

rate. Without such backing, for example, the Portland Project was unable to sustain its programs of curricular refinement and teacher training. For only a modest cost, a major overhaul of science teaching might not now have to be reinvented.

Do the experiences with the Portland Project carry some special messages for the teachers Lederman mentions in California or Illinois, thrown into the front lines of science education reform? Perhaps these: Be prepared for a long commitment, and emphasize training. Also this: Look through your files and journals from the 1970s. You may find there some things useful for the '90s.

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Leon M. Lederman's Reference Frame column regarding high school science curricula certainly represents a balanced, integrated approach toward bringing our secondary schools up to international standards. My comment regards his concluding "catch" (22?)—"We do not now have the teachers who can carry out such a program"—and his suggestion that we might have sufficient teachers if young PhDs moved into new openings.

To teach in public schools, state certification is required, including specific student teaching at the level (for example, secondary) at which one is to be certified. Such course work and teaching experience amount to some two years beyond usual physics department offerings. A physics PhD simply does not qualify one to teach in secondary schools.

The question becomes, then, How does a physics PhD support him- or herself while pursuing the additional certificate-required curriculum? Such time and expense (including student loans to be repaid at a public school salary) is significant. As an alternative, might state standards be relaxed for new physics teachers? Young physics PhDs typically have considerable teaching experience at the lower-division college level (as teaching assistants), but such experience does not comply with present secondary certification guidelines, no matter that it is relevant.

It would certainly be worthwhile for AIP to consider these questions and issues. Young physics PhDs can be a valuable asset to public school teaching, particularly if its science content is to become more state of the art.

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Human Nature Keeps Nukes Necessary

Joseph Rotblat and Donald J. Montgomery (February, page 81) suggest that my plea for preserving US nuclear weapons competence (May 1994, page 13) is motivated by the self-interest of one employed doing weapons research. I am sure they realize that much, much more is at stake than jobs. (I myself am retired from Los Alamos National Laboratory.)

The test of a scientific theory is experiment. The test of a political theory (before application) is history. Rotblat's theories applied to the late 1930s fail the historical tests. During that era no country tried harder for peace than England. But Hitler interpreted her lack of preparation for war and her overanxiety for peace as weakness and unwillingness to fight, so he invaded Poland and began

World War II in Europe. Rotblat's confidence in international agreements to ban weapons is another failure of the Hitler test, for Hitler had secretly rearmed and then ignored or abrogated agreements. In the interests of "peace" no action was taken then by the democracies.

My generation had to learn the hard way the bitter, bitter lesson that it is not enough to want peace, to demonstrate and organize for peace, even to have peace treaties or arms limitations, but rather that it is absolutely necessary to back up peace efforts with substantial, modern, evident-to-an-enemy military might. As a consequence of our ignorance we (and other generations) suffered terribly, unbelievably because we had disarmed in peacetime. These things must not happen again.

It's too dangerous to rest our security on the claim or hope that this time it will be different. Human nature is still Hitler-like—witness Bosnia, Iraq, China. And roughly every five years since 1945 a new nation has become nuclear weapons capable.¹ Consequently the free world must be nuclear weapon prepared. For antiterrorist and counter-further-proliferation reasons we must also continue to research all kinds of nuclear devices.



"Every time I see Edwin Hubble, he's moving rapidly away from me."

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The Hiroshima Neutron Dosimetry Enigma

In an attempt to address the discrepancy between transport calculations and dosimetry measurements at the Hiroshima site, Robert Fleischer (February 1994, page 9) has solicited glass specimens with which to conduct track-recorder neutron dosimetry at Hiroshima and Nagasaki. This discrepancy is not new: It is a perplexing neutron dosimetry enigma that has persisted in spite of international programs that have been carried out for more than four decades to quantify the radiation exposures of atom bomb survivors. The last of these programs was initiated in the early 1980s under the auspices of the joint US-Japan Radiation Effects Research Foundation and culminated in a final report designated as Dosimetry System 1986.¹ This DS86 final report provides a comprehensive description of efforts expended (prior to 1987) to quantify neutron and gamma-ray doses experienced by atom bomb survivors.

In chapter 5 of the DS86 final report, William E. Loewe and coworkers not only acknowledged the persistence of this Hiroshima-site neutron dosimetry discrepancy but described earlier proposals for track-recorder neutron dosimetry at Hiroshima and Nagasaki that were advanced during the DS86 program² as well as actual track-recorder experiments with Nagasaki-site specimens that preceded the DS86 program.³ All post-DS86 neutron measurements at the Hiroshima site, conducted with radiometric ⁶⁰Co, ¹⁵²Eu, ¹⁵⁴Eu and ³⁶Cl monitors, verify the discrepancy identified in chapter 5 of the DS86 final report. The unresolved discrepancy between reported experimental results (*E*) and DS86 calculations (*C*) of thermal neutron fluences at the Hiroshima site is significant. The *E/C* ratio increases dramatically with increasing range, varying from approximately 0.5 near ground zero up to values much greater than 10 for ranges greater than 1400 m.

Recent analyses⁴ reveal that the DS86 neutron dosimetry enigma is a complex puzzle that comprises a number of different factors. While track-recorder neutron dosimetry possesses potential merit, such an attempt addresses only one of the factors. Moreover, each of these factors can be composed of a number of distinct experi-

mental or calculational effects. As a consequence, a simple panacea for the DS86 neutron dosimetry enigma is precluded. Treatment of these experimental and calculational effects, with careful attention to many specific details, will be required before any progress can be achieved in the resolution of this enigma.

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Is Nitrogen Fertilizer Use Nearing a Balance?

Figure 5 of "Human Impacts on the Nitrogen Cycle," by Ann P. Kinzig and Robert H. Socolow (November 1994, page 24), dramatizes the rapid rise of nitrogen fertilizer production from 1950 to 1985. The authors write that "the rate of nitrogen fixation due to fertilizer production today is approximately 90 Tg(N)/yr" and that their graph "shows that the total global use [my emphasis] of nitrogen fertilizer in 1960 was only about 10 million metric tons of nitrogen per year, about one-tenth of today's levels." (One teragram is equal to a million metric tons.)

These important matters merit up-to-date information. The solid curve in the figure at right is copied from the article's figure 5. The Food and Agriculture Organization of the United Nations annually reports fertilizer use,¹ which I show by blue data points in my figure. Red data points show future fertilizer use projected by the World Bank.² In 1960, 9.17 Tg of nitrogen fertilizer were used. According to FAO, the maxima in fertilizer use and production occurred in 1988–89: 85.7 and 79.61 Tg, respectively.

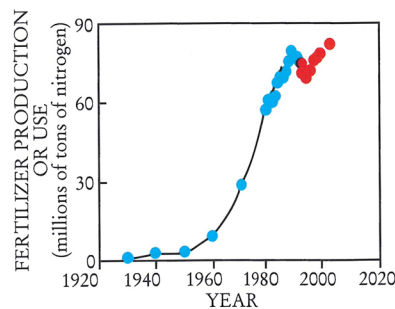
The magnitude of 80 Tg can be

grasped as 1.6 kg per hectare deposited evenly over the Earth's 51 billion hectares of land and water. By comparison, on an Iowa farm,³ 15 kg of nitrogen per hectare fell in rain and from the air, the farmer applied about 100 kg per hectare in fertilizer, and corn removed 110 kg per hectare.

The 8% per year rise from 1960 to 1985 dramatized in *PHYSICS TODAY* stopped in the 1980s. Since 1988 falling use in the former Soviet Union and Eastern Europe has lowered the global total. Behavior in other developed nations, however, provides a better harbinger of the longer-term future. From 1980 to 1990 use in France trended upward only 2.4% per year and then fell 7.4% per year from 1991 to 1993. Since 1980 in the US, there has been no change in use at all.¹

In the 1960s the book *Famine-1975*⁴ and its proposal of a triage for a time of famine exemplified the mood. The 9.17 Tg of nitrogen fertilizer used in 1960 could not supply the world's 3 billion people with even a meager 50 grams of protein per day. (The subcommittee on the tenth edition of the Recommended Dietary Allowances⁵ recommends that men take in about 60 g of protein daily, and women about 50.) Agriculture was failing to feed humanity.

In 1990 the protein of *all* crops harvested contained 70 Tg of nitrogen.⁶ The improved 70 g of protein per day⁷ in the food supply of the 5.3 billion people made for a total of 23 Tg of nitrogen. Only a fraction of the nitrogen cycling in fields can reach dinner tables, because some fields grow feed and fiber rather than food, and only half the root and shoot of major crops is edible grain and harvested. The 70 and 23 Tg of nitrogen are reasonably in balance with



the 79 Tg of nitrogen applied in fertilizer in 1990.

Intensive agronomic care must of course continue minimizing mining of soil nitrogen in some places and waste of fertilizer nitrogen in others. In the meantime, the similarity of the quantities of nitrogen in synthetic fertilizer, harvested crops and food on the table