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Physics in Perspective

Book Reviews

Stephanie Pace Marshall, Judith A. Scheppler, and Michael J. Palmisano, ed., *Science Literacy for the Twenty-First Century*. Amherst and New York: Prometheus Books, 2003, 321 pages. $29.00 (cloth).

This collection of thirty-one essays by eminent scientists and science educators commemorates the eightieth birthday of Leon Lederman, who has the unusual distinction of being at once a Nobel laureate and one of the nation's foremost science educators. Like most collections of essays by different authors, this collection is a mixed bag ranging from thought-provoking to pedestrian, and over a variety of topics. The editors have arranged the essays into six broad categories: Invitations to Scientific Study, Reframing Science Learning, Reframing Science Teaching, Scientific Stewardship, Demystifying Science for Public Policy, and The Lederman Legacy for Education.

Nearly all of the essays are about some aspect of science literacy for non-scientists. At least five general themes emerge: America's science-education system is failing badly and in many ways both as regards science literacy and also as regards education for future scientists. Second, the nation desperately needs a scientifically literate populace, as suggested for example by the American Association for the Advancement of Science's report, *Science for All Americans*; but the scientific community is far from answering this need and in fact many scientists see science literacy as a low priority that they prefer to ignore. Third, "inquiry" or "active-engagement" pedagogical methods really work and are a key to improving science education. Fourth, it is at least as important to teach how science works as it is to teach the facts and theories of science. Fifth, there is a difference between doing science, which requires technical proficiency including mathematics, and understanding science, which requires hard but non-technical thinking.

All authors appear to have a common understanding of the meaning of science literacy. As James Trefil puts it: A scientifically literate person can deal with scientific matters arising in public life with the same ease that an educated person would exhibit in dealing with political, legal, or economic matters. Most essayists agree with Trefil that "this kind of literacy isn't a luxury – it's a necessity. Without it, our democratic system would degenerate into one in which decisions are made either by an intellectual elite or by demagogue-driven mobs."

This is in many ways a hopeful collection, because it recounts many science-literacy successes: Fermilab's involvement in K-12 science education (Marjorie Bardeen); the Illinois Teachers Academy for Mathematics and Science, a center for retraining K-6 teachers (Lourdes Monteagudo); the Illinois Math and Science Academy for scientifically talented high school students (Stephanie Pace Marshall); MIT's "open-courseware" experiment to make its course materials available, free of charge, anywhere on Earth (Charles Vest); Rice University's Model Laboratory program to involve middle-school teachers in science education by year-long residency in an urban Houston middle school (Elnora Harcombe and Neal Lane); the fascinating story of "miracle worker" Annie Sulliven's interactive and inquiry-based teaching methods in the "impossible" educational triumph of guiding the deaf and blind Helen Keller toward an astonishing command of idiomatic English, and of Alexander Graham Bell's involvement in that triumph (Dudley Herschbach); people's innate interest in topics like black holes, warp drive, and time travel, and the implications for education (Lawrence Krauss); the ingrained but sadly unrecognized, love of nature and science demonstrated in people's enthusiasms for fishing, horticulture, ecotourism, hunting, automobile repair, dinosaurs, and gambling probabilities (Stephen Jay Gould); Lederman's efforts to reexamine the high-school science curriculum and to encourage a more logical sequence putting physics first, chemistry second, and biology third (the editors' "Brief Biography").

But these essays also have their dark side. Ironically, this is most vividly illustrated by Leon Lederman, instigator of many of the hopeful programs recounted in these essays. Lederman begins the book's Epilogue with characteristic wit: "The wisdom contained in this book is awesome, the praise is fulsome, and my response task is gruesome. There is a common theme, the many failures of our education sys-

tem…." His essay is devoted to listing the obstacles to attaining science literacy for all Americans. It is a daunting list: Science, technology, and invention are often confused. The nature of scientific inquiry is missed. Parents too often have little interest or time to pay attention to the quality of their children's schooling. Poverty, hunger, poor health, and the lack of nutrition, health care, dental care, and exercise, all make it difficult for children to learn. Children in our urban ghettos too often do not have the family support, encouragement, and help they need. Peer pressures are often negative. America's cultural diversity makes the task more complex. Poor schools fail to provide needed educational technology, and even some basic educational materials.

There's more: Estimation, statistical inference, and probability are rarely taught. Meaningful and coherent science curricula do not exist. Unfortunately, science is introduced through ninth-grade biology. High-stakes testing and the need for accountability has mushroomed to unreasonable proportions. There is insufficient appreciation of the importance of science to non-science students. The system continues to propagate the myth that women and some minority groups cannot do mathematics and science. For far too many students, the motivation for learning, or even for staying in school after tenth grade, is missing. Student mobility and teacher turnover are too frequent and disruptive. There are problems in recruiting, training, and retaining good teachers. In particular, there is an endemic shortage of science and mathematics teachers. Teachers are not given serious time to prepare, to develop professionally, to work with other teachers, or to mentor. Many universities do not require a serious science sequence; one would think that a two-year sequence of science with laboratory would be a minimum requirement for an educated college graduate, but the typical requirement is a single "rocks-for-jocks" course. Media coverage of science is dismal and does not convey the excitement, value, or significance of scientific developments. And finally: the greatest obstacle is resistance to change.

Leon Lederman's evident sense of social responsibility is reflected in several essays. Many authors noted that general science literacy is essential for democracy in our science-dominated culture. I was struck by the number of times global warming was mentioned as an example of the socially relevant topics that we should be teaching. Sheila Tobias's article, "Women and Physics," focuses on physics majors, but connects with science literacy through its opening quotation from Rachel Ivie and Katie Stowe's 2000 report, Women in Physics: "There can be no science literacy in the population absent the full participation of women in all fields of science…." Mae Jemison suggests that funded research should always include a component for public education, perhaps to be used in a partnership with K-12 education.

Shirley Malcom, director of education for the American Association for the Advancement of Science, suggests that many physics teachers reject Lederman's recommendation to put physics first because physics would then have to be taught to all students, and these physics teachers believe many people are incapable of learning physics. Malcom and all of the other essayists clearly believe that physics literacy is feasible for all people. Bruce Alberts, president of the National Academy of Sciences and chair of the National Research Council, charges that scientists and engineers have been "completely disconnected" from pre-college science and mathematics education, and that university science and mathematics departments have failed to teach exciting inquiry-based introductory courses that are relevant to the world outside the university.

Melvin Schwartz, who shared the 1988 Nobel Prize in physics with Leon Lederman and Jack Steinberger for the discovery of the muon neutrino, makes a telling observation. As chair of a Columbia University committee to revise the core undergraduate curriculum, he proposed that science should be treated like the humanities: Every student should be required to take a two-year sequence covering the major discoveries in science and mathematics. But most of the other scientists on his committee were "completely opposed" to the idea, because teaching freshmen would detract from their research time. "Since their careers depended on the number of papers they could turn out, there was no incentive for participating in such a program." There could be no more telling indictment of the failure of our universities to provide science education for all students.

Among the small number of essays lying outside the realm of science literacy, the contributions of astrophysicists Edward "Rocky" Kolb and of Michael Turner on the "inner space/outer space connection" between quantum physics and cosmology are noteworthy. Lederman and David Schramm conceived the idea of an astrophysics group at Fermilab to exploit this connection (see the "Brief Biography" of Lederman), and recruited Kolb and Turner to head the project. This group recently published

a wonderful survey for non-specialists, Connecting Quarks with the Cosmos (National Academies Press, 2003), on the major unsolved issues at the intersection between high-energy physics and cosmology. Kolb's and Turner's essays are a reminder to science educators of the fascinating contemporary topics that we could, but mostly do not, teach.

This is a volume full of inspiring examples and ideas for obtaining a scientifically literate populace, and a gloomy recounting of the obstacles blocking that goal.

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