Science in India is the topic of several letters, which describe some encouraging developments—"[T]he knowledge revolution has started fueling a culture of academic and technological entrepreneurship in India not witnessed before"—some sources of problems, and an idea for a new funding resource. Regarding speculations of resurrecting the mammoth species by cloning DNA, a reason is given as to why "it would never work." And the success of the National Science Foundation's Urban Systemic Initiatives program in science and math education is discussed as to what the numbers mean and where credit is due.

Science in India

C. N. R. Rao's comments in his Editorial "Science in the future of India" (12 Nov., p. 1295) regarding the state of research and science education in India seem to convey a degree of despair that I wish to qualify. I have myself returned to India after a long stay abroad and feel encouraged to find several positive developments. For example, the growth of the software industry is probably the best example of technology entrepreneurship. The investment in research and development (R&D) by companies such as IBM and Philips NV (Netherlands) with the Indian Institutes of Technology, and such investment by General Electric and DuPont with the Council for Scientific and Industrial Research's National Chemical Laboratory in Pune, India, are just a few examples among several illustrative of India's R&D potential. There is also growth, albeit slow, of medical biotechnology companies that are entirely research-based enterprises, and these are set to grow rapidly.

It is true that much remains to be done to extend primary, secondary, and university education to more of the population in India, which must be accomplished before we can expect to be competitive in the new era of knowledge. But certain states in India, such as Mahārāshtra, Karnātaka, Andhra Pradesh, Kerala, and Tamil Nadu, appear to be making progress. Similarly, some of the leading academic institutions are attracting private R&D funds in growing amounts. The more productive academics and scientists have begun to earn handsome rewards from consulting work and industrial collaborations to supplement their salaries, which, in turn, have improved as well.

In a developing country such as India, it is unlikely that there will ever be sufficient funds for the training and development of the entire young population. But the knowledge revolution has started fueling a culture of academic and technological entrepreneurship in India not witnessed before. This will be a key to generate wealth and surpluses with which to fund educational and social needs. In a recent article (*1*), India was ranked first as the source of knowledge workers (those in software, hardware, and related technology industries), ahead of other Asian countries such as the Philippines, China, Australia, Japan, Taiwan, Vietnam, South Korea, Malaysia, Singapore, Thailand, Hong Kong, and Indonesia, in that order.

Thus, there are many positive developments in the sphere of science, technology, and entrepreneurship in India in the last few years compared with the previous fifty. Although I share, to a large degree, the sentiments expressed by Rao, I am of the view that they need to be tempered by the emerging developments that are most encouraging and portend a much brighter future for scientific research, education, and entrepreneurship. While conveying my optimism, I am acutely aware that India still has the largest number of people in the world who can neither read nor write, and that large parts of India's primary, secondary, and higher education institutions are crying for modernization and change.

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It is easy to share Rao's concerns about the lack of resources for the development of science in India. However, I do not agree that the situation is as bad as Rao suggests. At virtually all levels of Indian society, there is a tremendous drive on the part of parents to provide a college education for their children. The inability of science to flourish in India is largely because of a flawed educational system. Higher education in India is designed to impart knowledge, but there seems to be little emphasis on critical thinking, problem solving, or technical skills. The result of such an education is scientific research that lacks innovation and is struggling to survive the challenge of limited resources.

To make matters worse, India desires to compete in science with the developed world, often at a heavy political price. At a time when resources are limited, critical investments required to develop basic science and educational infrastructure are spent on grandiose projects. Unless Indian science sets realistic goals, an occasional spark of brilliance will not compensate for the general problems with the system. Additional funding will be of little use until there is a basic shift in strategies and goals for higher education and scientific research in the country.

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Response

Ganguly brings out an aspect of India that I did not touch on. It must be noted, however, that scientific research in India is almost entirely funded by the government, as is education. I hope that industry will come to the aid of science and higher education in the next few years.

Regarding Joshi's notion that India should not try to compete in science with the developed world, I do not agree. It is necessary for a large country like India to be innovative in science and technology for various reasons, one being industrial growth and export promotion. To compete at least in a few chosen areas is a realistic goal. I suggested increased funding for education to alleviate specifically some of the problems mentioned by Joshi. Improving the quality of education at all levels should be one of the main goals of the country.

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Rao rightly points out that as a developing country India must delegate resources to "carry out programs in science and technology that focus on the minimum basic needs of the common person and on the promotion of sustainable development,... develop an adequate infrastructure for energy, transportation, and communications,...[and] develop its own expertise... in a few chosen areas of science and technology." To meet these goals, India will need to invest more in science, but it will also need more resources than it has now.

The large number of Indians living in the developed world, especially in Europe and North America, are a major source of foreign exchange for India. In the past, most of this money went to families back home to buy food and other daily necessities, but now much of it is ending up in stock markets and business ventures.

If college-educated Indians living abroad endowed to their respective alma maters graduate fellowships, professor-

ships, research funds, or science prizes, it would create a large pool of new funds for science. This plan would require willingness and effort on the part of the Indian educational establishments to develop comprehensive databanks of their graduates and to approach their alumni for donations. The current attitude in most Indian universities seems to be one of disinterest, neglect, and even hostility toward their graduates.

The Indian Institutes of Technology (IITs) are one of the few success stories of Indian education. The IITs are said to be the best gifts to the United States and Canada because a large proportion of their graduates are working in those countries. Imagine the difference it would make if all graduates from the ITTs started a fund for an endowment in their respective alma mater.

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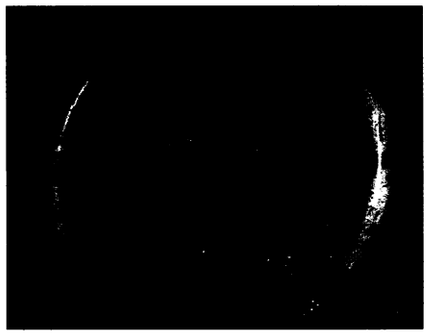
Too Mammoth an Undertaking

In his News of the Week article "Siberian mammoth find raises hopes, questions" (29 Oct., p. 876), Richard Stone describes the excavation of a presumably well-preserved mammoth and the possibility of researchers attempting to resurrect the species. It is a matter of debate if it is desirable to "create" mammoths or other extinct species. However, it would never work. The excavated organic material is thousands of years old, and cloning requires a cell with a complete and undamaged genome. Just a single DNA base in the wrong place could lead to lethality or severe genetic disorders.

A number of DNA studies on mammoths have been published (*1*), and the retrieval of single-copy nuclear DNA has recently been reported (*2*), but even the best preserved permafrost specimens yielded fragmented and damaged DNA.



Not the place to be if this ice-bound mammoth were cloned, but cloning seems an unlikely prospect.

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NSF Urban Systemic Initiatives

In their Editorial "Science learning, science opportunity (*Science*'s Compass, 8 Oct., p. 237), National Science Foundation (NSF) Director Rita R. Colwell and National Science Board Chairman Eamon M. Kelly give a glowing but what seems a largely unfounded report on the accomplishments of the NSF systemic reform initiatives. The authors cite as evidence an increase in student performance in mathematics in Chicago, Illinois (61 out of 62 high schools), and a tripling of students passing science and mathematics advanced placement (AP) tests in Dallas, Texas.

Although it is true that Chicago public high schools have shown increases in standardized (Illinois Goals Assessment Pro-