Feature Book Review

Seeking the Big Picture on Science: Taking an Integrated Approach to Teaching Scientific Literacy

Review of: *The Sciences – An Integrated Approach, Sixth ed.*, by James Trefil and Robert Hazen; 2010; 555 pp.; John Wiley & Sons, Inc.; ISBN: 978-0-470-11854-2 and *Science Matters – Achieving Scientific Literacy (New Edition)*, by Robert M. Hazen and James Trefil; 2009; 360 pp.; Anchor Books (New York); ISBN: 978-0-307-45458-4

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One of my favorite undergraduate microbiology teachers used to remind us that the study of biology was important because “we are all biological citizens in a biological world.” Authors James Trefil and Robert Hazen would probably modify that statement, and say that studying science is important because “we are all physical citizens in a physical universe.” In the two books they have coauthored, *The Sciences – An Integrated Approach*, and *Science Matters*, the authors undertake the grand task of conveying “Science,” with a capital “S,” from atoms to ecosystems and from the scientific method to the very latest advances in biotechnology.

Although both books cover the same sweeping, multidisciplinary world of science, *The Sciences* is a textbook the authors created to teach a course in “Great Ideas in Science” for undergraduate nonscience majors, while *Science Matters* is a portable trade paperback for those beyond their school years, but who are nonetheless seeking to become “scientifically literate.” The books reviewed here are both new, updated editions, and anyone who has been in the sciences for more than 10 years knows that works including topics like the structure of the universe, the earth sciences (global warming included), or genetics and biotechnology will require frequent updating. Almost all of the chapters in *The Sciences* have had some changes reflecting new scientific content, and the authors list the significant ones in the Preface. Individual chapters were

also updated in *Science Matters*, and one additional chapter on advances in Biotechnology was added.

The first key word in describing these books is “Integrated.” The authors feel that, although college science majors may benefit from taking multiple, in-depth semester-

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SCIENCE MATTERS

ACHIEVING SCIENTIFIC LITERACY

FROM PLATE TECTONICS TO LEPTONS TO THE FIRST LIVING CELL, NOW YOU CAN UNDERSTAND THE SIMPLE SCIENCE BEHIND OUR COMPLEX WORLD

ROBERT M. HAZEN
& JAMES TREFIL

New Edition,
Expanded and
Updated

long classes covering separate disciplines (i.e., chemistry vs. biology, etc.), in reality, the universe includes all of the sciences in a state of constant interplay, and everyone would benefit from having at least an intuitive, broad-based view of science as a whole. Thus, the second key word to consider when approaching these books is “literacy.” Because we live in a society that is saturated with the effects of scientific research, the authors hope to contribute to training “Scientific Citizens,” so that we might all obtain the knowledge we need to make thoughtful decisions regarding public issues—from climate change to stem cell research. And so, the real beauty of both books does not rely on the scientific topics themselves (as beautiful as they may be), but rather on the clever and creative ways the authors meld all scientific disciplines into one seamless story.

Both books share two characteristics that set them apart, and perhaps make them more effective as teaching tools. The first is an organization around “Great Ideas,” in which the authors present a comprehensive concept to be tackled (e.g., “All matter above and beneath Earth’s surface moves in cycles”; “Nuclear energy depends on the conversion of mass into energy”; “All living things are made from cells, the chemical factories of life”, etc.). The second feature is that the authors try to make the topics very relevant to our everyday lives. In *The Sciences*, one of the ways this rele-

vance emerges is through a “day in the life” device, where the beginning of each chapter contains a snippet called “Science through the Day,” moving the reader from sunrise to sundown on a trip to the beach. These are often clever scenarios, such as “A Hot Breakfast” in the chapter on Thermodynamics (why can’t we unjuice an orange?), or “Sunburn!” in the chapter on The Living Cell (how *does* our burnt skin replenish itself?). In *Science Matters*, which is a much shorter book, the relevance is contained within the chapters themselves, and the authors are very good at using common and interesting examples from everyday life to drive their points home (e.g., roller coasters, GPS, the 2004 tsunami).

An additional feature that most readers (and teachers) might appreciate is the sparse use of mathematics. *The Sciences*, a textbook, contains more equations than *Science Matters*, but they are kept to an absolute minimum, only used where needed to describe a process thoroughly. This entire approach, however, is letting out the dirty little secret that many scientists won’t confess to—that is, *Science is Simple*. Of course *arriving* at scientific truth is not simple in the least, but throughout both books the authors convey the elegance and great simplicity behind the principles and theories that so many people have worked so hard to elucidate.

Because the books were written for different audiences, they each have their own unique features. *The Sciences* does not deviate too far from a classic textbook format, and so it contains the familiar Chapter Summaries, Review Questions (newly updated), and Problem Sets. Also, very well thought-out Discussion Questions and Discovery Labs (simple and optional “lab” exercises) provide useful resources for teachers to take advantage of if they choose. True to their “integrated” philosophy, each of the 25 chapters in *The Sciences* begins with a cleverly organized introductory page that merges ideas from multiple scientific disciplines that are encompassed within the Great Idea to be addressed. Also introducing each chapter is an “Integrated Science Question,” which is returned to at the end of the chapter in the form of bullet points summing up the main concepts. Examples of such questions include “How much longer can the Sun sustain life on Earth?” in the chapter on The Stars, and “Can we predict destructive earthquakes?” in the chapter on Plate Tectonics.

Another notable “integrative” feature of *The Sciences* is the use of special “Topics” throughout each chapter, to show how all of the sciences are contained within each other. These include “The Science of Life” (how the concept is involved in biology), “The Ongoing Process of Science” (current questions being addressed by scientists now), “Science in the Making” (mini science history lessons), and “Technology” (how concepts are applied). It is worth drawing special attention to the authors’ daring use of “Stop and Think!” and “Thinking More About It” boxes. The “Stop and Think!” boxes are short, analytical questions that are designed to, well, make the student actually stop reading, think about what they just read, and apply their knowledge. The “Thinking More About It” boxes are longer, more thoughtful ruminations on current real-life issues related to the concept just studied, such as “Aging” for the concept of Entropy, “Nuclear Waste” regarding The Nucleus, or “Dietary Fads” relating to The Molecules of Life. This text represents a paradigm shift in the approach to teaching

science to the nonscience major and contains an abundance of resources for creative use in the classroom.

In *Science Matters*, which is *not* a textbook, the goal is more unabashedly to educate a wider swath of society to help them become scientifically literate. In the Introduction, Hazen and Trefil define their notion of scientific literacy as “the knowledge you need to understand public issues.” They point out wisely that scientific literacy is different from technological literacy (such as the ability to program your DVD player), and that it is important for civic, aesthetic, and intellectual reasons. Thus, the book is organized around 19 Great Ideas (or “Core Concepts”), and is written in a very readable, storytelling style. The book begins with the general idea of “Knowing” in science, then goes through the Great Ideas in a general order of physics, then chemistry, then life sciences, ending in a chapter on Ecosystems, with the most beautiful core concept that “All life is connected.” One particularly nice feature is a section called “Frontiers” at the end of each chapter, where current state-of-the-research questions are discussed. This has the excellent effect of showing that science is an active, changing, open-ended process and that there are many things we still do not understand.

As a scientist, I enjoyed reading *Science Matters* very much, and I liked that I was able to fill in some of my own gaping holes of knowledge, particularly in the earth sciences. However, I am still curious about how true newcomers to science might fare in upgrading their understanding after reading this book on their own. With that said, I think

that *Science Matters* would be splendid for short, adult education classes in scientific literacy. But I think that the person who is motivated to pick up this book at a bookstore would likely possess the proper mindset to gain a fairly thorough grasp of the sciences and the role they play in society.

The only thing that *Science Matters* might benefit from would be a few more well-organized figures, a suggestion I make because the few pictures that are included are simple, to-the-point, and helpful. Also, I noticed that the authors mention the Doppler effect in Chapter 10, but don’t explain what it is until Chapter 11. But this is a minor organizational point and will hopefully be corrected in the next edition. And although the authors point out that many societal issues, including the rise of drug-resistant microbes and the spread of “bird-flu,” are important reasons for becoming scientifically literate, as a microbiologist who has a particular interest in “microbial literacy,” I would like to see these topics specifically addressed in future editions.

Overall, Drs. Hazen and Trefil are to be commended for tackling the Herculean task of telling the grand story of Science for all and keeping the works updated in an energetic way. In both *The Sciences* and *Science Matters*, the authors’ love of science is abundantly evident, and I believe that this sincere enthusiasm can be wonderfully infectious. I’m certain that this will serve to inspire the students and individuals who read these works, especially with the guidance of an equally enthusiastic instructor.