

Science for All Americans: Seeking a Common Knowledge Core Across Disciplines

It is not difficult to see why K–12 science education is in trouble. In his letter, Art Hobson (PHYSICS TODAY, December 2002, page 12) approvingly quotes the authors of *Science for All Americans* for their view that, “without a scientifically literate population, the outlook for a better world is not promising.”¹ However the authors of that document promote obsolete and incorrect information about the foundations of physics. On page 47, for example, they write, “Scientists continue to investigate atoms and have discovered even smaller constituents of which electrons . . . are made.” That same sentence is repeated in *Benchmarks for Science Literacy*,² which is currently used as the foundation for curriculum reform across the US.

Much more serious than any specific erroneous statement is the document’s almost grotesque failure at the foundation of physics. You probably thought that the basic premise of the modern theory of matter was quantum mechanics, or at least that it was the standard model, right? Well, *Science for All Americans* says, “The basic premise of the modern theory of matter is that the elements consist of a few different kinds of atoms—particles far too tiny to see in a microscope—that join together in different configurations to form substances. There are one or more—but never many—kinds of these atoms for each of the approximately 100 elements.” The first sentence indicates that the way you form “substances” is by combining different isotopes of a single element!

Is it any wonder that our K–12 education system is in such bad shape when such an illiterate, anti-

quoted report has been circulated and used for more than a decade?

NASA’s Maryland Space Grant Consortium has been trying for the past decade to bring university-level science professionalism into Maryland’s K–12 school system. It is an uphill task.

References

1. F. J. Rutherford, A. Ahlgren, *Science for All Americans*, Oxford U. Press, New York (1990). Available online at <http://www.project2061.org/tools/sfaaol/sfaatoc.htm>.
2. American Association for the Advancement of Science, *Benchmarks for Science Literacy*, Oxford U. Press, New York (1993), p. 80.

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The director of Project 2061 replies: Richard Conn Henry makes two points in his letter, one identifying awkward language and one criticizing the exclusion of advanced physics topics from *Science for All Americans*. We will certainly fix the awkward language, as we have done in the past, and thank him for pointing it out. However, we stand by our choice of learning goals.

Our authors attempted to define a common core of knowledge, across science, mathematics, and technology, that would be optimally useful and enlightening (given constraints of students’ time, interests, and abilities) for every high-school graduate, not just for those who aspire to scientific or technical careers. Difficult decisions about what was both important and possible included input from numerous chemistry and physics faculty, who have found that few college students understand the particulate nature of matter and the significance of the periodic table, let alone the significance of the standard model.

Science for All Americans does not claim to be a ceiling, but a floor; high-school and college faculty consider it quite ambitious. Perhaps with better materials and teaching we can achieve universal science lit-

eracy on which to build understanding of more sophisticated ideas such as quantum mechanics and biological signal transduction.

Project 2061 views *Science for All Americans* and *Benchmarks for Science Literacy* as living documents, subject to ongoing review and suggested revisions by scientists and educators. We welcome criticism and take it seriously. Interested readers can compare sections on cells, structure of matter, and energy transformations in their original 1989 print version with those in the current online version at our Web site, <http://www.project2061.org>.

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In the continuing discussion about K–12 physics education, one or two sentences in Leon Lederman’s response (PHYSICS TODAY, August 2002, page 74) caught my eye. Lederman says, “Here I only insist that the design be for *all* children.” That got my attention, because I have been working for 25 years at that goal of science for all Americans. It was also the goal of F. James Rutherford, former assistant director of NSF and former assistant secretary of the US Department of Education, perhaps the most knowledgeable physicist in science education that the country has ever produced.

From plenary lectures on science education that I have presented at major scientific and teachers’ society meetings, I summarize some questions that I do not see answered in the writers’ comments in the August 2002 Letters. For scientists interested in having all Americans learn science, I pose the following:

► For whom are you designing your reform? All students? Including the urban poor? The science able? The nonscientist/engineer (NSE) population? Future physicists?

► If you are concerned about all students, can you demonstrate to yourself even some knowledge of their

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typical educational background, lives, and challenges?

► What should students know more or better? Is physics more important for all than English, geography, or music? What is the evidence? CEOs, Cabinet officials, and media stars seem to do well with essentially no clue about physics. In what way would they improve by learning physics?

► As a scientist, have you reviewed the enormous amount of available literature on these topics from our university colleagues in education?

Let me provide a reference to some baffling and scary data relevant to our hopes and ambitions. Rent or purchase copies of the videos *A Private Universe* and *Minds of Their Own* from the Annenberg Project series. Watch them and answer this question: Will your reform improve the performance of these students? If not, what value do you perceive in putting physics in ninth grade for all students?

The students in those videos are graduating seniors of Harvard University and MIT, most with superb high-school experience. Yet more than 90% thought that the reason Earth had summer and winter was that it came closer to (or farther from) the Sun. Even more could not identify photosynthesis as the mechanism by which a tree accumulates mass. The same percentage of MIT engineering graduates in their caps and gowns could not light a bulb with a battery and one wire.

I've concluded that less than 10% of the American populace can handle any kind of abstraction. Fortunately, almost 100% can learn by using other senses and right-brain pathways. Hence my recent focus, and my recommendation to those who want to get more students into physics, is to start with reality and touch: touch-science. This recommendation builds on the unchangeable reality of the sequence of human sensory development, which starts with touch in the womb. The hands-on approach puts students in touch with such real sciences as agriculture, Earth, health, and materials. And as data from the University of Washington show,¹ using materials as the gateway to abstract science is valuable to both citizens and protophysicists. Out of the many who become interested spring more, and possibly better, physicist-citizens.

Reference

1. T. Stoebe, G. Whittaker, K. Hinckley,

Jour. Mat. Ed. (in press). Electronic copies available from Thomas Stoebe, stoebe@u.washington.edu.

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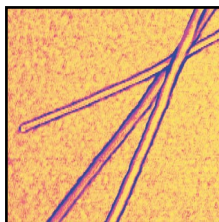
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Lederman replies: It is a pleasure to assist Rustum Roy, who is equally renowned as a science educator and a materials scientist. Roy has usefully summarized the criteria that scientists should satisfy in order to be effective in the K–12 domain.

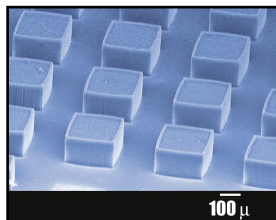
The reform of science education must be for all high-school graduates, future citizens, consumers, family members, and voters. Perhaps never before has this nation needed voters with the qualities of a science way of thinking (see my Reference Frame column "Revolution in Science Education: Put Physics First," PHYSICS TODAY, September 2001, page 11).¹ Therefore, I work on a core science curriculum designed for *all* K–12 students. The goal is a seamless math–science curriculum, for

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