Letters

National Security and Scientific Training

In his article "Scientific communication and national security in 1984" (4 May, p. 460), M. B. Wallerstein considers the relative threats to U.S. scientific expertise posed by free communication and by governmental limitation of free scientific exchange. However, the data presented clearly demonstrate an equally disturbing problem facing American technology in the near future: the recently declining percentage of predoctoral and postdoctoral trainees in the sciences who are American citizens (*1*). While I believe that the United States has an obligation to open its training facilities to people of all nations, and our foreign trainees provide a tremendous resource for our own scientific advancement, the trend indicates that a decreasing fraction of the most intellectually gifted young people from the United States are opting for scientific training at the university level. Although I do not see foreign citizens receiving education in this country as a threat to our security, I fear that our failure to train our own talented students may lead to weakening of our own ability to continue to be a dominant force in scientific advancement in the future.

The driving force behind the falling percentage of U.S. students in our training programs is not generated externally. Rather, the widespread public perception of decreasing opportunities for employment, long-term research support, and financial support during training may have made a scientific career less attractive to our students. Foreign students may not be so easily discouraged. Those from developed countries may see excellent opportunities at home after their training is completed. Those from underdeveloped countries may perceive scientific support in the United States as being vastly superior to alternative careers in their own countries and so are not as easily discouraged. In the long run, I believe that maintaining our population of trained scientists, investigators, and teachers will be more critical to our national security than information flow through our university training programs and scientific journals. Only by improving the climate for scientific training and research can the United States motivate its most talented students toward scientific careers and maintain its position of scientific leadership.

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Reference

1. Division of Science Resources, *Foreign Participation in U.S. Science and Engineering. Higher Education and Labor Markets* (National Science Foundation, Washington, D.C., 1981), pp. 5 and 21.

Crystalline Anisotropy

We would like to comment on Arthur L. Robinson's Research News article of 8 June, "Crystal anisotropy directs solidification" (p. 1085).

The article implies that the work done at Schlumberger was related to James Langer's consulting here. He was a consultant for another research group and had no influence on the early development of our geometrical approach to dendritic growth. The article also implies that we think our model has minimal physical content. We do not. We consider the fact that we tried to get the simplest possible equations which exhibit dendritic growth the biggest *asset* of our work. Finally, we disagree with Langer's statement that work to date seems to show that "the marginal stability hypothesis is holding up," as our group has presented evidence to the contrary.

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Much more important to the physics of crystal growth than anisotropy are the nonlocal effects to which Robinson alludes, and which are neglected in the models he describes. To help the nonexpert understand this, one may use the following analogy, which is not only telling but also *rigorous* in a precise mathematical sense: the "local" or "boundary layer" models of crystal growth describe a world where lightning does not fall on lightning rods. This is because in a local model a lightning rod is a small object influencing only its immediate environment. In the real world, as Benjamin Franklin discovered, if the rod is sufficiently sharp, it will have a long-range effect on the electric field. In the same way, a sharp dendrite influences the concentration and temperature far from its tip: the two problems are described by the same Laplace equation.

This would not matter much if dendrites remained smooth, so that no feature as sharp as a lightning rod would ever appear, but such is *not* the case. Instead, dendrites become very sharp locally, as the picture on page 1086 and the "fake" on page 1087 prove abundantly: in fact, the last evolution stage displayed on Ben-Jacob's figure is well beyond the domain of validity of his boundary layer model. In the little cusps that do so much to render the picture appealing, the boundary layer overlaps with itself. As far as I know, whenever the pictures begin to look like snowflakes, the boundary layer model has already broken down.

An approach taking full account of the nonlocal aspects of the problem pursued indicates that growing crystal interfaces develop mathematical singularities such that the local models are untenable.

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Irradiated Food

Despite the letter from Samuel S. Epstein and John W. Gofman (30 Mar., p. 1354), those concerned about the safety of irradiated food need not settle for the assurances of either industry or the Food and Drug Administration. Numerous international professional organizations over the past two decades have reviewed and researched the potential health hazards that were of concern to those in the industry and still are to those opposed to the use of irradiation. A recent statement (*1*) presents the findings of a meeting of the Board of the International Committee on Food Microbiology and Hygiene of the International Union of Microbiological Societies, with the participation of the World Health Organization, the Food and Agriculture Organization, and