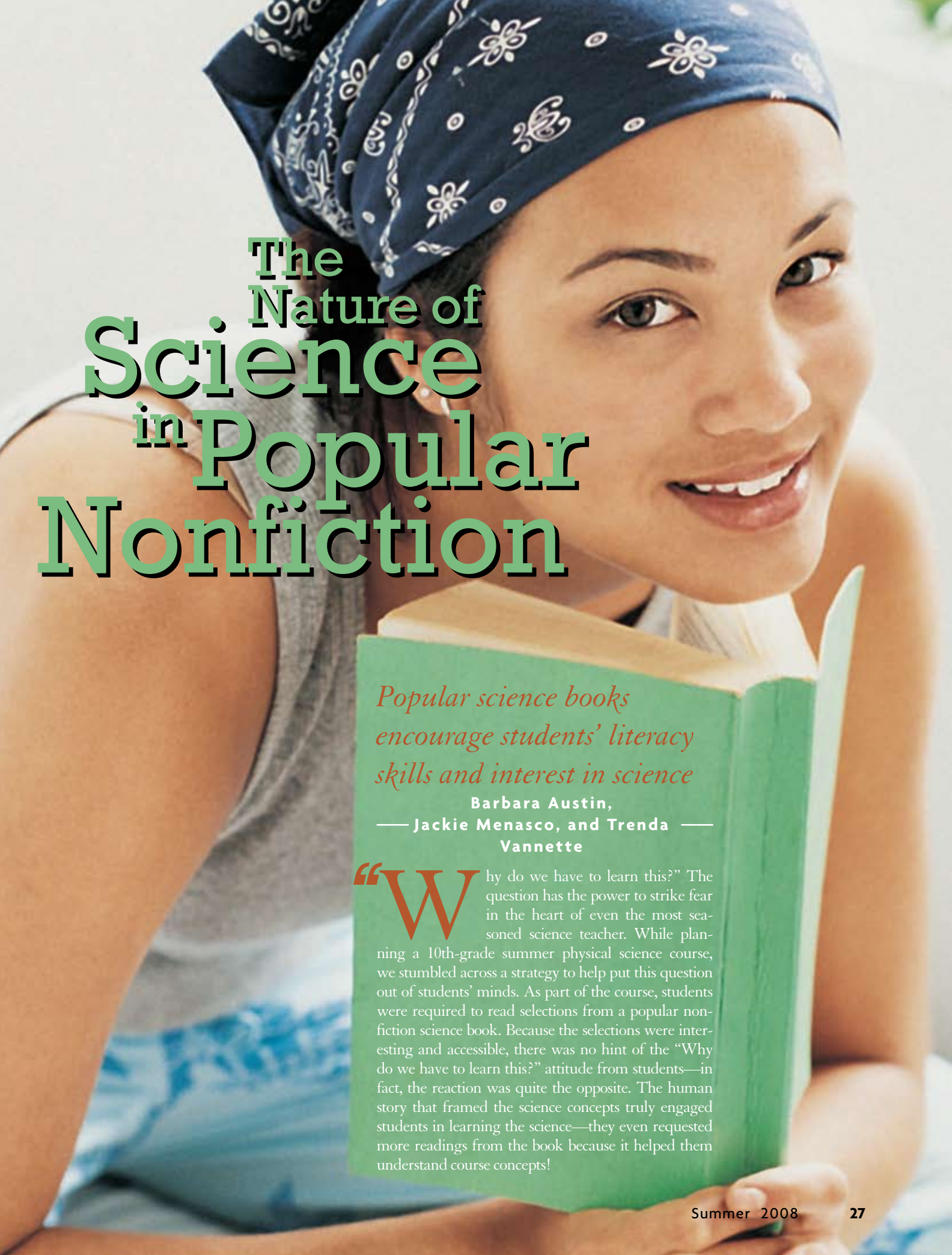

The Nature of Science in Popular Nonfiction

Popular science books encourage students' literacy skills and interest in science

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"Why do we have to learn this?" The question has the power to strike fear in the heart of even the most seasoned science teacher. While planning a 10th-grade summer physical science course, we stumbled across a strategy to help put this question out of students' minds. As part of the course, students were required to read selections from a popular nonfiction science book. Because the selections were interesting and accessible, there was no hint of the "Why do we have to learn this?" attitude from students—in fact, the reaction was quite the opposite. The human story that framed the science concepts truly engaged students in learning the science—they even requested more readings from the book because it helped them understand course concepts!

By having students read a popular nonfiction science book, we were able to promote literacy and provide an authentic portrayal of the nature of science in a way that was fun and interesting for them. This article describes our experience using a nonfiction science book in the classroom and suggests literacy activities to enhance science and reading comprehension.

Promoting literacy

There is a growing body of research that suggests that learning language is critical to learning science (e.g., Douglas et al. 2006; Fradd et al. 2001). Both science and literacy educators have noted the shared nature of learning strategies that are essential for deep understanding of science concepts and processes. Our course design included the intentional use of literacy strategies to promote effective physical science learning. These strategies—which include such activities as concept maps, stop and jot, and chunking—are presented in Figure 1.

Because the nonfiction science reading was a last-minute addition to the course, we chose a single book—*A Short History of Nearly Everything* by Bill Bryson (2003)—that aligned with the course objectives. Drawing from the fields of Earth science, astronomy, chemistry, physics, and biology, this book presents the scientific worldview of how the universe, the Earth, and life came to be. We chose this book because it contains substantive and accurate science, as well as the historical development of scientific concepts. The writing style is accessible, rather than "textbookish," and therefore appeals to a lay audience. The class read one chapter for each of the five course units—Matter, Energy and Waves, Motion and Force, Electrostatics and Electricity, and Magnets and Electromagnetism—plus an additional chapter that presented a brief overview of what is known about the universe today. Although we chose to use the Bryson book for our course assignment, there are many other popular nonfiction science books that could also serve this purpose (see "Other reading suggestions," p. 31).

FIGURE 1

Descriptions of literacy strategies.

Picture drawing	Students draw pictures of experimental setups, experimental outcomes, or physical phenomenon described in the text (e.g., Rutherford's gold foil experiment).
Connections	Students make a connection between what they read in one or two pages of text and what they have learned in class (e.g., radiocarbon dating and nuclear stability).
Topic sentences	Students identify the topic sentences in one section of a chapter.
Concept map	Students develop a concept map for one or two pages of a chapter.
Similarities/differences chart	Illustrated in Figure 4 (p. 31). Teachers provide a list of elements for language-developing students, but require language-proficient students to identify the elements themselves.
Conclusion/evidence chart	For each scientific conclusion, students identify the evidence that supports it. Ideally, this evidence comes from both the historical record discussed in the text and students' collection of experimental data.
Chunking	Students divide a chapter into the individual ideas that comprise it. Teachers can ask language-proficient students to identify the structural role of each chunk (e.g., introduction, transition paragraph between ideas, illustration, supporting idea, further development of the main idea).
Stop and jot	Students write a two to five word summary of each paragraph in a section of a chapter.
Questions	Students answer text-specific questions.
Story map	Illustrated in Figure 2.
Newspaper	Students retell a chapter or section of a chapter in their own words by creating a newspaper of the text. The newspaper can include news stories, editorials, classified advertisements, commercial advertisements, or comics. This strategy could work well as a jigsaw.

In addition to readings from *A Short History of Nearly Everything*, teaching activities included a combination of learning cycles, demonstrations, short lectures, and small and whole group "sense-making" discussions. Students were assigned readings from the book the night after being taught related material, along with various literacy strategies to assist with reading comprehension. For example, in the chapter about the atomic structure of matter, students were given three tasks to accompany specific readings from the chapter:

FIGURE 2

Story map.

Title: _____

Setting:

Characters: _____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

Problem:

Events:

1st: _____

2nd: _____

3rd: _____

4th: _____

5th: _____

6th: _____

Solution:

1. Draw a picture of the experimental setups, outcomes, or physical phenomenon described in the paragraph on Rutherford's scattering experiments.
2. Make three connections between what you read and what you learned in class.
3. Identify the topic sentences in this passage.

For other chapters, some of the literacy strategies assigned with the readings required the use of visual organizers such as concept maps, similarities/differences charts, and conclusion/evidence charts. Other strategies included chunking portions of chapters, stop and jot, and responding to questions about specific passages. (**Note:** For an explanation of these strategies, see Figure 1.) Students found these reading strategies so useful that even when they were optional assignments, most students still did them.

One literacy strategy that seemed unusual to use in conjunction with a nonfiction book led to a particularly interesting class discussion. In a chapter about dating Earth (taught during the unit on the periodic table), students were assigned the task of creating a story map, as shown in Figure 2. Defining the "problem" is one field in the story map. Some students thought the chapter's problem was determining the age of Earth; others thought it was determining why lead was contaminating everything. This was because the first half of the chapter focuses on the difficulties encountered by Clair Patterson in dating Earth (using his uranium-lead dating method) and why he had to invent sterile techniques in order to avoid lead contamination.

Coming to a consensus about the chapter's actual problem involved a lengthy and detail-rich discussion during which students repeatedly referred to multiple items from their story maps. Typically, this type of discussion would involve a handful of students dominating the conversation. However, in this instance, most students had something to contribute. We hypothesize that this was because scaffolding students' reading of the chapter with a story map promoted comprehension of the main points and retention of details.

Portraying the nature of science

A Short History of Nearly Everything is engaging reading for novice science students. In addition to promoting literacy, another benefit is the book's content—there is a lot of science. For example, the chapter about atoms presents factual and conceptual information about the prevailing theory of matter. In addition, the book is an excellent supplement to the typical content found in textbooks, as

FIGURE 3

Characteristics of the nature of science presented in *A Short History of Nearly Everything*.

Characteristic	Chapter 4: The measure of things	Chapter 7: Elemental matters	Chapter 8: Einstein's universe	Chapter 9: The mighty atom
Empirical	Norwood measures the length of a degree in Earth's meridian.	Periodic table is created from empirical evidence; theory about why it is arranged that way comes much later.	Michelson and Morley conduct famous experiment.	Brownian motion provides evidence of the atom's existence.
Observational and inferential	Triangulation of Venus' transits across the Sun is used to calculate distances between planets in our solar system.	Avogadro's number is developed.	Planck creates the idea of quanta.	Rutherford conducts gold foil experiment.
Creative and logical	Newton mathematically proves the elliptical motion of planets.	Lavoisier develops conservation of mass idea from weighing rusting objects.	Einstein devises theory of relativity.	Bohr interprets atomic spectra.
Subjective	Halley supposes motion of planets is an inverse square law; Newton supposes Earth is flattened at the poles.	Brand believes gold can be distilled from human urine.		Dalton asserts an irreducible particle.
Tentative	Increasingly better measurements of the length of a degree are taken.	Periodic table is developed and improved.	Michelson and Morley's experiment causes demise of "the ether."	Theory of matter is developed and improved.
Socially and culturally situated	Due to argument with Hooke, Newton almost does not release the third volume of *The Principia*.	Scientific societies influence progress of science; solitaire game inspires development of the periodic table.		Atomic bomb is developed in the historical context of World War II.
Systematic and methodical	Observational methods are used (measuring distances on Earth).	Serendipitous discoveries occur (e.g., phosphorous; electrolysis to find elements).	Michelson and Morley perform controlled experimentation.	Schrödinger's cat shows thought experiments and modeling.

BRYSON 2003

it provides information not usually included in textbooks. Each chapter contains an accurate portrayal of the nature of science presented through a specific topic's history and how it came to be developed and accepted into the body of science knowledge. In a chapter about measuring the size of Earth, for instance, Bryson includes information that could lead to substantive discussions about several aspects of the nature of science, including the creativity required to devise experiments, observation versus inference, collaboration and peer review, squabbling between scientists, and a concrete example about how the knowledge base of science advances.

In class, the nature of science as revealed by Bryson typically comprised the majority of discussions about the homework reading. These conversations were supported by students engaging in inquiry-based develop-

ment of scientific knowledge. For example, during the unit on waves and energy, students were given two types of Slinkys and asked to describe the motion of a wave on each Slinky with enough precision that someone who could not see the waves could accurately draw and understand them. Students spent the morning developing the ideas of wavelength, frequency, speed, amplitude, reflection, and refraction as they described the waves. During and after inquiry-based learning activities such as this one, we prompted students to draw parallels between events in the history of science and their own science-related activities to further develop their understanding of the nature of science and what it looks like in operation. Examples of the nature of science as presented in the Bryson readings can be found in Figure 3.

Another benefit of using *A Short History of Nearly Everything* is the inclusion of women in the unfolding story of science. Bryson expands the world of women in science beyond Marie Curie and Mary Leakey. In his retelling of the discovery of DNA's structure (credited to James Watson and Francis Crick), Bryson not only includes the vital contribution of Rosalind Franklin's crystallography images in revealing the helical DNA structure, but also provides insights into the difficulties faced by this woman scientist. Bryson also explains the important contributions of women astronomers at Harvard University, including Henrietta Leavitt, who discovered the period-luminosity relationship for Cepheid variable stars, and Annie Jump Cannon, who devised the current system of stellar classifications. As with Franklin, Bryson includes information on the institutionalized second-class status of these great minds. Finally, Bryson goes beyond the well-known women of science by including the lesser-known scientists of today, including Victoria Bennett (geochemist), Rosalind Harding (geneticist), Maeve Leakey (paleoanthropologist), Lynn Margulis (biologist), and Helen Michel (chemist).

Understanding course concepts

Reading about the human drama associated with the development of the scientific knowledge base inspired our students to really learn the science concepts so that, in turn, they could better understand the story unfolding in the book. Many students began reading *A Short History of Nearly Everything* both before and after instruction. Students claimed they wanted to read the book beforehand because it gave them some familiarity with terms and motivated them to learn what we were teaching. Students reread it afterward because they could better appreciate the science discussed in the book, which made the human side of the story even more interesting.

Other reading suggestions

A Short History of Nearly Everything is a versatile resource because it includes content that spans all of the disciplines. A school could buy a classroom set to be used by all instructors in the science department. However, there are many other books about science written for the popular audience that could also be used. For example, *Great Feuds in Science* by Hal Hellman (1998) provides the details of 10 disputes from the history of science, including who developed calculus (Sir Isaac Newton or Gottfried Leibniz) and who, if anyone, found the "missing link" in evolution (Donald Johanson or the Leakeys). Several chapters describe the development of major ideas in Earth science, including Galileo Galilei's fight to displace the Earth-centered universe model and Lord Kelvin's faulty logic about the age of Earth. Like Bryson, Hellman includes controversies involving women in 2 of his 10 feuds, including the "missing link" dispute (Mary Leakey) and the posthumous challenge of Margaret Mead's findings by Derek Freeman.

Chapter 8 in the Hellman book retells Alfred Wegener's controversial proposal of continental drift. It is rich with data descriptions and insights about how the body of scientific knowledge develops. Geological concepts mentioned in this chapter include: the composition of different layers of Earth, a proposed origin of mid-ocean ridges, reversals of Earth's magnetic field, and a brief description of plate tectonics.

The first part of Chapter 8 deals with parallels between Wegener and Charles Darwin. A literacy tool that would complement this section is a similarities/differences chart, such as the one shown in Figure 4. While reading, students note the elements listed in the first column as they pertain to Wegener and Darwin. A "+" is placed in the scientist's column if the element applies to his experience, and a "–" is placed in the column if the element does not apply to his experience. Students with high levels of literacy should

FIGURE 4

Similarities/differences chart.

Elements from the reading	Darwin	Wegener
Uses the term "origin" in the title of book	+	+
Theory includes concepts from many scientific disciplines	+	+
Not the first to devise the theory	+	+
Takes a long time between developing theory and publishing it	+	–
Attacks on theory are not religiously based	–	+

be able to create their own list of elements. To make this assignment easier for students with lower language skills, a teacher could give students a chart with the elements already listed, so that students would only have to fill in the "+/–". A second literacy tool that would also complement this chapter is a support/refute chart. As students read the chapter, they place statements that support Wegener's hypothesis in one column and statements that refute it in another.

As with the Bryson book, the Hellman book contains a lot of accurate information about the nature of science. The title alone is an indication of science's social and subjective aspects, which are presented in the feuds included. The chapter about Wegener portrays the creativity required to develop scientific hypotheses and the tentative nature of science.

Another potential source of readings is *The Best American Science and Nature Writing* series (Greene 2006). The 2006 edition includes articles from all content areas and revisits older topics, such as gravity and mass, and cutting-edge topics, such as whether it is prudent to work on extending the human life span. "Are antibiotics killing us?" would be an interesting chapter to read during a unit on microbiology or human systems. (**Note:** This chapter begins with an example of a sexually transmitted disease, which may be inappropriate in some classrooms, so teachers may want to censor the first few paragraphs.) Microbial concepts presented in the chapter include conjugation and transformation, contextualized in how bacteria acquire antibiotic resistance; human systems concepts include the role of bacteria in digestion and disease.

"Are antibiotics killing us?" also contains a lot of information about various scientists and their experiments and hypotheses, which makes it rather easy for students to get confused. One literacy tool that might help students stay on track with this chapter is the creation of a newspaper. Small groups (story groups) can be assigned short passages about which to write a newspaper story, editorial, advertisement, or cartoon. The story groups are then redistributed into newspaper groups, with each member of the newspaper group using their work from the story group to develop a multiple-item newspaper. Each newspaper group should individualize the products of the story groups through design layout and content revision as the group sees fit. Having each group create their own newspaper would scaffold the reading and synthesis of individual parts of the chapter. As with the Bryson and Hellman books, this chapter includes interpersonal controversy and human drama in science that will entice students to finish it. Insights into the nature of science found in this chapter include its tentativeness, the difference between inference and observation, subjectivity, and creativity.

The shelf in the public library or bookstore that houses *A Short History of Nearly Everything* is an excellent source for other popular nonfiction science books. (**Editor's note:** For more nonfiction reading suggestions, see "Reading Aloud" by Delo on p. 33 of this issue.)

Conclusion

When we incorporated a popular nonfiction science book into our curriculum, we did not know that it would have such a positive impact on our students, so we did not collect any formal data about outcomes. However, our impression is that this approach was an effective means to motivate students to learn science, scaffold literacy skills, and accurately portray the nature of science. In our next implementation of the course, we plan to survey students about both affective and academic outcomes as a result of reading popular science texts.

In our experience, typically only a handful of students will initiate conversations about science. After the readings, the vast majority of students initiated informal conversations with one another about the book and asked teachers about the everyday applications of science found in the readings, such as how magnetic resonance imaging (MRI) or rail guns work. Additionally, as the course progressed, in formal conversations about the book and class content, students began to address our target nature-of-science issues in trying to explain their interpretations of the book's events, such as why quarks were invented.

Although at first many students expressed trepidation about having to learn physical science, by the middle of the course, they were all very enthusiastic about the readings and were engaged in learning science to better understand the book. ■

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References

Bryson, B. 2003. *A short history of nearly everything*. New York: Broadway Books.

Douglas, R., M.P. Klentschy, K. Worth, and W. Binder, eds. 2006. *Linking science and literacy in the K–8 classroom*. Arlington, VA: NSTA Press.

Fradd, S.H., O. Lee, F.X. Sutman, and M.K. Saxton. 2001. Promoting science literacy with English language learners through instructional materials development: A case study. *Bilingual Research Journal* 25(4): 417–439.

Greene, B., ed. 2006. *The best American science and nature writing 2006*. New York: Houghton Mifflin Company.

Hellman, H. 1998. *Great feuds in science: Ten of the liveliest disputes ever*. New York: John Wiley & Sons.