BOOK REVIEWS

Teaching About Evolution and the Nature of Science. Working Group on Teaching Evolution, National Academy of Sciences. 1998. National Academy Press, Washington, DC. 140 p. $19.95 paper.

The National Academy of Sciences (NAS) is a private, nonprofit society of distinguished scientists dedicated to the use of science and technology for the general welfare. The Academy is mandated to advise the federal government on scientific and technical matters under a charter granted to it by Congress in 1863. This book represents the Academy's response to the alarming scientific illiteracy of the American public which is made even worse by the pressure applied to teachers and school boards by groups opposed to the teaching of evolution in public schools. It is addressed to teachers and administrators who deliver or oversee classroom instruction in biology. The book summarizes the overwhelming evidence for evolution and recommends ways of teaching it. The Working Group that assembled the book is composed of 13 scientists and educators.

The first chapter asks the questions, "Why teach evolution?" One answer is because the theory of evolution is the best explanation for the diversity of life, the similarity of related organisms, and life's ability to alter the physical world such as the atmosphere and soil. These are things that all educated people must understand. Chapter two presents the usual evidence for evolution found in textbooks. It introduces Darwin, Wallace, Mendel, fossils, origin of whales, Galapagos finches, human evolution, and so forth. Evolution is defined as "Change in the hereditary characteristics of groups of organisms over the course of generations," another way of saying "descent with modification" or "change in gene frequency." Natural selection is defined as "Greater reproductive success among particular members of a species arising from genetically determined characteristics that confer an advantage in a particular environment." Chapter three deals with the nature of science and discuses Copernicus and heliocentricism, dating methods and geologic time, phylogenetic trees, and continental drift. There is an excellent, one-page essay by Ernst Mayr on how science differs from religion. The first three chapters are liberally illustrated with very good color photographs and drawings, including a series of hominid skulls, an excellent example of speciation involving North American lacewing species, and a plate tectonics map.

It is worth quoting a few lines from the discussion of the nature of science. ". . .had Darwin and Wallace not published their hypotheses, the concept of biological evolution would nevertheless have emerged as the accepted explanation for the history of life on earth. The same cannot be said in other areas of human endeavor; for example, had Shakespeare never published, we would most assuredly never have had his plays. The publications of scientists, unlike those of playwrights, are a means to an end—they are not the end itself."

The first three chapters contain very familiar material albeit nicely presented. A novel approach, however, is presented in three dialogues in which several teachers talk about the problems associated with teaching evolution. These are very realistic and helpful. I suspect high school teachers will identify with these fictional conversations.

Chapter four explains the 1996 *National Science Education Standards* and how they relate to evolution and the nature and history of science in grades K-4, 5-8, 9-12. Chapter five provides answers to frequently asked questions about evolution. For example, "If humans evolved from apes, why are there still apes?", "Can a person believe in God and still accept evolution?", "Why can't we teach creation science in my school?", and "Should students be given lower grades for not believing in evolution?"

Chapter six, the largest, with 44 pages, provides eight sample activities that teachers can use to develop a student's understanding of evolution and scientific inquiry. Some of these activities involve simulating natural selection; comparing apes and humans; interpreting fossil footprints; comparing geological time with human lifespan; reading excerpts from Lamarck, Wallace, and Darwin to develop an historical perspective for evolutionary theory; and developing a mathematical model of population growth. The historical readings, "fossil footprints," tables and graphs, and other useful materials are provided.

Chapter seven establishes criteria for evaluating school science programs and provides worksheets for analysis of materials and pedagogy. The appendices review six significant court decisions concerning evolution and creationism, cite statements from various professional organizations regarding teaching evolution, and provide references for further reading.

This is a very supportive and helpful book, and I strongly recommend it to teachers, especially at the high school level. The Working Group on Teaching Evolution of the NAS can be congratulated on a job well done.

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Chemicals and Long-Term Growth: Insights from the Chemical Industry. Edited by Ashish Arora, Ralph Landau, and Nathan Rosenberg. 1998. John Wiley & Sons, Inc. (Wiley-Interscience), New York, NY. 564 p. $69.95.

In the preface to this book, editor Landau describes the concept of a cross-disciplinary analysis of the factors determining the growth and success, or lack of success, of the chemical industry throughout its history, in four of the most advanced industrial countries. The concept required enlisting a number of experts in different disciplines to contribute different parts of the analysis. The resulting book lists seventeen collaborators (including the three editors, who also were contributors to various portions of the book).

This is an ambitious undertaking. As expected, gathering the ideas of a number of different contributors with considerably different backgrounds and perspectives leads to an unevenness in style and format. Nevertheless, the editors have succeeded in producing a book that presents valuable information on how and why this important piece of the world economy developed.

In addition to editor Landau's preface, the three editors collaborated in an introduction (Chapter 1) describing the organization and purpose of the book, and a section of conclusions that can be drawn from the various parts of the book (Chapter 15). The conclusions include some references and inferences concerning very current situations in the chemical industry portion of the world's economy, but the book's scope is considerably greater than a review of current issues.

The book looks at factors affecting the chemical industry throughout its history in four general ways: 1) the effect of national differences in educational policies and attitudes towards technical education on this relatively "Hi-tech" industry; 2) the effect of government policies on the industry; 3) the effect of structural (organization, mergers, competition, cartels) factors and changes in structural factors on the industry; and 4) the effect of differences in types of governance (and owner involvement) on specific companies. In addition to an analysis of these specific effects, there are sections that describe the history of the chemical industry. Chapter 5 traces the development and success of several specific parts of the chemical industry (particularly the polymer segment) and documents the role of the specialized engineering and design firm in the spread of the technology. This section should be informative and entertaining to those who were involved (as was this reviewer).

Most of the contributors have incorporated very extensive analyses on the chemical industry that is useful in presenting their analyses and will probably be useful to those who want to do further work on this subject. The very extensive citations of sources will make this book a valuable resource for economic researchers. An indication of the uneven style of the book can be seen in these citations, ranging from three pages to more than four pages of citations and bibliography in chapters 9, 10, and 11, to Chapter 14 with no citations at all.

Chapter 14 is much different in thrust from the other contributions. Chapter 14 presents an extensive argument in support of the use of internal rate of return as the best measurement of a company's performance, and then presents analyses of several major companies, identifying differences in their success and drawing conclusions, particularly conclusions relative to the degree of influence that owners have over the managers. The argument in support of internal rate of return as a measure of performance is persuasive, but may discourage potential readers with its complexity in financial concepts.

Chemicals and Long-Term Economic Growth: Insights from the Chemical Industry brings together the contributions of a team of experts. As such it can be a resource of significant value to future investigators.

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Are We Unique? James Trefil. John Wiley & Sons. 1997. 242 p. $24.95 hardcover.

This is a volume of intellectual fun for people who use *Scientific American* as leisure reading. Filled with brain teasers from fields as far flung as paleontology, animal communication, artificial intelligence, neuroscience, and religion, it withstands sampling from an airplane seat or beach, as well as the armchair in your own study. The book is loaded with interesting facts you may have missed in high school or college psychology, such as how the human brain is wired and how neurons work, or topics you studied once but did not completely understand the first time around, such as evolution or how computers work. (Trefil reminds us, for instance, that the evolutionary process "...is under no obligation to be perfectly efficient. Evolution produces organisms that are good enough to survive—not necessarily the organism that good engineers would build if they were starting from scratch.")

A virtuoso teacher, Trefil explains deep concepts in ways that allow you to see them from a different light and make you wish he had been available the first time you wondered about them. The endeavor is ultimately aimed toward understanding; first, whether humans are really different from other animals and, second, whether our brain is capable of performing functions that differ from those done by the most advanced computers. The road of prerequisites to that goal is circuitous, and many stops along the way read like delightful publications you regret not having time for anymore: *How Do Things Work?*, *All About Electronics*, *Popular Science*, *Popular Mechanics*, and so forth. Trefil's book explains, for instance, how smart the brainless sea anemone really is, how PET scans work, how transistors work, and what emergent properties of complex systems are. In the course of two jokes, it explodes myths about artificial intelligence. Trefil explains why computers do not have intuition. His book even tackles the psychologically slippery subject of the soul and the existence of love, as well as how humans can know something that cannot be proved. Trefil walks gracefully and respectfully between the realms of science and philosophy. Moreover, he lays out his arguments so logically and clearly that, with each one, we soon find ourselves saying, "but of course this is so, it was obvious," even though we would have been unlikely to do such heavy thinking and make such penetrating realizations the first or second time around.

After describing basic brain functions in a smooth and helpful way, Trefil goes on to grapple with difficult questions such as what it is to be conscious (or aware of our own mortality) and how a computer can beat us at chess. All the while he is explaining what is known, he stays open to what is not yet known. This commendable attitude keeps the history of intellectual discourse (and the breakthroughs of Newton, Einstein, and Heisenberg) as a continuous referent. In exploring computer modeling of the brain as well as creating computers to do what a brain does, though in a different way, he remarks that, "It may turn out that as the science of complexity develops there will be laws that say, in effect, that when you get to a certain level you cannot duplicate systems, even if you understand them completely." Yet he later acknowledges, "It is possible that if the theory of complexity turns out to impose the kinds of limits that I am suggesting, it might also happen that those limits can be circumvented by clever engineers." On the other hand, he also points out that "...it might turn out that when you put a sufficiently complex system together, you will be unable to predict what its properties are in practice because the connection between the individual parts and the final behavior is too complicated to know." Trefil has mastered complex issues and found ways to explain them with such clarity and humor that an author of introductory textbooks would envy his manner. As you may have gathered by now, this book is well worth reading, if only for the opportunity to peer into the great depth and breadth of an author's mind that itself is unique and marvelous to behold.

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High School Mathematics at Work: Essays and Examples for the Education of All Students. Mathematical Sciences Education Board. National Research Council. 1998. 177 p. $27.95 paper.

High School Mathematics at Work is a collection of essays about mathematics and tasks from mathematics in the workplace and the everyday world. They are provided in an attempt to strengthen the mathematical education of all students, those going directly into the workforce, as well as those going on to further education. The authors are mostly from universities, although also included is a person in business, a governor, and members of state departments of education. The first part of the book addresses the connection between mathematics and the workplace and everyday living, while subsequent parts address issues raised by this approach including assessment (for example SATs), curricular concerns, and teacher education.

In between the essay parts of the book are some wonderful examples of activities in which the authors illustrate their contention that a technological world "calls for increasing connection between mathematics and its applications" and that these connections can be used to teach mathematics to everyone. The many topics include elevator scheduling, heating-degree-days, drug dosages (taking into account filtering by the kidneys and liver), comparative hospital quality, the timing of traffic lights, and lottery winnings—take it all at once or spread the payments out over a lifetime. Each of these tasks is dealt with on many different levels of mathematical difficulty.

However, the book does not stop with providing intriguing tasks. It also grapples with the issues and problems associated with using this approach in teaching mathematics at the secondary level. Just as the reader is thinking "but what about —?", the authors pick up on the question and make an effort to address your question. The authors are convinced that everyone can benefit from grappling with various applications. The tasks, they contend, will motivate students and teach the mathematics needed by students, as well as those headed into the workforce. For example, could not periodic phenomena, such as tides, temperature or smog components over 24-hour time frames, or predator-prey relationships, be studied by all students instead of limiting considerations of periodic functions to trigonometry classes?

Personal experience indicates that such approaches are valuable. In a college mathematics class, when modeling various environmental changes by finding functions to match data points, students have come to understand the concepts of slope and rate of change in greater depth than they ever did when the topic was addressed from a purely algebraic viewpoint. Tasks in this book were not chosen just because they connect with real life but because they are activities that help the students develop mathematical ways of thinking, including algorithms, reasoning by continuity and by combinatorics, symbolic systems, and complex interactions.

Although the authors of this book set forth their premise well with examples, a bigger task lies ahead. No high school mathematics teacher has the time or energy to develop a whole curriculum based on these ideas alone. A few exemplary tasks can supplement the current curriculum but not substitute for it. Much more work lies ahead to create meaningful tasks that incorporate the necessary mathematical ideas and processes so that all students will complete their high school learning ready to progress to their next level in a prepared manner. Secondly, convincing young educators to venture into this largely unexplored way of teaching/learning will also present a challenge. University mathematics students are shy about veering very far from the tried and true—the algorithmic way in which they were taught and have thrived. Those at the university level will have to use such activities in their own classrooms so these students will gain an appreciation of this method.

This difficulty is squarely faced in the epilogue. "The tasks in *High School Mathematics at Work* constitute neither a complete curriculum nor even student-ready curricular materials. All readers are welcome to see in these tasks potential for strengthening the mathematics education of all students, but no one should conclude that it is enough to teach these tasks or even a collection of exercises inspired by them. Any tasks need to be embedded in a coherent, well-developed mathematics curriculum that provides the mathematical understanding that a high school graduate should have." This book does provide the inspiration and reasons to work toward this end, however. More than rhetoric, it comes complete with some thought provoking examples to assist us in this examination. Educators at both the high school and university levels, especially potential mathematics teachers, and curriculum designers are urged to read the book and continue the dialogue.

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