

ers, parents, administrators, and the 134 other constituencies that make up our educational system. A next step, following the compelling arguments of Gary Kinsland, would mandate four years of science and add geology or Earth and space science. And of course my colleagues and I strongly favor elective science courses like advanced placement and more. We must then examine and restructure the K–8 science and mathematics sequence along the lines argued by Lev Berger and Donald Rehfuss. Here I only insist that the design be for *all* children and within a flexible set of consensus standards; there should be a variety of local options for branch topics and for implementing teaching methods. We want to stress connections between the science disciplines and between the sciences and the humanities and social sciences, as Paul Rutherford articulated so well.

Martin Stewart has reminded us that teaching physics to 9th graders may well exacerbate the problem of teaching to students with a wide variety of preparations. But the few hundred schools now experienced in the P-C-B sequence seem to manage, and as we begin to create a seamless K–8 math and science curriculum, the problems will diminish.

The only difficulty I have is with Vinson Bronson, who, in my view, misses the point. I do not advocate teaching conceptual physics in 9th grade, because of speed-versus-time graphs and drawing free-body diagrams. These are important examples of how science works—and they illustrate some of the advantages of 9th-grade physics over conventional 9th-grade biology. However, in 9th grade, students should learn about atoms, their structure, and their behavior in company. Atoms make molecules—that is the basic theme for all of chemistry and, increasingly, for modern biology. It is this hierarchy that recommends 9th-grade physics before chemistry and biology. My comment on Bronson's last quotation: Biology is not at the center of the sciences, but at the pinnacle. Physicists, chemists, and mathematicians rejoice in the growing comprehension of life, and we are proud to support the pyramid, on top of which sits triumphant biology.

It is difficult for me to understand, however, how the “phenomena of life” are relevant to cosmology, astrophysics, particle physics, the solar system, the quantum principles that support condensed matter

physics, or even the earlier phases of geological history. But George Gaylord Simpson was a great biologist. Why do I have an uneasy feeling that I am the one who is missing the point?

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## Love, Not Paycheck, Motivates Best Physics Students

**R**arely do I read an issue of *PHYSICS TODAY* or other science journal and not find some hand-wringing about the decline in the number of physics majors (*PHYSICS TODAY*, January 2002, page 42; November 2001, page 32; October 2001, page 11). I started hearing this kind of lament when I was in high school in the late 1970s: “I cannot urge students strongly enough to seek a degree in the physical sciences. In the 1990s, there will be a shortage of physical scientists that will be disastrous to the nation. People with PhDs in physics will be able to get any job they want.”

I defended a PhD in physics at Caltech in 1992 and searched for a postdoc position during 1991–93. Jobs were scarce, and many of my peers ended up modeling fast neutrons or fast money—not what they expected. Incoming students caught on, and many stayed away from physics. No sermons about the disastrous consequences of a lack of physics majors can compete with Adam Smith's “invisible hand” (in *The Wealth of Nations: An Inquiry into the Nature and Causes*, 1776). That is, if no one is buying widgets, then maybe you should not be in the widget business.

I managed to find a position teaching physics and chemistry at a private high school. Now I love teaching, and I love doing research. The bittersweet reality is that I get to enjoy the one while I miss the other.

A new popular argument to boost physics enrollment has appeared (*PHYSICS TODAY*, April 2001, page 42): A physics degree prepares a student for many jobs outside academia. But few study physics in order to practice medicine or law; most physics students spend 4 to 10 years in school because they love physics.

Nonphysics jobs do not provide a strong attraction to a physics major. Professors praise nonacademic careers for physics majors, but I have seen few forego tenured positions to seek those careers. If they did, university positions would open for young aspirants. Any takers? Don't crowd the door.

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## Phenomenologists Are Underrated in Theory–Experiment Debate

**A**lthough Norman Ramsey's letter in the September 2001 issue of *PHYSICS TODAY* (page 78) claims not to be taking sides in the debate between theory and experiment, his message is clear. We are now back in particle physics with the same need for critical experiments that Ramsey noted for quantum electrodynamics in 1947. Today's theorists must face present reality with the humility appropriate to the situation.

We have a standard model that everyone admits is incomplete. Experimenters are looking for clues to the new physics beyond the standard model, but no theorist can provide reliable advice on where or how to look. It is all up for grabs.

We have a theory called quantum chromodynamics (QCD) for strong interactions—a theory that everyone believes is correct. But nobody knows how to calculate parameters crucially important for our search for new physics, like the strong interaction phases in weak decay final states. Theorists on the lattice think that they are making great progress when they can get a good approximation to the mass of  $\rho$ , which we know already from experiment. But they are useless in getting values of parameters that we don't know, need to know, and should be given by QCD.

The search for new physics and for critical tests of the standard model in charge conjugation–parity (*CP*) violation is being carried out at accelerators by large experimental collaborations that have no theory telling them where to look. The one exception is the seminal paper by Ikaros Bigi and Tony Sanda,<sup>1</sup> which pinpointed the “golden”  $K_s + J/\psi$