and understand the material." To be realistic, however, one first-year or sophomore astronomy course is often the only time we physical scientists get a crack at a student. We have to make the most of that opportunity by describing the most exciting aspects of our fields. Of course, we should be as clear as possible and link the discussion to a wider context and to scientific ways of thought, but if we wait until we "reinstate rigor in science instruction," we will miss the overwhelming majority of students.

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Low-Dose Radiation No Risk to Air Crews

Having read the letters in the April 2000 issue of PHYSICS TODAY (page 11) in response to Zbigniew Jaworowski's article "Radiation Risk and Ethics" in the September 1999 issue (page 24), I'd like to add to the discussion. Jet airliner crews receive larger daily ionizing radiation doses from cosmic rays than almost any sector of the US population. This exposure has involved a large number of people over some 40 years.

At 10 000 meters altitude, the cosmic ray intensity is about 2 rem/year. Cockpit crews, those that actually operate the aircraft, are limited by labor rules to about 1000 duty hours per year, which is about 0.12 year. Cabin crews are not so limited; therefore, we assume that they work the usual 40-hour week, or 0.24 year. Jet air crews get at least 0.25 to 0.5 rem/y dose of cosmic radiation in addition to their typical dose of about 0.3 rem/y.[1] They receive elevated ionizing radiation doses greater than 0.5 rem/y.

The rem is the product of the quality factor (QF) times the rads, the energy deposited in tissue. Rads can be measured with a dosimeter; however, the QF is a matter for interpretation. For electromagnetic radiation—x rays, for example—the QF is taken to be 1. The QF for neutrons is open to some dispute, but is often taken to be 10, the argument being that neutrons can induce nuclear reactions that cause additional tissue damage. Cosmic rays are predominantly very energetic protons, which cause spallation reactions in tissue and produce neutrons. The cosmic-ray QF should exceed 1 for the same reasons as it does for neutrons, yet the author of ref. 1 uses 1 for the cosmic-ray QF.

The era of jet travel was inaugurated with the Boeing 707 in 1958; some jet airliner crew members have retired after 40 years. Many crew members have been women of childbearing age; they have not produced an excess of children with birth defects. That the insurance industry has not singled out jet airliner crews for increased premiums for life or health coverage suggests that the excess radiation exposure has not posed a health threat. Perhaps it is time to reconsider the effects of low-level radiation exposures.

Reference

1. R. C. Weast, ed., *CRC Handbook of Chemistry and Physics*, vol. 69, CRC Press, Boca Raton (1988), p. F163.

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Math Encoding Gets Extra Credit

In the December 2000 issue of PHYSICS TODAY (page 76) you reported that Design Science had acquired WebEQ, a suite of software tools for building dynamic math Web pages based on MathML (Mathematical Markup Language). Unfortunately, your article describes MathML as a "program produced by Wolfram Research," which is incorrect.

MathML is an XML encoding for mathematical expressions standardized through the World Wide Web Consortium (W3C),[1] and was developed by the W3C Math Working Group. While Wolfram Research was represented on the working group, so were many other organizations, including Design Science, Waterloo Maple, IBM, and the American Mathematical Society. Complete working group membership information is available at ref. 2.

References

1. http://www.w3.org/TR/MathML2.
2. http://www.w3.org/TR/MathML2/appendixi.html.

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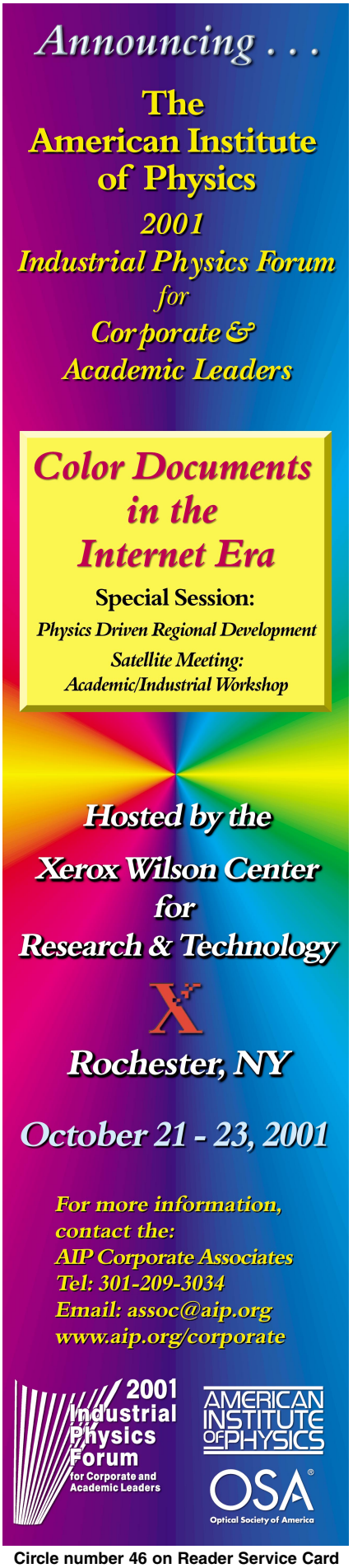
Correction

February 2001, page 74—In performing the work that earned her one of the three 2000 Leo Apker Awards, Heather J. Lynch completed her thesis under the supervision of Lydia L. Sohn at Princeton University. ■



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