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Students Need Scientific Habits and Basic Concepts

As a recently retired high-school teacher—my second career after decades in industry—I read Jerry Gollub and Robin Spital's excellent article (PHYSICS TODAY, May 2002, page 48) with great interest. I agree completely that "the promotion of scientific habits of mind is more important than particular choices concerning [course] content." In that regard, I have two comments, directed to teachers of high-school physics.

The advice advanced by the authors is equally applicable to non-AP high-school physics courses. The acquisition of scientific habits of mind is just as important to the fledgling arts major as it is to the science-oriented student. The reduction of junk science used by our next generation of political, social, and environmental leaders would be a welcomed consequence.

A trimming of course content to focus on depth of understanding provides opportunity for a "habits of mind" unit, about two weeks in length, to start the first semester. I found that a stimulating and mind-opening unit can be built around the principles espoused by Arnold Arons in the "Underpinnings" chapter of his classic book, *A Guide to Introductory Physics Teaching* (Wiley, 1990). An underpinnings unit prepares students for an insightful year of physics by shoring up their generally weak understanding of ratios, scaling, operational definitions, and even the meaning of "because"!

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DARI to Go Where Radiation Has Gone Before

The new DARI (Dose Annuelle due aux Radiations Internes) unit proposed by Georges Charpak and Richard Garwin (PHYSICS TODAY, June 2002, page 24) has been defined elsewhere as a measure of the internal "irradiation experienced during a single year by an individual due to the radiation emitted by the radioactive materials present in the human body that have nothing to do with any line of work."[1] Equal to precisely 0.2 millisieverts, the DARI takes into account, as the PHYSICS TODAY article states, "the biological effects of different decay particles." This exposure arises principally from the body's natural levels of potassium-40 and carbon-14; both are sources of sparsely ionizing radiation. Because the sievert numerically equals the gray for such radiation, one DARI equals 0.2 milligray. The sievert is not a directly measurable quantity, because it relies on radiation- and tissue-weighting factors that have been set arbitrarily by committee consensus.[2] However, the gray, the unit of absorbed dose, is a ratio of measurable quantities—the joule and the kilogram.

I suggest that the DARI be related to the gray rather than the sievert. Moreover, I recommend that DARI be interpreted as a threshold of individual sparsely ionizing radiation exposure that would elicit any harmful effect in humans or in any of their

tissues. Such a threshold value would be quite reasonable, considering our present knowledge that no harmful effects to humans occur at exposures less than 20 milligray. A threshold based on the DARI being equal to 0.2 milligray would thus contribute to the current discussion on developing a system of radiation protection that is based on risk to the individual.[4] The nonmeasurable sievert and the linear no-threshold hypothesis—impossible to test at exposures low enough to call into question the concept of dose as an amorphous average quantity[5]—are the real sources of confusion in the system used presently.

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Hiroshima Bomb's Explosive Yield Less than Reported

Paul Guinnessy reports that the explosive yield of the Hiroshima bomb was 20 kT (PHYSICS TODAY, August 2002, page 23). However, that value is at variance with the most reliable ones in the open literature, in which one typically sees values of 12.5 to 15 kT.[1] The comprehensive calculation by John Malik gives the value of 15 kT, with an error of 20%.[2]

The 20-kT value was initially given by President Harry S. Truman in August 1945. Physicists at Los Alamos knew it was an overestimate that was based, perhaps, on information Truman had from the Trinity test. But the Trinity test data were for a different type of bomb—a plutonium implosion device, not the uranium gun-type model that was used on Hiroshima.

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Correction

January 2003, page 44—The last work cited in reference 4 should be G. Mace, E. Clothiaux, T. Ackerman, *J. Climate* **14**, 2185 (2001). The page number for reference 6 should be 2091. ■