S., and A. Goudvis. 2000. *Strategies that work: Teaching comprehension to enhance understanding*. York, ME: Stenhouse Publishers.
- National Research Council. 1996. *National science education standards*. Washington, DC: National Academies Press.

Children's Book Cited

- Willis, J. 2003. *Dr. Xargle's book of Earthlets*. London, UK: Anderson Press Ltd.

Editors' Note: *Picture-Perfect Science Lessons* builds on the texts of 38 children's picture books to teach science. Some of these books feature animals that have been anthropomorphized—sheep crash a jeep, a hermit crab builds his house. While we recognize that many scientists and educators believe that personification, teleology, animism, and anthropomorphism promote misconceptions among young children, others believe that removing these elements would leave children's literature severely underpopulated. Furthermore, backers of these techniques not only see little harm in their use but also argue that they facilitate learning.

Because *Picture-Perfect Science Lessons* specifically and carefully supports scientific inquiry—"The Changing Moon" lesson, for instance, teaches students how to weed out misconceptions by asking them to point out inaccurate depictions of the Moon—we, like our authors, feel the question remains open.

Acknowledgments

We would like to give special thanks to science consultant Carol Collins for sharing her expertise in teaching inquiry-based science, for giving us many wonderful opportunities to share *Picture-Perfect Science Lessons* with teachers, and for continuing to support and encourage our efforts.

We would also like to express our gratitude to language arts consultant Susan Livingston for opening our eyes to the power of modeling reading strategies in the content areas and for teaching us that every teacher is a reading teacher.

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- The contributions of the following reviewers are also gratefully acknowledged: Mariam Jean Dreher, Nancy Landes, Christine Anne Royce, Carol Collins, Lisa Nyberg, Chris Pappas, and Ken Roy.

About the Authors

Karen Ansberry is an elementary science curriculum leader and a former fifth- and sixth-grade science teacher at Mason City Schools, in Mason, Ohio. She has a bachelor of science in biology from Xavier University and a master of arts in teaching from Miami University. Karen lives in historic Lebanon, Ohio, with her husband, daughter, twin boys, two dogs, and two cats.

Emily Morgan is the science leader for the High AIMS Consortium in Cincinnati, Ohio. She is a former elementary science lab teacher at Mason City Schools in Mason, Ohio, and a seventh-grade science teacher at Northridge Local Schools in Dayton, Ohio. She has a bachelor of science in elementary education from Wright State University and a master of science in education from the University of Dayton. Emily lives in West Chester, Ohio, with her husband, son, dog, and two cats.

Karen and Emily, along with language arts consultant Susan Livingston, received a Toyota Tapestry grant for their Picture-Perfect Science grant proposal in 2002. Since then, they have enjoyed facilitating teacher workshops at elementary schools, universities, and professional conferences across the country. They are also the authors of *More Picture-Perfect Science Lessons: Using Children's Books to Guide Inquiry, K-4*.



KAREN ANSBERRY, RIGHT, AND EMILY MORGAN DEVELOPED *PICTURE-PERFECT SCIENCE LESSONS* BASED ON THEIR WORKSHOPS SUPPORTED BY A TOYOTA TAPESTRY GRANT.

About the Picture-Perfect Science Program

The Picture-Perfect Science program originated from Emily Morgan's and Karen Ansberry's shared interest in using children's literature to make science more engaging. In Emily's 2001 master's thesis study involving 350 of her third-grade science lab students at Western Row Elementary, she found that students who used science trade books instead of the textbook scored significantly higher on district science performance assessments than students who used the textbook only. Convinced of the benefits of using picture books to engage students in science inquiry and to increase science understanding, Karen and Emily began collaborat-

ing with Susan Livingston, the elementary language arts curriculum leader for the Mason City Schools in Ohio, in an effort to integrate literacy strategies into inquiry-based science lessons. They received grants from the Ohio Department of Education (2001) and Toyota Tapestry (2002) to train all third-grade through sixth-grade science teachers, and in 2003 they also trained seventh- and eighth-grade science teachers with district support. The program has been presented both locally and nationally, including at the National Science Teachers Association national conferences.

For more information on Picture-Perfect Science teacher workshops, go to www.pictureperfectscience.com.

Lessons by Grade

Chapter	Grade	Picture Books
6	Earthlets	3–6 <i>Dr. Xargle’s Book of Earthlets</i> <i>Seven Blind Mice</i>
7	Name That Shell!	3–4 <i>Seashells by the Seashore</i> <i>A House for Hermit Crab</i>
8	Rice Is Life	3–6 <i>Rice Is Life</i> <i>Rice</i>
9	What’s Poppin’?	5–6 <i>Popcorn!</i>
10	Mystery Pellets	3–6 <i>White Owl, Barn Owl</i> <i>Butternut Hollow Pond</i>
11	Close Encounters of the Symbiotic Kind	4–6 <i>What’s Eating You? Parasites— The Inside Story</i> <i>Weird Friends: Unlikely Allies in the Animal Kingdom</i>
12	Turtle Hurdles	3–4 <i>Turtle Watch</i> <i>Turtle, Turtle, Watch Out!</i>
13	Oil Spill!	3–6 <i>Prince William</i> <i>Oil Spill!</i>
14	Sheep in a Jeep	3–4 <i>Sheep in a Jeep</i>
15	Sounds of Science	3–4 <i>Sound</i> <i>The Remarkable Farkle McBride</i>
16	Chemical Change Café	3–6 <i>Pancakes, Pancakes!</i>
17	The Changing Moon	3–6 <i>Rise the Moon</i> <i>The Moon Book</i> <i>Papa, Please Get the Moon for Me</i>
18	Day and Night	3–6 <i>Somewhere in the World Right Now</i>
19	Grand Canyon	3–6 <i>Erosion</i> <i>Grand Canyon: A Trail Through Time</i>
20	Brainstorms: From Idea to Invention	5–6 <i>Imaginative Inventions</i> <i>Girls Think of Everything: Stories of Ingenious Inventions by Women</i>

Chapter	Grade	Picture Books
21	Bugs!	3–4 <i>The Perfect Pet</i> <i>Bugs Are Insects</i> <i>Ant, Ant, Ant! (An Insect Chant)</i>
22	Batteries Included	4–6 <i>Electrical Circuits</i> <i>Too Many Toys</i>
23	The Secrets of Flight	3–6 <i>How People Learned to Fly</i> <i>Kids’ Paper Airplane Book</i>
24	Down the Drain	3–6 <i>Down the Drain: Conserving Water</i> <i>A Cool Drink of Water</i>
25	If I Built a Car	4–6 <i>If I Built a Car</i> <i>Inventing the Automobile</i>

Activity-specific safety guidelines are highlighted throughout the lessons. For a more thorough discussion of safety procedures, see *The NSTA Ready-Reference Guide to Safer Science* or *Exploring Safely*. The National Science Teachers Association has also created a convenient *Safety in the Elementary Science Classroom* flipchart. This colorful and student-friendly safety resource can be hung on the wall for easy reference or a quick refresher.

Resources

- Kwan, T., and J. Texley. 2002. *Exploring safely: A guide for elementary teachers*. Arlington, VA: NSTA Press.
- National Science Teachers Association (NSTA). 2003. *Safety in the elementary science classroom* flipchart. Arlington, VA: NSTA Press.
- Roy, K. R. 2007. *The NSTA ready-reference guide to safer science*. Arlington, VA: NSTA Press.

Why Read Picture Books in Science Class?

Think about a book you loved as a child. Maybe you remember the zany characters and rhyming text of Dr. Seuss classics such as *Green Eggs and Ham* or *The Lorax*. Perhaps you enjoyed the page-turning suspense of *The Monster at the End of This Book* or the fascinating facts found in Joanna Cole's *Dinosaur Story*. You may have seen a little of yourself in *Where the Wild Things Are*, *Curious George*, or *Madeline*. Maybe your imagination was stirred by the detailed illustrations in *Jumanji* or the stunning photographs in Seymour Simon's *The Moon*. You probably remember the warm, cozy feeling of having a treasured book such as *The Snowy Day* or *Goodnight Moon* being read to you by a parent or grandparent. But chances are your favorite book as a child was *not* your fourth-grade science

textbook! The format of picture books offers certain unique advantages over textbooks and chapter books for engaging students in a science lesson. More often than other books, fiction and nonfiction picture books stimulate students on both the emotional and intellectual levels. They are appealing and memorable because children readily connect with the imaginative illustrations, vivid photographs, and engaging storylines, as well as the experiences and adventures of characters, the fascinating information that supports them in their quest for knowledge, and the warm emotions that surround the reading experience.

What characterizes a picture book? We like what *Beginning Reading and Writing* says: "Picture books are unique to children's literature as they are defined by format rather

than content. That is, they are books in which the illustrations are of equal importance as or more important than the text in the creation of meaning” (Strickland and Morrow 2000). Because picture books are more likely to hold children’s attention, they lend themselves to reading comprehension strategy instruction and to engaging students within an inquiry-based cycle of science instruction. “Picture books, both fiction and nonfiction, are more likely to hold our attention and engage us than reading dry, formulaic text. ... Engagement leads to remembering what is read, acquiring knowledge and enhancing understanding” (Harvey and Goudvis 2000). We wrote *Picture-Perfect Science Lessons* so teachers can take advantage of the positive features of children’s picture books by supplementing the traditional science textbook with a wide variety of high-quality fiction and nonfiction science-related picture books.

The Research

1. Context for Concepts

Literature gives students a context for the concepts they are exploring in the science classroom. Children’s picture books, a branch of literature, have interesting storylines that can help students understand and remember concepts better than they would by using textbooks alone, which tend to present science as lists of facts to be memorized (Butzow and Butzow 2000). In addition, the colorful pictures and graphics in picture books are superior to many texts for explaining abstract ideas (Kralina 1993). As more and more content is packed into the school day, and higher expectations are placed on student performance, it is critical for teachers to cover more in the same amount of time. Integrating curriculum can help accomplish this. The wide array of high-quality children’s literature available today can help you model reading comprehension strategies while teaching science content in a meaningful context.

2. More Depth of Coverage

Science textbooks can be overwhelming for many children, especially those who have reading problems. They often contain unfamiliar vocabulary and tend to cover a broad range of topics (Casteel and Isom 1994; Short and Armstrong 1993; Tyson and Woodward 1989). However, fiction and nonfiction picture books tend to focus on fewer topics and give more in-depth coverage of the concepts. It can be useful to pair an engaging fiction book with a nonfiction book to round out the science content being presented.

For example, the Chapter 13 lesson “Oil Spill!” features both *Prince William*, a fictionalized account of a young girl’s experience rescuing an oil-covered baby seal, and *Oil Spill!*, a nonfiction book detailing causes and effects of oil spills. The emotion-engaging storyline and the realistic characters in *Prince William* hook the reader, and the book *Oil Spill!* presents facts and background information. Together they offer a balanced, in-depth look at how oil spills affect the environment.

3. Improved Reading and Science Skills

Research by Morrow, Pressley, Smith, and Smith (1997) on using children’s literature and literacy instruction in the science program indicated gains in science as well as literacy. Romance and Vitale (1992) found significant improvement in both science and reading scores of fourth graders when the regular basal reading program was replaced with reading in science that correlated with the science curriculum. They also found an improvement in students’ attitudes toward the study of science.

4. Opportunities to Correct Science Misconceptions

Students often have strongly held misconceptions about science that can interfere with their learning. “Misconceptions, in the field of science education, are preconceived ideas that

differ from those currently accepted by the scientific community” (Colburn 2003). Children’s picture books, reinforced with hands-on inquiries, can help students correct their misconceptions. Repetition of the correct concept by reading several books, doing a number of experiments, and listening to scientists invited to the classroom can facilitate a conceptual change in children (Miller, Steiner, and Larson 1996).

But teachers must be aware that scientific misconceptions can be inherent in picture books. Although many errors are explicit, some of the misinformation is more implicit or may be inferred from text and illustrations (Rice 2002). This problem is more likely to occur within fictionalized material. Mayer’s (1995) study demonstrates that when both inaccuracies and science facts are presented in the same book, children do not necessarily remember the correct information.

Scientific inaccuracies in picture books can be useful for teaching. Research shows that errors in picture books, whether identified by the teacher or the students, can be used to help children learn to question the accuracy of what they read by comparing their own observations to the science presented in the books (Martin 1997). Scientifically inaccurate children’s books can be helpful when students analyze inaccurate text or pictures after they have gained understanding of the correct scientific concepts through inquiry experiences.

For example, in “The Changing Moon” lesson, Chapter 17, students analyze the inaccurate moon phases in Eric Carle’s *Papa, Please Get the Moon for Me* and then correct them through their own illustrations of the story. This process takes students to a higher level of thinking as they use their knowledge to evaluate and correct the misinformation in the picture book.

Use With Upper Elementary Students

Picture-Perfect Science Lessons is designed for students in grades 3 through 6. Although picture

books are more commonly used with younger children, we have good reasons to recommend using them with upper elementary students. In *Strategies That Work* (2000), reading experts Harvey and Goudvis maintain that “the power of well-written picture books cannot be overestimated... picture books lend themselves to comprehension strategy instruction at every grade level.” The benefits of using picture books to teach science and reading strategies are not reserved for younger children. We have found them effective for engaging students, for guiding scientific inquiry, and for teaching comprehension strategies to students in kindergarten through eighth grade. We believe that the wide range of topics, ideas, and genres found in picture books reaches all readers, regardless of their ages, grades, reading levels, or prior experiences.

Selection of Books

Each lesson in *Picture-Perfect Science Lessons* focuses on one or more of the National Science Education Standards. We selected one to three fiction and/or nonfiction children’s picture books that closely relate to the Standards. An annotated “More Books to Read” section is provided at the end of each lesson. If you would like to select more children’s literature to use in your science classroom, try the Outstanding Science Trade Books for Students K–12 listing, a cooperative project between the National Science Teachers Association (NSTA) and the Children’s Book Council (CBC). The books are selected by a book review panel appointed by the NSTA and assembled in cooperation with the CBC. Each year a new list is featured in the March issue of NSTA’s elementary school teacher journal, *Science and Children*. See www.nsta.org/ostbc for archived lists.

When you select children’s picture books for science instruction, you should consult with a knowledgeable colleague who can help you check them for errors or misinformation. You might talk with a high school science teacher, a

retired science teacher, or a university professor. To make sure the books are developmentally appropriate or lend themselves to a particular reading strategy you want to model, you could consult with a language arts specialist.

Finding the *Picture-Perfect* Books

Each activity chapter includes a “Featured Picture Books” section with titles, author names, summaries, and other publication details. The years and publisher names listed are for the most recent editions available—paperback, wherever possible—as of the printing of *Picture-Perfect Science Lessons, Expanded 2nd Edition*.

All of the trade books featured in *Picture-Perfect Science Lessons* are currently in print and can be found at your local bookstore or online retailer. Many of the picture books—including previously hard-to-find and out-of-print books such as *Bubble, Bubble; That Magnetic Dog*; and *Rice Is Life*—are available at www.nsta.org/store. There you can also buy *all* of the *Picture-Perfect Science Lesson* books in one handy collection at a reduced cost.

Considering Genre

Considering genre when you determine how to use a particular picture book within a science lesson is important. Donovan and Smolkin (2002) identify four different genres frequently recommended for teachers to use in their science instruction: story, nonnarrative information, narrative information, and dual purpose. *Picture-Perfect Science Lessons* identifies the genre of each featured book at the beginning of each lesson. Summaries of the four genres, a representative picture book for each genre, and suggestions for using each genre within the BSCS 5E learning cycle we use follow. (The science learning cycle known as the BSCS 5E Model is described in detail in Chapter 4.)

Storybooks

Storybooks center on specific characters who work to resolve a conflict or problem. The major purpose of stories is to entertain, not to present factual information. The vocabulary is typically commonsense, everyday language. An engaging storybook can spark interest in a science topic and move students toward informational texts to answer questions inspired by the story. For example, “Earthlets,” Chapter 6, uses the storybook *Dr. Xargle’s Book of Earthlets* to hook learners and engage them in an inquiry about mystery samples from Planet Earth.

Scientific concepts in stories are often implicit, so teachers must make the concepts explicit to students. As we mentioned, be aware that storybooks often contain scientific errors, either explicit or implied by text or illustrations. Storybooks with scientific errors should not be used in the introduction of a topic, but may be used later in the lesson to teach students how to identify and correct the misconceptions. For example, “The Changing Moon,” Chapter 17, features Eric Carle’s *Papa, Please Get the Moon for Me*, a storybook that contains many scientific inaccuracies. This book would not be appropriate for introducing how the Moon seems to change shape, but it can be a powerful vehicle for assessing the ability of learners to analyze the scientific accuracy of a text.

Nonnarrative Information Books

Nonnarrative information books are factual texts that introduce a topic, describe the attributes of the topic, or describe typical events that occur. The focus of these texts is on the subject matter, not specific characters. The vocabulary is typically technical. Readers can enter the text at any point in the book. Many contain features found in nonfiction such as a table of contents, bold-print vocabulary words, a glossary, and an index. Young children tend to be less familiar with this genre and need many opportunities to experience this type of text. Using nonnarrative information books helps

students become familiar with the structure of textbooks, as well as “real-world” reading, which is primarily expository. Teachers may want to read only those sections that provide the concepts and facts needed to meet particular science objectives.

We wrote the articles included in some of the lessons (see Chapters 8, 11, 14, and 16) in nonnarrative information style to give students more opportunity to practice reading this type of text. For example, “Close Encounters of the Symbiotic Kind,” Chapter 11, includes an article written in an expository style that shows key words in bold print. Another example of nonnarrative information writing is the book *Rice*, which contains nonfiction text features such as a table of contents, bold-print words, diagrams, a glossary, and an index. *Rice* is featured in “Rice Is Life,” Chapter 8. The appropriate placement of nonnarrative information text in a science learning cycle is after students have had the opportunity to explore concepts through hands-on activities. At that point, students are engaged in the topic and are motivated to read the nonnarrative informational text to learn more.

Narrative Information Books

Narrative information books, sometimes referred to as “hybrid books,” provide an engaging format for factual information. They communicate a sequence of factual events over time and sometimes recount the events of a specific case to generalize to all cases. When using these books within science instruction, establish a purpose for reading so that students focus on the science content rather than the storyline. In some cases, teachers may want to read the book one time through for the aesthetic components of the book and a second time for specific science content. *Butternut Hollow Pond*, an example of a narrative information text, is used in “Mystery Pellets,” Chapter 10. This narrative presents the dynamics of survival and competition in a pond ecosystem and contains factual information about a pond food web. The narrative informa-

tion genre can be used at any point within a science learning cycle. This genre can be both engaging and informative.

Dual-Purpose Books

Dual-purpose books are intended to serve two purposes: present a story and provide facts. They employ a format that allows readers to use the book like a storybook or to use it like a nonnarrative information book. Sometimes information can be found in the running text, but more frequently it appears in insets and diagrams. Readers can enter on any page to access specific facts, or they can read it through as a story. You can use the story component of a dual-purpose book to engage the reader at the beginning of the science learning cycle. For example, Chapter 8 features the book *Rice Is Life*, which is used to engage the students in an investigation about rice.

Dual-purpose books typically have little science content within the story. Most of the informational ideas are found in the insets and diagrams. If the insets and diagrams are read, discussed, explained, and related to the story, these books can be very useful in helping students refine concepts and acquire scientific vocabulary *after* they have had opportunities for hands-on exploration. *White Owl, Barn Owl* is a dual-purpose book used in Chapter 10, “Mystery Pellets.” Although the story part is about a girl and her grandfather’s search for an owl, the insets can be read to give students factual information about the characteristics and life cycles of barn owls.

Using Fiction and Nonfiction Texts

As we mentioned previously, pairing fiction and nonfiction books in read alouds to round out the science content being presented is effective. Because fiction books tend to be very engaging for students, they can be used to hook students

at the beginning of a science lesson. But most of the reading people do in everyday life is nonfiction. We are immersed in informational text every day, and we must be able to comprehend it to be successful in school, at work, and in society. Nonfiction books and other informational text such as articles should be used frequently in the elementary classroom. They often include text structures that differ from stories, and the opportunity to experience these structures in read alouds can strengthen students' abilities to read and understand informational text. Duke (2004) recommends four strategies to help teachers improve students' comprehension of informational text. Teachers should

- increase students' access to informational text;
- increase the time they spend working with informational text;
- teach comprehension strategies through direct instruction; and
- create opportunities for students to use informational text for authentic purposes.

Picture-Perfect Science Lessons addresses these recommendations in several ways. The lessons expose students to a variety of nonfiction picture books and articles on science topics, thereby increasing access to informational text. The lessons explain how word sorts, anticipation guides, pairs reading, and the use of nonfiction features all help improve students' comprehension of the informational text by increasing the time they spend working with it. Each lesson also includes instructions for explicitly teaching comprehension strategies within the learning cycle. The inquiry-based lessons provide an authentic purpose for reading informational text, as students are motivated to read or listen to find the answers to questions generated within the inquiry activities.

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Reading Aloud

This chapter addresses some of the research supporting the importance of reading aloud, tips to make your read-aloud time more valuable, descriptions of Harvey and Goudvis's six key reading strategies (2000), and tools you can use to enhance students' comprehension during read-aloud time.

Why Read Aloud?

Being read to is the most influential activity for building the knowledge required for eventual success in reading (Anderson et al. 1985). It improves reading skills, increases interest in reading and literature, and can even improve overall academic achievement. A good reader demonstrates fluent, expressive reading and models the thinking strategies of proficient readers, helping to build background knowledge and fine-tune students' listening skills. When a teacher does the reading, children's minds are free to anticipate, infer, connect, question, and comprehend (Calkins 2000). In addition, being read to is risk free.



READ-ALoud TIME IS A SPECIAL PART OF MRS. WILSON'S CLASS.

In *Yellow Brick Roads: Shared and Guided Paths to Independent Reading 4-12* (2000), Allen says, "For students who struggle with word-by-word reading, experiencing the whole story can finally give them a sense of the wonder and magic of a book."

Reading aloud is appropriate in all grade levels and for all subjects. It is important not only when children can't read on their own but also even after they have become proficient readers (Anderson et al. 1985). Allen supports this view: "Given the body of research supporting the importance of read-aloud for modeling fluency, building background knowledge, and developing language acquisition, we should remind ourselves that those same benefits occur when we extend read-aloud beyond the early years. You may have to convince your students of the importance of this practice, but after several engaging read-alouds they will be sold on the idea" (2000). Just as students of all ages enjoy a good picture book, none of them is too old to enjoy read-aloud time.

Ten Tips for Reading Aloud

We have provided a list of tips to help you get the most from your read-aloud time. Using these suggestions can help set the stage for learning, improve comprehension of science material, and make the read-aloud experience richer and more meaningful for both you and your students.

1 Preview the Book

Select a book that meets your science objectives *and* lends itself to reading aloud. Preview it carefully before sharing it with the students. Are there any errors in scientific concepts or misinformation that could be inferred from the text or illustrations? If the book is not in story form, is there any nonessential information you could omit to make the read-aloud experience better? If you are not going to read the whole book, choose appropriate starting and stopping points before reading.

2 Set the Stage

Because reading aloud is a performance, you should pay attention to the atmosphere and

physical setting of the session. Gather the students in a special reading area, such as on a carpet or in a semicircle of chairs. Seat yourself slightly above them. Do not sit in front of a bright window where the glare will keep students from seeing you well or in an area where students can be easily distracted. You may want to turn off the overhead lights and read by the light of a lamp or use soft music as a way to draw students into the mood of the text. Establish expectations for appropriate behavior during read-aloud time, and before reading, give the students an opportunity to settle down and focus their attention on the book.

3 Celebrate the Author and Illustrator

Always announce the title of the book, the author, and the illustrator before reading. Build connections by asking students if they have read other books by the author or illustrator. Increase interest by sharing facts about the author or illustrator from the book's dust jacket or from library or internet research. This could be done either before or after the reading. The following resources are useful for finding information on authors and illustrators:

Books

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Websites

- www.teachingbooks.net—Teaching Books continually identifies, catalogs, and maintains reliable links to children’s books’ author and illustrator websites and organizes them into categories relevant to teachers’ needs.
- www.cbcbooks.org—The Children’s Book Council (CBC) is a nonprofit trade organization encouraging literacy and the use and enjoyment of children’s books. Its website has a feature titled “About Authors and Illustrators” with links to author and illustrator websites.

4 Read with Expression

Practice reading aloud to improve your performance. Try listening to yourself read on a tape recorder. Can you read with more expression to more fully engage your audience? Try louder or softer speech, funny voices, facial expressions, or gestures. Make eye contact with your students every now and then as you read. This strengthens the bond between reader and listener, helps you gauge your audience’s response, and cuts down on off-task behaviors. Read slowly enough that your students have time to build mental images of what you are reading, but not so slowly that they lose interest. When reading a nonfiction book aloud, you may want to pause after reading about a key concept to let it sink in, then reread that part. At suspenseful parts in a storybook, use dramatic pauses or slow down and read softly. This can move the audience members to the edge of their seats!

5 Share the Pictures

Don’t forget the power of visual images to help students connect with and comprehend what you are reading. Make sure you hold the book in such a way that students can see the pictures on each page. Read captions if appropriate. In some cases, you may want to hide certain

pictures so students can infer from the reading before you reveal the illustrator’s interpretation of the text.

6 Encourage Interaction

Keep chart paper and markers nearby in case you want to record questions or new information. Try providing students with “think pads” in the form of sticky notes to write on as you read aloud. Not only does this help extremely active children keep their hands busy while listening, but it also encourages students to interact with the text as they jot down questions or comments. After the read aloud, have students share their questions and comments. You may want students to place their sticky notes on a class chart whose subject is the topic being studied. Another way to encourage interaction without taking the time for each student to ask questions or comment is to do an occasional “Turn and Talk” during the read aloud. Stop reading, ask a question, allow thinking time, and have each student share answers or comments with a partner.

7 Keep the Flow

Although you want to encourage interaction during a read aloud, avoid excessive interruptions that may disrupt fluent, expressive reading. Aim for a balance between allowing students to hear the language of the book uninterrupted and providing them with opportunities to make comments, ask questions, and share connections to the reading. As we have suggested, you may want to read the book all the way through one time so students can enjoy the aesthetic components of the story. Then go back and read the book for the purpose of meeting the science objectives.

8 Model Reading Strategies

Use read-aloud time as an opportunity to model questioning, making connections, visualizing, inferring, determining importance, and synthesizing. Modeling these reading comprehension

strategies when appropriate before, during, and/or after reading helps students internalize the strategies and begin to use them in their own reading. These six key strategies are described in detail later in this chapter.

9 Don't Put It Away

Keep the read-aloud book accessible to students after you read it. They will want to get a close-up look at the pictures and will enjoy reading the book independently. Don't be afraid of reading the same book more than once. Younger children especially benefit from the repetition.


10 Have Fun

Let your passion for books show. It is contagious! Read nonfiction books with interest and wonder. Share your thoughts and questions about the topic and your own connections to the text. When reading a story, let your emotions show—laugh at the funny parts and cry at the sad parts. Seeing an authentic response from the reader is important for students. If you read with enthusiasm, read-aloud time will become special and enjoyable for everyone involved.

Reading Comprehension Strategies

A common misconception about reading is that students are fully capable of reading to learn in the content areas by the time they reach the upper elementary grades. But becoming a proficient reader is an ongoing, complex process, and people of all ages must develop strategies to improve their reading skills. In *Strategies That Work*, Harvey and Goudvis (2000) identify six key reading strategies that are essential for achieving full understanding when we read. These strategies are used where appropriate in each lesson and are seamlessly embedded into the 5E Model. The strategies should be

modeled as you read aloud to students from both fiction and nonfiction texts. Research shows that explicit teaching of reading comprehension strategies can foster comprehension development (Duke and Pearson 2002). Explicit teaching of the strategies is the initial step in the gradual-release-of-responsibility approach to delivering reading instruction (Fielding and Pearson 1994). During this first phase of the gradual-release method, the teacher *explains* the strategy, demonstrates *how* and *when* to use the strategy, explains *why* it is worth using, and *thinks aloud* to model the mental processes used by good readers. Duke (2004) describes this process: "I often discuss the strategies in terms of good readers, as in 'Good readers think about what might be coming next.' I also model the uses of comprehension strategies by thinking aloud as I read. For example, to model the importance of monitoring understanding, I make comments such as, 'That doesn't make sense to me because ...' or 'I didn't understand that last part—I'd better go back.'" Using the teacher modeling phase within a science learning cycle reinforces what students do during reading instruction, when the gradual-release-of-responsibility model can be continued. After teacher modeling, students should be given opportunities in the reading classroom for both guided and independent practice until they are ready to apply the strategy in their own reading.

Descriptions of the six key reading comprehension strategies featured in *Strategies That Work* (Harvey and Goudvis 2000) follow. The  icon highlights these strategies here and within the lessons.



Making Connections

Making meaningful connections during reading can improve comprehension and engagement by helping learners better relate to what they read. Comprehension breakdown that occurs when reading or listening to expository text can come

from a lack of prior information. These three techniques can help readers build background knowledge where little exists:

- *Text-to-Self* connections occur when readers link the text to their past experiences or background knowledge.
- *Text-to-Text* connections occur when readers recognize connections from one book to another.
- *Text-to-World* connections occur when readers connect the text to events or issues in the real world.



Questioning

Proficient readers ask themselves questions before, during, and after reading. Questioning allows readers to construct meaning, find answers, solve problems, and eliminate confusion as they read. It motivates readers to move forward in the text. Asking questions is not only a critical reading skill, but it is also at the heart of scientific inquiry and can lead students into meaningful investigations. To help you model the questioning strategy, we suggest writing your questions on sticky notes before the read aloud and placing them on the appropriate pages of the book.



Visualizing

Visualizing is the creation of mental images while reading or listening to text. Mental images are created from the learner's emotions and senses, making the text more concrete and memorable. Imagining the sensory qualities of things described in a text can help engage learners and stimulate their interest in the reading. When readers form pictures in their minds, they are also more likely to stick with a challenging text. During a reading, you can stop and ask students to visualize the scene. What sights, sounds, smells, and colors are they imagining?



Inferring

Reading between the lines, or inferring, involves learners merging clues from the reading with prior knowledge to draw conclusions and interpret the text. Good readers make inferences before, during, and after reading. Inferential thinking is also an important science skill and can be reinforced during reading instruction.



Determining Importance

Reading to learn requires readers to identify essential information by distinguishing it from nonessential details. Deciding what is important in the text depends on the purpose for reading. In *Picture-Perfect Science Lessons*, the lesson's science objectives determine importance. Learners read or listen to the text to find answers to specific questions, to gain understanding of science concepts, and to identify science misconceptions.



Synthesizing

In synthesizing, readers combine information gained through reading with prior knowledge and experience to form new ideas. To synthesize, readers must stop, think about what they have read, and contemplate its meaning before continuing on through the text. The highest level of synthesis involves those "Aha!" moments when readers gain new insights and, as a result, change their thinking.

Tools to Enhance Comprehension

We have identified several activities and organizers that can enhance students' science understanding and reading comprehension in the lessons. These tools, which support the Harvey and Goudvis reading comprehension strategies, are briefly described on the following pages and in more detail within the lessons.



Anticipation Guides

Anticipation guides (Herber 1978) are sets of questions that serve as a pre- or post-reading activity for a text. They can be used to activate and assess prior knowledge, determine misconceptions, focus thinking on the reading, and motivate reluctant readers by stimulating interest in the topic. An anticipation guide should revolve around four to six key concepts from the reading that learners respond to before reading. They are motivated to read or listen carefully to find the evidence that supports their predictions. After reading, learners revisit their anticipation guide to check their responses. In a revised extended anticipation guide (Duffelmeyer and Baum 1992), learners are required to justify their responses and explain why their choices were correct or incorrect.



Chunking

Chunking is dividing the text into manageable sections and reading only one section at any one time. This gives learners time to digest the information in a section before moving on. Chunking is also a useful technique for weeding out essential from nonessential information when reading nonfiction books. Reading only those parts of the text that meet your learning objectives focuses the learning on what is important.



Cloze Paragraph

Cloze is an activity to help readers infer the meanings of unfamiliar words. In the cloze strategy, key words are deleted in a passage. Students then fill in the blanks with words that make sense and sound right. (See Chapter 22 for an example of a cloze paragraph.)



Visual Representations

Organizers such as T-charts; I Wonder/I Learned charts; O-W-L charts (“**O**bservations, **W**onderings, **L**earnings”); the Frayer Model

(Frayer, Frederick, and Klausmeier 1969); semantic maps (Billmeyer and Barton 1998); and personal vocabulary lists (Beers and Howell 2004) can help learners activate prior knowledge, organize their thinking, understand the essential characteristics of concepts, or see relationships among concepts. They can be used for pre-reading, assessment, or summarizing or reviewing material. Visual representations are effective because they help learners perceive abstract ideas in a more concrete form. Examples of these visual representations, with instructions for using them within the lesson, can be found throughout the book. (See Chapters 6, 8, and 14 for examples of T-charts. See Chapter 9 for an example of an I Wonder/I Learned chart. See Chapters 6 and 16 for examples of the Frayer Model. See Chapters 7, 10, and 11 for examples of O-W-L charts. See Chapter 8 for an example of a semantic map. See Chapter 19 for a variation of a personal vocabulary list.)



Pairs Read

Pairs read (Billmeyer and Barton 1998) requires the learners to work cooperatively as they read and make sense of a text. While one learner reads aloud, the other listens and then makes comments (“I think ...”), asks questions (“I wonder ...”), or shares new learnings (“I didn’t know ...”). Encourage students to ask their partners to reread if clarification is needed. Benefits of pairs read include increased reader involvement, attention, and collaboration. In addition, students become more independent and less reliant on the teacher.



Rereading

Nonfiction text is often full of unfamiliar ideas and difficult vocabulary. Rereading content for clarification is an essential skill of proficient readers, and you should model this frequently. Rereading content for a different purpose can aid comprehension. For example, you might read aloud a text for enjoyment and then revisit the text to focus on specific science content.



Sketch to Stretch

During sketch to stretch (Seigel 1984), learners pause to reflect on the text and do a comprehension self-assessment by drawing on paper the images they visualize in their heads during reading. They might illustrate an important event from the text, sketch the characters in a story, or make a labeled diagram. Have students use pencils so they understand that the focus should be on collecting their thoughts rather than creating a piece of art. You may want to use a timer so students understand that sketch to stretch is a brief pause to reflect quickly on the reading. Students can share and explain their drawings in small groups after sketching.



Stop and Jot

Learners stop and think about the reading and then jot down a thought. They may write about something they've just learned, something they are wondering about, or what they expect to learn next. If they use sticky notes for this, the notes can be added to a whole-class chart to connect past and future learning.



Turn and Talk

Learners each pair up with a partner to share their ideas, explain concepts in their own words, or tell about a connection they have to the book. This method allows each child to respond so that everyone in the group is involved as either a talker or a listener. Saying "Take a few minutes to share your thoughts with someone" gives students an opportunity to satisfy their needs to express their own thoughts about the reading.



Word Sorts

Word sorts (Gillett and Temple 1983) help learners understand the relationships among key concepts and help teach classification. They can also reveal misconceptions if you use them as a pre-reading activity. Ask learners to sort

vocabulary terms, written on cards, into different categories. In an *open sort*, learners sort the words into categories of their own making. They can classify and reclassify to help refine their understanding of concepts. In a *closed sort*, you give them the categories for sorting. Learners can also use the vocabulary words to build sentences about specific concepts before and after reading. (See Chapters 10 and 11 for examples of word sorts.)



Using Features of Nonfiction

Many nonfiction books include a table of contents, index, glossary, bold-print words, picture captions, diagrams, and charts that provide valuable information. Because children are generally more used to narrative text, they often skip over these text structures. It is important to model how to interpret the information these features provide the reader. To begin, show the cover of a nonfiction book and read the title and table of contents. Ask students to predict what they'll find in the book. Show students how to use the index in the back of the book to find specific information. Point out other nonfiction text structures as you read and note that these features are unique to nonfiction. Model how nonfiction books can be entered at any point in the text, because they generally don't follow a storyline.

Why Do Picture Books Enhance Comprehension?

Students should be encouraged to read a wide range of print materials, but picture books offer many advantages when teaching reading comprehension strategies. Harvey and Goudvis (2000) not only believe that interest is essential to comprehension, but also maintain that because picture books are extremely effective for building background knowledge and teaching

content, instruction in reading comprehension strategies during picture book read alouds allows students to better access that content. In summary, picture books are invaluable for teaching reading comprehension strategies because they are extraordinarily effective at keeping readers engaged and thinking.

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Teaching Science Through Inquiry

The word inquiry brings many different ideas to mind. For some teachers, it may evoke fears of giving up control in the classroom or spending countless hours preparing lessons. For others, it may imply losing the focus of instructional objectives while students pursue answers to their own questions. And for many, teaching science through inquiry is perceived as intriguing but unrealistic. But inquiry doesn't have to cause anxiety for teachers. Simply stated, inquiry is an approach to learning that involves exploring the world and that leads to asking questions, testing ideas, and making discoveries in the search for understanding. There are many degrees of inquiry, and it may be helpful to start with a variation that emphasizes a teacher-directed approach and then gradually builds to a more student-directed approach. As a basic guide, the National Research Council (2000) identifies five essential features for classroom inquiry, shown in Figure 3.1.

Figure 3.1. Five Essential Features of Classroom Inquiry

- 1** Learners are engaged by scientifically oriented **questions**.
- 2** Learners give priority to **evidence**, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- 3** Learners formulate **explanations** from evidence to address scientifically oriented questions.
- 4** Learners **evaluate** their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- 5** Learners **communicate** and justify their proposed explanations.

From *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (NRC 2000).

Essential Features of Classroom Inquiry

The following descriptions illustrate each of the five essential features of classroom inquiry using Chapter 11, “Close Encounters of the Symbiotic Kind.” Any classroom activity that includes all five of these features is considered to be inquiry.

- 1 *Learners are engaged by scientifically oriented questions.* In “Close Encounters of the Symbiotic Kind,” students are given “mystery objects” (plant galls) that engage them in the initial question, “What are these objects?” In this case, the mystery objects pique students’ curiosity, stimulating additional questions.
- 2 *Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.* Students use measuring tools and hand lenses to make quantitative and qualitative observations about the mystery objects and use the observations as evidence to develop answers to questions.
- 3 *Learners formulate explanations from evidence to address scientifically oriented questions.* Students develop explanations about the mystery objects based on their observations.
- 4 *Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.* After using a dichotomous key to identify their objects and reading an article about plant galls, students evaluate, and possibly eliminate or revise, their explanations.
- 5 *Learners communicate and justify their proposed explanations.* Students show their mystery objects to the rest of the class, share their explanations, and justify the explanations with evidence. This provides other students the opportunity to ask questions,

examine the evidence, identify faulty reasoning, and suggest alternative explanations.

Benefits of Inquiry

Developing an inquiry-based science program is a central tenet of the *National Science Education Standards* (NRC 1996). So what makes inquiry-based teaching such a valuable method of instruction? Many studies state that it is equal or superior to other instructional modes and results in higher scores on content achievement tests. *Inquiry and the National Science Education Standards* (NRC 2000) summarizes the findings of *How People Learn* (Bransford, Brown, and Cocking 1999), which support the use of inquiry-based teaching. Those findings include the following points:

- Understanding science is more than knowing facts. Most important is that students understand the major concepts. Inquiry-based teaching focuses on the major concepts, helps students build a strong base of factual information to support the concepts, and gives them opportunities to apply their knowledge effectively.
- Students build new knowledge and understanding on what they already know and believe. Students often hold preconceptions that are either reasonable in only a limited context or scientifically incorrect. These preconceptions can be resistant to change, particularly when teachers use conventional teaching strategies (Wandersee, Mintzes, and Novak 1994). Inquiry-based teaching uncovers students’ prior knowledge and, through concrete explorations, helps them correct misconceptions.
- Students formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they already know. In an inquiry-based model, students give priority to evidence when they prove or disprove their pre-

conceptions. Their preconceptions are challenged by their observations or the explanations of other students.

- Learning is mediated by the social environment in which learners interact with others. Inquiry provides students with opportunities to interact with others. They explain their ideas to other students and listen critically to the ideas of their classmates. These social interactions require that students clarify their ideas and consider alternative explanations.
- Effective learning requires that students take control of their own learning. When teachers use inquiry, students assume much of the responsibility for their own learning. Students formulate questions, design procedures, develop explanations, and devise ways to share their findings. This makes learning unique and more valuable to each student.
- The ability to apply knowledge to novel situations, that is, transfer of learning, is affected by the degree to which students learn with understanding. Inquiry provides students a variety of opportunities to practice what they have learned and connect to what they already know, and therefore moves them toward application, a sophisticated level of thinking that requires them to solve problems in new situations.

Inquiry learning not only contributes to better understanding of scientific concepts and skills but, because science inquiry in school is carried out in a social context, also contributes to children's social and intellectual development (Dyasi 1999). Within an inquiry-based lesson, students work collaboratively to brainstorm questions, design procedures for testing their predictions, carry out investigations, and ask thoughtful questions about other students' conclusions. This mirrors the social context in which "real science" takes place.

What Makes a Good Question?

Questioning lies at the heart of inquiry and is a habit of mind that should be encouraged in any learning setting. According to *Inquiry and the National Science Education Standards* (NRC 2000), "Fruitful inquiries evolve from questions that are meaningful and relevant to students, but they also must be able to be answered by students' observations and scientific knowledge they obtain from reliable sources." One of the most important skills students can develop in science is understanding which questions can be answered by investigation and which cannot. The teacher plays a critical role in guiding the kinds of questions the students pose. Students often ask *why* questions, which cannot be addressed by scientific investigations. For example, "Why does gravity make things fall toward Earth?" is a question that would be impossible to answer in the school setting.

Testable questions, on the other hand, generally begin with *how can*, *does*, *what if*, or *which* and can be investigated using controlled procedures. For example, encouraging students to ask questions such as "How can you slow the fall of an object?" "Which object falls faster, a marble or a basketball?" or "What materials work best for constructing a toy parachute?" guides them toward investigations that can be done in the classroom.

Helping students select developmentally appropriate questions is also important. For example, "What will the surface of the Moon look like in a hundred years?" is a question that is scientific but much too complex for elementary students to investigate. A more developmentally appropriate question might be "How does the size of a meteorite affect the size of the crater it makes?" This question can be tested by dropping different-size marbles into a pan of sand, simulating how meteors hit the Moon's surface. It is essential to help students formulate age-appropriate and testable

questions to ensure that their investigations are both engaging and productive.

Variations Within Classroom Inquiry

Inquiry-based teaching can vary widely in the amount of guidance and structure you choose to provide. Table 3.1 describes these variations for each of the five essential features of inquiry.

The most open form of inquiry takes place in the variations on the right-hand column of the Inquiry Continuum. Most often, students do not have the abilities to begin at that point. For example, students must first learn what makes a question scientifically oriented and testable before they can begin posing such questions themselves. The extent to which you structure what students do determines whether the inquiry is *guided* or *open* inquiry. The more responsibility you take, the more guided the inquiry. The more responsibility the students have, the more open the inquiry. Guided inquiry experiences, such as those on the left-hand side of the Inquiry Continuum, can be effective in focusing learning on the development of particular science concepts. Students, however, must have open inquiry experiences, such as those in the right column of the Inquiry Continuum, to develop the fundamental abilities necessary to do scientific inquiry.

One common misconception about inquiry is that all science subject matter should be taught through inquiry. It is neither possible nor practical to teach all science subject matter through inquiry (NRC 2000). For example, you would not want to teach lab safety through inquiry. Good science teaching requires a variety of approaches and models. *Picture-Perfect Science Lessons* combines a guided inquiry investigation with an open inquiry investigation. Dunkhase (2000) refers to this approach as “coupled inquiry.” In *Picture-Perfect Science Lessons*, the guided inquiries are the lessons

presented in each chapter. The lessons generally fall on the left-hand (teacher-guided) side of the Inquiry Continuum. The Inquiry Place suggestion box (discussed in depth later in this chapter) at the end of each lesson produces experiences falling more toward the right-hand, or student self-directed, side of the Inquiry Continuum.

Checkpoint Labs in Guided Inquiry

One way to manage a guided inquiry is to use a “checkpoint lab.” This type of lab is divided into sections, with a small box located at the end of each section for a teacher check mark or stamp. Six lessons in this book contain checkpoint labs to guide teams of students through an inquiry (Chapters 9, 13, 14, 19, 20, and 22). In a checkpoint lab, each team works at its own pace. A red cup and a green cup taped together at the bottoms are used to signal the teacher. When teams are working, they keep the green cup on top. When teams have a question or when they reach a checkpoint, they signal the teacher by flipping their cups so that red is on top.

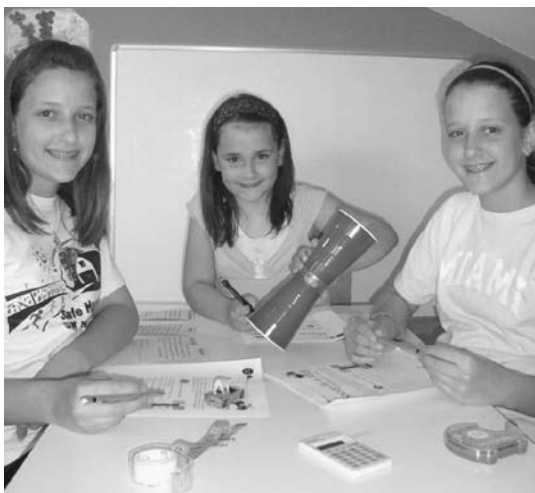
Tips for Managing a Checkpoint Lab

- Give students task cards (like those provided in “Sheep in a Jeep,” Chapter 14) to assign each student a job.
- Tell students that every member of the team is responsible for recording data and writing responses. All team members must be at the same checkpoint in order to get the stamp or check mark and continue on to the next section.
- Explain how to use the red-green cup. Tell students that when the green cup is on top, it is a signal to you that the team is progressing with no problems or questions.

Table 3.1. Inquiry Continuum

		<i>Teacher Guided</i> ←————→ <i>Learner Self-Directed</i>		
ESSENTIAL FEATURE	VARIATIONS			
1. <i>Learners are engaged in scientifically oriented questions.</i>	Learner engages in question provided by teacher or materials.	Learner sharpens or clarifies the question provided.	Learner selects among questions, poses new questions.	Learner poses a question.
2. <i>Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.</i>	Learner is given data and told how to analyze.	Learner is given data and asked how to analyze.	Learner is directed to collect certain data.	Learner determines what constitutes evidence and collects it.
3. <i>Learners formulate explanations from evidence to address scientifically oriented questions.</i>	Learner is provided with explanations.	Learner is given possible ways to use evidence to formulate explanations.	Learner is guided in process of formulating explanations from evidence.	Learner formulates explanation after summarizing evidence.
4. <i>Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.</i>	Learner is told connections.	Learner is given possible connections.	Learner is directed toward areas and sources of scientific knowledge.	Learner independently examines other resources and forms the links to explanations.
5. <i>Learners communicate and justify their proposed explanations.</i>	Learner is given steps and procedures for communication.	Learner is provided broad guidelines to sharpen communication.	Learner is coached in development of communication.	Learner communicates and justifies explanations.
		<i>Teacher Guided</i> ←————→ <i>Learner Self-Directed</i>		

Adapted from *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (NRC 2000).



SIGNALING THE TEACHER WITH A RED-GREEN CUP

When the red cup is on top, it is a signal that the team needs you.

- Explain that there are only two situations in which students should flip the red cup on top:
 - ◆ Everyone on the team is at a checkpoint, or
 - ◆ The team has a question.
- Tell students that before they flip the cup to red for a question, they must first ask everyone else on the team the question (“Ask three, then me”). Most of the time, the team will be able to answer the question without asking you.
- When a team reaches a checkpoint and signals you, make sure every member of the team has completed all of the work in that section. Then ask each member a probing question about that part of the lab. Asking each student a question holds each one accountable and allows you to informally assess each student’s learning. Examples of probing questions are
 - ? How do you know?
 - ? What does this remind you of?
 - ? What do you think will happen next?

Inquiry Place

As we mentioned earlier, a box called Inquiry Place is provided at the end of each lesson to help you move your students toward more open inquiries. The Inquiry Place lists questions related to the lesson that students may select to investigate. Students may also use them as sample questions for writing their own scientifically oriented and testable questions. After selecting one of the questions in the box or formulating their own questions, students can make predictions, design investigations to test their predictions, collect evidence, devise explanations, examine related resources, and communicate their findings.

The Inquiry Place boxes suggest that students share the results of their investigations with one another through a poster session. Scientists, engineers, and researchers routinely hold poster sessions to communicate their findings. Here are some suggestions for poster sessions:

- Posters should include a title, the researchers’ names, a brief description of the investigation, and a summary of the main findings.
- Observations, data tables, and/or graphs should be included as evidence to justify conclusions.
- The print should be large enough that people can read it from a distance.
- Students should have the opportunity to present their posters to the class.
- The audience in a poster session should examine the evidence, ask thoughtful questions, identify faulty reasoning, and suggest alternative explanations to presenters in a polite, respectful manner.

Not only do poster sessions mirror the work of real scientists, but they also provide you with excellent opportunities for authentic assessment.

Implementing the guided inquiries in this book along with the Inquiry Place suggestions at the end of each lesson provides a framework for moving from teacher-guided to learner-self-directed inquiry. The Inquiry Place Think Sheet on page 25 (Figure 3.2) can help students organize their own inquiries.

An example of how the Inquiry Place can be used to give students the opportunity

to engage in an open inquiry follows. This particular example is from “The Changing Moon,” Chapter 17. In that lesson, students learn about the Moon’s phases by observing them for a month, modeling the phases with a foam ball and lamp, and reading about the Moon. This is how one teacher chose to use the Inquiry Place following a guided inquiry lesson:

After “The Changing Moon” lesson, Mrs. Bell begins a discussion about the Moon’s surface. She and her students talk about the craters on the Moon and the fact that they are caused by meteorites.

Mrs. Bell: *There are so many different-size craters on the Moon. I wonder, does the speed of the meteorite affect the size of the crater it makes? I have some supplies we can use as a model: a pan of sand to represent the surface of the Moon and marbles to represent the meteorites. How can we use these supplies to find the answer to the question?*

Mrs. Bell writes the question on the board: “Does the speed of a meteorite affect the size of the crater it makes?”

Pedro: *We can drop the marbles in the pan at different speeds and measure the craters.*

Mrs. Bell: *How can we get the marbles to hit at different speeds?*

Hannah: *We can drop one from high and one from low and measure the craters.*

Mrs. Bell: *Is there a way we can measure the height of the drop?*

Rudy: *We can use a meterstick. We’ll drop one from 50 centimeters and the other from 1 meter.*

Mrs. Bell: *Good. Is there a way we can collect even more data than just two drops?*

Julia: *We can drop it from 25 centimeters, 50 centimeters, 75 centimeters, and 100 centimeters.*

Mrs. Bell: *How can we record our data?*

Eva: *We can make a table with the height on one side and the size of the crater on the other side.*

Mrs. Bell: *Great idea! Let’s make a data table on the board. Now, what do we need to keep the same to make this a fair experiment? (Silence.)*

Mrs. Bell: *For example, should we use four different-size marbles?*

Jeff: *No, we should use the same marble each time to keep it fair.*

Mrs. Bell: *Good. Is there anything else we need to do to keep it fair?*

Mikayla: *We should use the same pan of sand each time.*

Mrs. Bell: *Yes! I think we are ready to begin the experiment. Let’s make some predictions first.*

Mrs. Bell and her class make predictions and then perform the experiment together and record their data on the board. They use their data as evidence to answer the question and reach the conclusion that faster-moving meteorites make larger craters than slower-moving meteorites.

Mrs. Bell: *Now that we have answered my question, I wonder if you have any questions about meteorites and craters that we could investigate using the pan and marble model.*

Mrs. Bell passes out the Inquiry Place Think Sheet to each student. She instructs them to answer number 1: “My questions about moon craters.” After providing students time to write down some questions, Mrs. Bell asks them to share some of their questions.

Rudy: *Where do meteorites come from?*

Mrs. Bell: *That’s a good question, Rudy. Can we use this model to find the answer?*

Rudy: *No.*

Mrs. Bell: *How could we find the answer to that question?*

Rudy: *Maybe at the library or on the computer.*

Mrs. Bell: *Yes. Maybe we can look for that answer next time we are in the library. Let’s try to think of questions that we can answer using the sand and marble model.*

Yushi: *We could find out if bigger meteorites make bigger craters.*

Marcus: *Do square meteorites make square craters?*

Hannah: *Do heavier meteorites make bigger craters?*

Julia: *Does it matter what kind of moon dirt it hits?*

Mrs. Bell rephrases the questions and writes them on the board.

- ? Does the size of a meteorite affect the size of the crater?
- ? Does the shape of a meteorite affect the shape of the crater?
- ? Does the mass of the meteorite affect the size of the crater?
- ? Does the type of surface the meteorite lands on affect the size of the crater?

Mrs. Bell: *Excellent! These four questions can be answered by investigating with the marble and pan model. Choose one of the questions that you would like to investigate and write it down for number 2.*

Mrs. Bell provides time for students to think about which question they want to investigate and to write it down. She then forms teams of students who have chosen the same question.

Mrs. Bell: *Now that you have formed your teams, complete the rest of the Inquiry Place Think Sheet together. When your experiment is planned and you are ready for the teacher checkpoint, signal by placing the green cup on top.*

Mrs. Bell circulates to ask questions and check progress as teams complete the Inquiry Place Think Sheet. Students finish planning the investigations and look forward to completing them the next day. They will share their findings during a poster session later in the week.

Figure 3.2. Inquiry Place Think Sheet

Name: _____

Inquiry Place Think Sheet

1 My questions about:

2 My testable question:

3 My prediction:

4 Steps I will follow to investigate my question:

5 Materials I will need:

6 How I will share my findings:

Checkpoint



PERFORMING THE INVESTIGATION DESIGNED ON THE INQUIRY PLACE THINK SHEET

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BSCS 5E Instructional Model

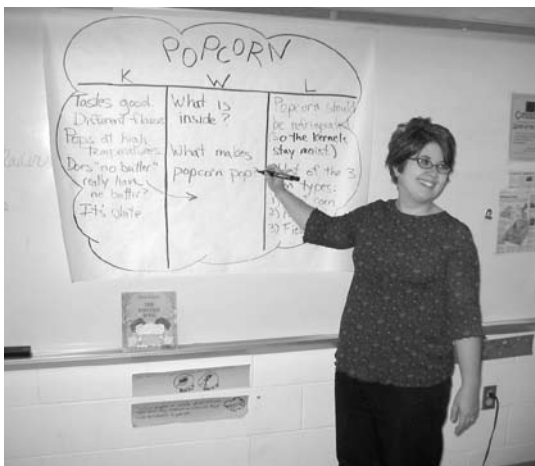
The guided inquiries in this book are designed using the BSCS 5E Instructional Model, commonly referred to as the 5E Model (or the 5Es). Developed by the Biological Sciences Curriculum Study (BSCS), the 5E Model is a learning cycle based on a constructivist view of learning. Constructivism embraces the idea that learners bring with them preconceived ideas about how the world works. According to the constructivist view, “learners test new ideas against that which they already believe to be true. If the new ideas seem to fit in with their pictures of the world, they have little difficulty learning the ideas ... if the new ideas don’t seem to fit the learners’ picture of reality then they won’t seem to make sense. Learners may dismiss them ... or eventually accommodate the new ideas and change the way they understand the world” (Colburn 2003). The objective of a constructivist model, therefore, is to provide students with experiences

that make them reconsider their conceptions. Then students “redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment” (Bybee 1997). The 5E Model provides a planned sequence of instruction that places students at the center of their learning experiences, encouraging them to explore, construct their own understanding of scientific concepts, and relate those understandings to other concepts. An explanation of each phase of the BSCS 5E Model—Engage, Explore, Explain, Elaborate, and Evaluate—follows.

Engage

The purpose of this introductory stage, *engage*, is to capture students’ interest. Here you can uncover what students know and think about a topic as well as determine their misconceptions. Engagement activities might include a

reading, demonstration, or other activity that piques students' curiosity.



ENGAGE: MRS. RADER GAVE EACH OF HER STUDENTS A BOWL OF POPCORN TO EAT WHILE SHE WROTE WHAT THEY KNOW AND WHAT THEY ARE WONDERING ABOUT POPCORN ("WHAT'S POPPIN'?" CHAPTER 9).

Explore

In the *explore* stage, you provide students with cooperative exploration activities, giving them common, concrete experiences that help them begin constructing concepts and developing skills. Students can build models, collect data, make and test predictions, or form new



predictions. The purpose is to provide hands-on experiences you can use later to formally introduce a concept, process, or skill.

EXPLORE: BEFORE FORMALLY INTRODUCING THE TERM *PITCH*, MISS SCHULTZ HAD HER STUDENTS TEST THEIR IDEAS AFTER BRAINSTORMING WAYS TO MAKE THEIR STRAW INSTRUMENTS PRODUCE HIGH AND LOW SOUNDS ("SOUNDS OF SCIENCE," CHAPTER 15).

Explain

In the *explain* stage, learners articulate their ideas in their own words and listen critically to one another. You clarify their concepts, correct misconceptions, and introduce scientific terminology. It is important that you clearly connect the students' explanations to experiences they had in the engage and explore phases.



EXPLAIN: STUDENTS IN MR. MICHALAK'S CLASS ARE JUSTIFYING HOW THEY SORTED THEIR CARDS IN THE CLOSE ENCOUNTER WORD SORT ("CLOSE ENCOUNTERS OF THE SYMBIOTIC KIND," CHAPTER 11).

Elaborate

At the *elaborate* point in the model, some students may still have misconceptions, or they may understand the concepts only in the context of the previous exploration. Elaboration activities can help students correct their remaining misconceptions and generalize the concepts in a broader context. These activities also challenge students to apply, extend, or elaborate on concepts and skills in a new situation, resulting in deeper understanding.



ELABORATE: A STUDENT IN MRS. HUDSPETH'S CLASS ELABORATES ON WHAT HE HAS LEARNED ABOUT MOTION BY DESIGNING A PARACHUTE FOR A TOY ANIMAL ("SHEEP IN A JEEP," CHAPTER 14).



EVALUATE: A STUDENT IN MRS. MANN'S CLASS HAS DESIGNED AN EXPERIMENT TO TEST THE EFFECTIVENESS OF AN INVENTION. MRS. MANN WILL EVALUATE THE STUDENT'S SKILLS IN DESIGNING AND CARRYING OUT AN EXPERIMENT ("BRAINSTORMS," CHAPTER 20).

Cycle of Learning

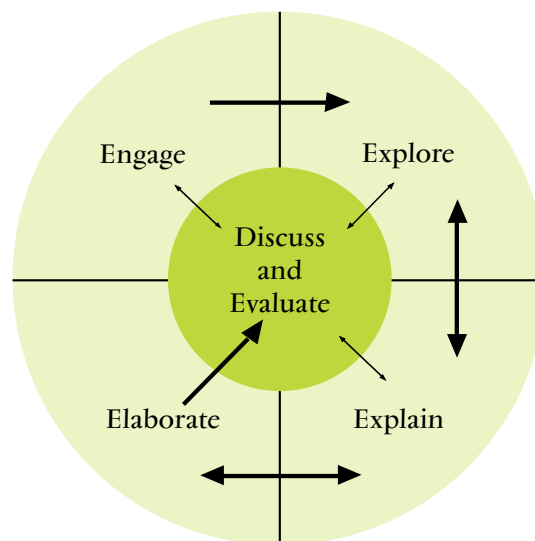
The 5Es are listed above in linear order—engage, explore, explain, elaborate, and evaluate—but the model is most effective when you use it as a cycle of learning as in Figure 4.1.

Evaluate

At the *evaluate* phase, you evaluate students' understanding of concepts and their proficiency with various skills. You can use a variety of formal and informal procedures to assess conceptual understanding and progress toward learning outcomes. The evaluation phase also provides an opportunity for students to test their own understanding and skills.

Although the fifth phase is devoted to evaluation, a skillful teacher evaluates throughout the 5E model, continually checking to see if students need more time or instruction to learn the key points in a lesson. Ways to do this include informal questioning, teacher checkpoints, and class discussions. Each lesson in *Picture-Perfect Science Lessons* also includes a formal evaluation such as a written quiz or poster session. These formal evaluations take place at the end of the lesson.

Figure 4.1. The BSCS 5Es as a Cycle of Learning



Adapted from Barman, C. R. 1997. *The learning cycle revised: A modification of an effective teaching model*. Arlington, VA: Council for Elementary Science International.

Table 4.1. The BSCS 5Es Teacher

What the Teacher Does		
	<i>CONSISTENT</i> with the BSCS 5E Model	<i>INCONSISTENT</i> with the BSCS 5E Model
engage	<ul style="list-style-type: none"> ● Generates interest and curiosity ● Raises questions ● Assesses current knowledge, including misconceptions 	<ul style="list-style-type: none"> ● Explains concepts ● Provides definitions and conclusions ● Lectures
explore	<ul style="list-style-type: none"> ● Provides time for students to work together ● Observes and listens to students as they interact ● Asks probing questions to redirect students' investigations when necessary 	<ul style="list-style-type: none"> ● Explains how to work through the problem or provides answers ● Tells students they are wrong ● Gives information or facts that solve the problem
explain	<ul style="list-style-type: none"> ● Asks for evidence and clarification from students ● Uses students' previous experiences as a basis for explaining concepts ● Encourages students to explain concepts and definitions in their own words, then provides scientific explanations and vocabulary 	<ul style="list-style-type: none"> ● Does not solicit the students' explanations ● Accepts explanations that have no justification ● Introduces unrelated concepts or skills
elaborate	<ul style="list-style-type: none"> ● Expects students to apply scientific concepts, skills, and vocabulary to new situations ● Reminds students of alternative explanations ● Refers students to alternative explanations 	<ul style="list-style-type: none"> ● Provides definite answers ● Leads students to step-by-step solutions to new problems ● Lectures
evaluate	<ul style="list-style-type: none"> ● Observes and assesses students as they apply new concepts and skills ● Allows students to assess their own learning and group process skills ● Asks open-ended questions 	<ul style="list-style-type: none"> ● Tests vocabulary words and isolated facts ● Introduces new ideas or concepts ● Promotes open-ended discussion unrelated to the concept

Adapted from *Achieving Scientific Literacy: From Purposes to Practices* (Bybee 1997).

Table 4.2. The BSCS 5Es Student

What the Student Does		
	CONSISTENT with the BSCS 5E Model	INCONSISTENT with the BSCS 5E Model
engage	<ul style="list-style-type: none"> ● Asks questions such as “Why did this happen?” “What do I already know about this?” “What can I find out about this?” ● Shows interest in the topic 	<ul style="list-style-type: none"> ● Asks for the “right” answer ● Offers the “right” answer ● Insists on answers and explanations
explore	<ul style="list-style-type: none"> ● Thinks creatively, but within the limits of the activity ● Tests predictions and hypotheses ● Records observations and ideas 	<ul style="list-style-type: none"> ● Passively allows others to do the thinking and exploring ● “Plays around” indiscriminately with no goal in mind ● Stops with one solution
explain	<ul style="list-style-type: none"> ● Explains possible solutions to others ● Listens critically to explanations of other students and the teacher ● Uses recorded observations in explanations 	<ul style="list-style-type: none"> ● Proposes explanations from “thin air” with no relationship to previous experiences ● Brings up irrelevant experiences and examples ● Accepts explanations without justification
elaborate	<ul style="list-style-type: none"> ● Applies new labels, definitions, explanations, and skills in new but similar situations ● Uses previous information to ask questions, propose solutions, make decisions, and design experiments ● Records observations and explanations 	<ul style="list-style-type: none"> ● “Plays around” with no goal in mind ● Ignores previous information or evidence ● Neglects to record data
evaluate	<ul style="list-style-type: none"> ● Demonstrates an understanding of the concept or skill ● Answers open-ended questions by using observations, evidence, and previously accepted explanations ● Evaluates his or her own progress and knowledge 	<ul style="list-style-type: none"> ● Draws conclusions, not using evidence or previously accepted explanations ● Offers only yes-or-no answers and memorized definitions or explanations ● Fails to express satisfactory explanations in his or her own words

Adapted from *Achieving Scientific Literacy: From Purposes to Practices* (Bybee 1997).

Each lesson begins with an engagement activity, but students can reenter the 5E Model at other points in the cycle. For example, in “Name That Shell!” Chapter 7, students *explore* the characteristics of shells and sort them. Then they *explain* the characteristics they used to sort the shells and the teacher introduces the scientific terms *bivalve* and *univalve*. Next the students reenter the *explore* phase by sorting the shells into bivalves and univalves. Moving from the *explain* phase back into the *explore* phase gives students the opportunity to add to the knowledge they have constructed so far in the lesson by participating in additional hands-on explorations.

The traditional roles of the teacher and student are virtually reversed in the 5E Model. Students take on much of the responsibility for learning as they construct knowledge through discovery, whereas in traditional models the teacher is responsible for dispensing information to be learned by the students. Table 4.1 shows actions of the teacher that are consistent

with the 5E Model and actions that are inconsistent with the model.

In the 5E Model, the teacher acts as a guide: raising questions, providing opportunities for exploration, asking for evidence to support student explanations, referring students to existing explanations, correcting misconceptions, and coaching students as they apply new concepts. This model differs greatly from the traditional format of lecturing, that is, leading students step-by-step to a solution, providing definite answers, and testing isolated facts. The 5E Model requires the students to take on much of the responsibility for their own learning. Table 4.2 shows the actions of the student that are consistent with the 5E Model and those that are inconsistent with the model.

References

- Bybee, R. W. 1997. *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.
- Colburn, A. 2003. *The lingo of learning: 88 education terms every science teacher should know*. Arlington, VA: NSTA Press.

National Science Education Standards

The National Science Education Standards were published in 1996, with the intent of helping our nation's students achieve science literacy. They outline what students at different grade ranges need to know, understand, and be able to do to be considered scientifically literate. The book *National Science Education Standards* defines scientific literacy as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (NRC 1996). The Standards are designed to be achievable by all students, regardless of their backgrounds or characteristics, and are based on the premise that science is an active process. “Learning science is something that students do, not something that is done to them. ‘Hands-on’ activities, while essential, are not enough. Students must have ‘minds-on’ experiences as well” (NRC 1996). *Picture-Perfect*

Science Lessons embraces this philosophy by engaging students in meaningful, hands-on science experiences that require them to construct their own knowledge.

The lesson objectives in *Picture-Perfect Science Lessons* have been adapted from the Standards. Because the content standards themselves are not very specific, we consulted the bulleted lists of fundamental concepts and principles that underlie each standard when developing lesson objectives. We refer to these as “fundamental understandings” and have included them at the beginning of each lesson in the box titled “Lesson Objectives: Connecting to the Standards.” For example, in “Earthlets,” Chapter 6, one of the content standards for K–4 that the lesson addresses is “Content Standard B: Physical Science.” The fundamental understanding from K–4 Content Standard B that we selected for this particular lesson is “Understand that objects have many observable properties, including size, weight,

CHAPTER
5

shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.”

The fundamental understandings used to develop the lesson objectives in *Picture-Perfect Science Lessons* were adapted from the “Guide to the Content Standard” sections of the *National Science Education Standards*, which describe the fundamental ideas that underlie the Standard.

Because *Picture-Perfect Science Lessons* focuses on student learning of specific science content objectives in grades 3 through 6, this chapter outlines only the National Science

Education Content Standards. The content standards for kindergarten through grade 4 are listed in Table 5.1. The content standards for grade 5 through grade 8 are listed in Table 5.2.

Table 5.3 (p. 36) shows the correlation between the lessons presented in this book and the National Science Education Standards for grades K–4 and 5–8.

Reference

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

Table 5.1. National Science Content Standards K–4***Unifying Concepts and Processes***

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

Content Standard A: Science as Inquiry

- Abilities necessary to do science inquiry
- Understandings about science inquiry

Content Standard B: Physical Science

- Properties of objects and materials
- Position and motion of objects
- Light, heat, electricity, and magnetism

Content Standard C: Life Science

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environments

Content Standard D: Earth and Space Science

- Properties of Earth materials
- Objects in the sky
- Changes in Earth and sky

Content Standard E: Science and Technology

- Abilities of technological design
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

Content Standard F: Science in Personal and Social Perspectives

- Personal health
- Characteristics and changes in populations
- Types of resources
- Changes in environments
- Science and technology in local challenges

Content Standard G: History and Nature of Science

- Science as a human endeavor

*National Science Education Standards (NRC 1996).***Table 5.2. National Science Content Standards 5–8*****Unifying Concepts and Processes***

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

Content Standard A: Science as Inquiry

- Abilities necessary to do science inquiry
- Understandings about science inquiry

Content Standard B: Physical Science

- Properties and changes in properties of matter
- Motions and forces
- Transfer of energy

Content Standard C: Life Science

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard D: Earth and Space Science

- Structure of the Earth system
- Earth's history
- Earth in the solar system

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

Content Standard G: History and Nature of Science

- Science as a human endeavor
- Nature of science
- History of science

National Science Education Standards (NRC 1996).

Table 5.3. Connecting to the National Science Education Standards

	Content Standard A Science as Inquiry	Content Standard B Physical Science	Content Standard C Life Science	Content Standard D Earth and Space Science	Content Standard E Science and Technology	Content Standard F Science in Personal and Social Perspectives	Content Standard G History and Nature of Science
Chapter 6: Earthlets	K-4, 5-8	K-4					
Chapter 7: Name That Shell!	K-4		K-4				
Chapter 8: Rice Is Life	K-4, 5-8		K-4				
Chapter 9: What's Poppin'?	5-8						
Chapter 10: Mystery Pellets	K-4, 5-8		K-4, 5-8				
Chapter 11: Close Encounters of the Symbiotic Kind	K-4, 5-8		K-4, 5-8				
Chapter 12: Turtle Hurdles			K-4			K-4	
Chapter 13: Oil Spill!	K-4, 5-8					K-4, 5-8	
Chapter 14: Sheep in a Jeep	K-4	K-4			K-4		
Chapter 15: Sounds of Science		K-4			K-4		
Chapter 16: Chemical Change Café	K-4, 5-8	K-4, 5-8					
Chapter 17: The Changing Moon	K-4, 5-8			K-4, 5-8			
Chapter 18: Day and Night	K-4, 5-8			K-4, 5-8			
Chapter 19: Grand Canyon	K-4, 5-8			K-4, 5-8			
Chapter 20: Brainstorms: From Idea to Invention	5-8				5-8	5-8	5-8
Chapter 21: Bugs!	K-4		K-4				
Chapter 22: Batteries Included	K-4, 5-8	K-4, 5-8					
Chapter 23: The Secrets of Flight		K-4			K-4, 5-8		
Chapter 24: Down the Drain	K-4, 5-8					K-4, 5-8	
Chapter 25: If I Built a Car					K-4, 5-8	K-4, 5-8	K-4, 5-8

Index

Page numbers in **boldface** type refer to figures or tables. Those followed by “n” refer to footnotes.

A

A Cool Drink of Water, 361, 362, 364

A House for Hermit Crab, 55, 56, 60

Adaptations, 139

of parasites, 143

Animal rescue, 181–182, 187–189

Ant, Ant, Ant! (An Insect Chant),
307, 308, 315, 316

Anthropomorphism, *xiii*

Anticipation guides, 14, 393

for “Bugs!” lesson, 310, 314, 318

for “Name That Shell!” lesson,
58–59, 64

for “Rice Is Life” lesson, 76, 82

for “The Changing Moon”
lesson, 252, 257

Assembly line design, 378–380, 387

Assessment, 393

Atomic structure, 39, 43

Automobile design, 373–391

B

Barn owls, 119–136

“Batteries Included” lesson,
325–333

background for, 327–328

BSCS 5E model for, 329–333

description of, 325

Inquiry Place for, 333

materials for, 326–327

objectives of, 325

picture books for, 325

safety rules for, 327, 328, 330, 332

student pages for, 327, 335–344

time needed for, 326

Biological Sciences Curriculum

Study (BSCS) 5E Instructional
Model, *xii*, 4, 27–32, 394. *See also*
specific lessons

as learning cycle, 29, **29**, 395–396

students’ roles in, **31**, 32

teacher’s roles in, **30**, 32

“Brainstorms: From Idea to
Invention” lesson, 291–297

background for, 293

BSCS 5E model for, 294–296

description of, 291

Inquiry Place for, 297

materials for, 292

objectives of, 291

picture books for, 291

student pages for, 293, 298–306

BSCS model. *See* Biological

Sciences Curriculum Study 5E

Instructional Model

Bubble, Bubble, 4

Bugs Are Insects, 307, 308, 312, 313

“Bugs!” lesson, 307–316

background for, 308–309

BSCS 5E model for, 310–316

description of, 307

Inquiry Place for, 316

materials for, 308

objectives of, 307

picture books for, 307

safety rules for, 311

student pages for, 308, 318–323

time needed for, 308

Butternut Hollow Pond, 5, 119, 120,
124–126, 131–134

C

Car design, 373–391

Checkpoint labs, 20–22, 393

for “Batteries Included” lesson,
332, 340–342

for “Brainstorms” lesson, 296,
304–306

for “Grand Canyon” lesson,
279–280, 285–287

for “Oil Spill!” lesson, 181,
184–186

for “Sheep in a Jeep” lesson,
194–195, 201–207

for “What’s Poppin’? lesson, 96,
97, 98–102, 105–116

“Chemical Change Café” lesson,
227–235

background for, 229–230

BSCS 5E model for, 230–234

description of, 227

Inquiry Place for, 235

materials for, 228–229

objectives of, 227

picture book for, 227

safety rules for, 228, 229, 231, 233

student pages for, 229, 236–246

time needed for, 228

Children’s Book Council, 3

Chunking, 14, 393

for “Grand Canyon” lesson, 280

“Close Encounters of the
Symbiotic Kind” lesson, 5, 18,
137–145

background for, 139

BSCS 5E model for, 140–144

description of, 137

Inquiry Place for, 145

materials for, 138

objectives of, 137

picture books for, 137

student pages for, 139, 146–160

time needed for, 138

Cloze paragraph, 14, 393

for “Batteries Included” lesson,
331–332

Conservation of water, 361–371

Constructivism, 393–394

Cooking activity, 233–234, 242–246

D

- “Day and Night” lesson, 263–269
 - background for, 264–265
 - BSCS 5E model for, 265–269
 - description of, 263
 - Inquiry Place for, 269
 - materials for, 264
 - objectives of, 263
 - picture book for, 263
 - safety rules for, 267
 - student pages for, 264
 - time needed for, 264
- Design process
 - “Brainstorms: From Idea to Invention” lesson, 291–306
 - “If I Built a Car” lesson, 373–391
- Determining importance, 13
 - for “Brainstorms” lesson, 294–295, 296
 - for “Bugs!” lesson, 312
 - for “Chemical Change Café” lesson, 233
 - for “Close Encounters of the Symbiotic Kind” lesson, 143–144
 - for “Day and Night” lesson, 267
 - for “Grand Canyon” lesson, 281
 - for “Mystery Pellets” lesson, 125
 - for “Oil Spill!” lesson, 180–181
 - for “Rice Is Life” lesson, 79
 - for “Sheep in a Jeep” lesson, 194
 - for “Sounds of Science” lesson, 219–220, 221
 - for “The Changing Moon” lesson, 252, 253
 - for “The Secrets of Flight” lesson, 351
 - for “Turtle Hurdles” lesson, 164–166
 - for “What’s Poppin’?” lesson, 100–101
- Dichotomous keys
 - for “Bugs!” lesson, 314, 321–322
 - for “Close Encounters of the Symbiotic Kind” lesson, 140–141, 147–148
 - for “Name That Shell!” lesson, 59–61, 65, 68
- Down the Drain: Conserving Water,*

361, 362, 364, 366

- “Down the Drain” lesson, 361–366
 - background for, 362
 - BSCS 5E model for, 363–366
 - description of, 361
 - Inquiry Place for, 366
 - materials for, 362
 - objectives of, 361
 - picture books for, 361
 - student pages for, 362, 368–371
 - time needed for, 362
- Dr. Xargle’s Book of Earthlets*, xi, 4, 37, 38, 40–41
- Dual-purpose books, 5, 394

E

- Earthlets as Explained by Professor Xargle*, 37, 40
- “Earthlets” lesson, 33, 37–45
 - background for, 39
 - BSCS 5E model for, 40–45
 - description of, 37
 - Inquiry Place for, 45
 - materials for, 38
 - objectives of, 37
 - picture books for, 37
 - student pages for, 39, 47–54
 - time needed for, 38
- Earth’s rotation, 263–275
- Electrical circuits, 325–344
- Electrical Circuits*, 325m326
- Energy balls, 325–329, 335
- Engineering, 375–377, 383–384
- Entomology, 307–323
- Erosion, 277–289
- Erosion*, 277, 280–281
- Exxon Valdez oil spill, 179

F

- Fiction books, 5–6
- 5E instructional model. *See* Biological Sciences Curriculum Study 5E Instructional Model
- Flight, 345–360
- Food chains and food webs, 121, 124–127, 133–136
- Frayer model, 14, 394–395
 - Chemical Change, 231, 241
 - Inference, 41–42, 48

G

- Genre of picture books, 4–5, 395
- Girls Think of Everything: Stories of Ingenious Inventions by Women*, 291, 292, 294, 296
- Glossary, 393–398
- Grand Canyon: A Trail Through Time*, 277, 281–282
- “Grand Canyon” lesson, 277–283
 - background for, 278–279
 - BSCS 5E model for, 279–282
 - description of, 277
 - Inquiry Place for, 283
 - materials for, 278
 - objectives of, 277
 - picture books for, 277
 - student pages for, 278, 284–289
 - time needed for, 278
- Guided inquiry activity, 20, **21**, 395

H

- Household water use, 361–371
- How People Learn*, 18
- How People Learned to Fly*, 345, 346, 348, 350
- Hybrid books, 5

I

- I Wonder/I Learned charts, 14, 395
 - for “Turtle Hurdles” lesson, 164, 167
 - for “What’s Poppin’?” lesson, 98
- If I Built a Car*, 373, 374, 375
- “If I Built a Car” lesson, 373–380
 - background for, 374–375
 - BSCS 5E model for, 375–380
 - description of, 373
 - Inquiry Place for, 380
 - materials for, 374
 - objectives of, 373
 - picture books for, 373
 - student pages for, 374, 382–391
 - time needed for, 374
- Imaginative Inventions*, 291, 292, 294
- Inferences vs. observations, 37–54
- Inferring, 13
 - for “Brainstorms” lesson, 294
 - for “Close Encounters of the Symbiotic Kind” lesson, 144

- for “Down the Drain” lesson, 364
- for “Earthlets” lesson, 40
- for “Mystery Pellets” lesson, 122, 124–125
- for “Name That Shell!” lesson, 60
- for “Oil Spill!” lesson, 180
- for “Rice Is Life” lesson, 75
- for “Turtle Hurdles” lesson, 164
- Informational books**
- dual-purpose, 5, 394
 - fiction books and, 5–6
 - improving students’ comprehension of, 6
 - narrative, 5, 396
 - nonnarrative, 4–5, 396
 - using features of nonfiction, 15
- Inquiry**, xii, 17–25
- benefits of, 18–19
 - checkpoint labs in, 20–22
 - essential features of, **17**, 18
 - guided, 20, **21**, 395
 - misconceptions about, 20
 - open, 20, **21**, 396–397
 - selecting questions for, 19–20
 - structured, 397–398
 - variations within, 20
- Inquiry and the National Science Education Standards*, 19
- Inquiry Place, 20, 22–25
- Insects, 307–323
- Inventing the Automobile*, 373, 374, 376, 378
- Inventions**
- “Brainstorms: From Idea to Invention” lesson, 291–306
 - “If I Built a Car” lesson, 373–391
- J**
- Journal**
- for “Rice Is Life” lesson, 76–77, 84–88
 - for “The Changing Moon” lesson, 250–251, 255
- K**
- Kids’ Paper Airplane Book*, 345, 346, 350, 351, 352
- L**
- Learning cycle, 29, **29**, 395–396
- Literacy, 2
- M**
- Making connections, 12–13
- for “Batteries Included” lesson, 332
 - for “Bugs!” lesson, 310
 - for “Close Encounters of the Symbiotic Kind” lesson, 144
 - for “Day and Night” lesson, 265
 - for “Earthlets” lesson, 44
 - for “If I Built a Car” lesson, 375–376
- Making music, 217–226
- Mass production, 377–378, 386
- Misconceptions, 2–3, 396
- about inquiry-based science, 20
- Model T, 380, 390–391
- Modeling**
- for “Day and Night” lesson, 265–267
 - for “The Changing Moon” lesson, 251–252
- Moon phases, 3, 23–24, 247–262
- Motion and force, 191–215
- “Mystery Pellets” lesson, 5, 119–128
- background for, 120–121
 - BSCS 5E model for, 122–127
 - description of, 119
 - Inquiry Place for, 128
 - materials for, 120
 - objectives of, 119
 - picture books for, 119
 - safety rules for, 122
 - student pages for, 120, 129–136
 - time needed for, 120
- N**
- “Name That Shell!” lesson, 55–61
- background for, 57
 - BSCS 5E model for, 58–61
 - description of, 55
 - Inquiry Place for, 61
 - materials for, 56
 - objectives of, 55
 - picture books for, 55
 - student pages for, 56, 62–70
- time needed for, 56
- Narrative information books, 5, 396
- National Science Education Standards, xii, 3, 18, 33–34, **35–36**, 396
- National Science Teachers Association, 3
- Nonnarrative information books, 4–5, 396
- O**
- Observations vs. inferences, 37–54
- Oil Spill!*, 2, 177, 178, 180–181
- “Oil Spill!” lesson, 2, 177–182
- background for, 179
 - description of, 177
 - Inquiry Place for, 182
 - materials for, 178
 - objectives of, 177
 - picture books for, 177
 - student pages for, 178, 184–189
 - time needed for, 178
- Open inquiry activity, 20, **21**, 396–397
- O-W-L charts, 14, 397
- for “Close Encounters of the Symbiotic Kind” lesson, 140, 146
 - for “Mystery Pellets” lesson, 122, 129
 - for “Name That Shell!” lesson, 58, 62
- P**
- Pairs read, 14, 397
- for “Chemical Change Café” lesson, 231
 - for “Close Encounters of the Symbiotic Kind” lesson, 141–142
 - for “If I Built a Car” lesson, 377
 - for “Rice Is Life” lesson, 76
 - for “Sheep in a Jeep” lesson, 196
- Pancakes, Pancakes!*, 227, 228, 232, 233
- Papa, Please Get the Moon for Me*, 3, 247, 248, 253, 259–260
- Paper airplane flight, 345–360
- Personal vocabulary list, 14, 397

Peterson First Guide to Insects of North America, 316

Physical and chemical changes, 227–246

Picture books, 1–6

benefits for upper elementary students, 3

to enhance comprehension, 15–16

genre of, 4–5, 395

pairing fiction and nonfiction texts, 5–6

scientific inaccuracies in, 3

selection of, 3–4

sources for, 4

Popcorn, 95–117

Popcorn!, 95, 96

Posters

for “Bugs!” lesson, 316, 323

for “Mystery Pellets” lesson, 124, 127

for “Name That Shell!” lesson, 61

for “Sheep in a Jeep” lesson, 196, 207

for “What’s Poppin’?” lesson, 102–103, 117

Preconceptions of students, 18–19

Prince William, 2, 177, 178, 180

Q

Questioning, 13

for “Day and Night” lesson, 265

for “If I Built a Car” lesson, 377

for “Oil Spill!” lesson, 180

for “The Changing Moon” lesson, 249

for “Turtle Hurdles” lesson, 164

R

Reading aloud, 9–16, 397

for “Batteries Included” lesson, 331

for “Brainstorms” lesson, 294

for “Earthlets” lesson, 40

rationale for, 9–10

for “Rice Is Life” lesson, 74

for “Sheep in a Jeep” lesson, 194

for “Sounds of Science” lesson, 221

for “The Changing Moon”

lesson, 249, 251

tips for, 10–12

for “Turtle Hurdles” lesson, 164

for “What’s Poppin’?” lesson, 98

Reading comprehension

enhancement tools, 13–16

anticipation guides, 14, 393

chunking, 14, 393

cloze paragraph, 14, 393

pairs read, 14, 397

rereading, 14, 397

sketch to stretch, 15, 397

stop and jot, 15, 397

turn and talk, 15, 398

using features of nonfiction, 15, 394

visual representations, 14

word sorts, 15, 398

Reading comprehension strategies,

6, 12–13, 397

determining importance, 13

inferring, 13

making connections, 12–13

questioning, 13

synthesizing, 13

visualizing, 13

Reading skills, 2, 9

Rereading, 14, 397

for “Oil Spill!” lesson, 181

Rice, 5, 71, 72, 78

Rice Is Life, 4, 5, 71, 72, 75

“Rice Is Life” lesson, 5, 71–81

background for, 73

BSCS 5E model for, 74–81

description of, 71

Inquiry Place for, 81

materials for, 72

objectives of, 71

picture books for, 71

student pages for, 73, 82–93

time needed for, 72

Rise the Moon, 247, 248

S

Safety rules

for “Batteries Included” lesson, 327, 328, 330, 332

for “Bugs!” lesson, 311

for “Chemical Change Café”

lesson, 228, 229, 231, 233

for “Day and Night” lesson, 267

for “Mystery Pellets” lesson, 122

for “The Secrets of Flight” lesson, 346

for “What’s Poppin’?” lesson, 99–100, 101, 109, 110

Science and Children, 3

Science concepts, 2

Scientific misconceptions, 2–3, 396

Scoring rubrics

for animal rescue letter, 182

for design a plant experiment, 80

for Grand Canyon brochure, 282

for insect poster, 323

for instrument presentations, 222

for making a picture book, 268

for popcorn poster session, 103

for turtle letter, 167

Sea turtles, 161–176

Seashell classification, 55–70

Seashells by the Seashore, 55, 58

Semantic maps, 14, 397

for “Rice Is Life” lesson, 74–75

template for, 74

for “The Secrets of Flight”

lesson, 348, 349

Seven Blind Mice, 37, 38, 44

Sheep in a Jeep, 191, 192, 194

“Sheep in a Jeep” lesson, 20,

191–199

background for, 192

BSCS 5E model for, 194–198

description of, 191

Inquiry Place for, 199

materials for, 192

objectives of, 191

picture book for, 191

student pages for, 192, 200–215

time needed for, 192

Sketch to stretch, 15, 397

for “Rice Is Life” lesson, 75

Somewhere in the World Right Now, 263, 264, 270–272

Sound, 217, 218

“Sounds of Science” lesson, 217–223
 background for, 218–219
 BSCS 5E model for, 219–222
 description of, 217
 Inquiry Place for, 223
 materials for, 218
 objectives of, 217
 picture books for, 217
 student pages for, 218, 224–226
 time needed for, 218

Stop and jot, 15, 397
 for “Rice Is Life” lesson, 75

Storybooks, 4, 397
 dual-purpose, 5, 394

Strategies That Work, xii, 3, 12, 397

Straw instruments, 218–221

Structured inquiry activity, 397–398

Sun position, 263–275

Symbiotic relationships, 137–160

Synthesizing, 13
 for “Down the Drain” lesson, 364
 for “Rice Is Life” lesson, 75
 for “Sounds of Science” lesson, 222

T

T-charts, 14, 398
 for “Bugs!” lesson, 313
 for “Earthlets” lesson, 40
 for “Rice Is Life” lesson, 80
 for “Sheep in a Jeep” lesson, 194
 for “Turtle Hurdles” lesson, 166–167, 175

That Magnetic Dog, 4

“The Changing Moon” lesson, xiin, 3, 23–24, 247–253
 background for, 248–249
 BSCS 5E model for, 249–253
 description of, 247
 Inquiry Place for, 253
 materials for, 248
 objectives of, 247
 picture books for, 247
 student pages for, 248, 255–262
 time needed for, 248

The Moon Book, 247, 248, 252, 269

The Perfect Pet, 307, 308, 312, 314

The Remarkable Farkle McBride, 217, 218, 222

“The Secrets of Flight” lesson, 345–352
 background for, 347
 BSCS 5E model for, 348–352
 description of, 345
 Inquiry Place for, 352
 materials for, 346
 objectives of, 345
 picture books for, 345
 safety rules for, 346
 student pages for, 346, 354–360
 time needed for, 346

The Sun Is My Favorite Star, 269

Too Many Toys, 325, 326, 332

Turn and talk, 15, 398
 for “Bugs!” lesson, 310
 for “Close Encounters of the Symbiotic Kind” lesson, 143
 for “Oil Spill!” lesson, 180

Turtle, Turtle, Watch Out!, 161, 162, 163, 164–166, 173

“Turtle Hurdles” lesson, 161–168
 background for, 163
 BSCS 5E model for, 164–167
 description of, 161
 Inquiry Place for, 168
 materials for, 162
 objectives of, 161
 picture books for, 161
 student pages for, 162, 169–176
 time needed for, 162

Turtle Watch, 161, 162, 163

U

Using features of nonfiction, 15, 394
 for “Down the Drain” lesson, 364
 for “Grand Canyon” lesson, 279
 for “Sounds of Science” lesson, 219

V

Visual representations, 14

Visualizing, 13
 for “If I Built a Car” lesson, 376
 for “Mystery Pellets” lesson, 125

for “Rice Is Life” lesson, 75
 for “Turtle Hurdles” lesson, 164

Vocabulary, 2, 5
 for “Grand Canyon” lesson, 280, 288
 personal list, 14, 397

W

Water use and conservation, 361–371

Weathering and erosion, 277–289

Weird Friends: Unlikely Allies in the Animal Kingdom, 137, 138, 144, 152

What’s Eating You? Parasites—The Inside Story, 137, 138, 144

“What’s Poppin’?” lesson, 95–103
 background for, 97
 BSCS 5E model for, 98–102
 description of, 95
 Inquiry Place for, 103
 materials for, 96–97
 objectives of, 95
 picture book for, 95
 safety rules for, 99–100, 101, 109, 110
 student pages for, 97, 105–117
 time needed for, 96

White Owl, Barn Owl, 5, 119, 120, 122

Word sorts, 15, 398
 for “Close Encounters of the Symbiotic Kind” lesson, 141–142, 149–150
 for “Earthlets” lesson, 40, 47
 for “Mystery Pellets” lesson, 125–127, 131–132
 for “Sheep in a Jeep” lesson, 196–197, 208–209

Writing a letter
 for “Oil Spill!” lesson, 182, 189
 for “Turtle Hurdles” lesson, 167, 176

Y

Yellow Brick Roads: Shared and Guided Paths to Independent Reading 4–12, 9