Nanotechnology could prove to be a "transformative" technology comparable in its impact to the steam engine in the 18th century, electricity in the 20th century, and the Internet in contemporary society (1, 2). Scientists are already developing nano-applications that are radically transforming a host of products and services, including battery-storage capacity, computer-chip minimization, drug delivery, facial creams, food processing, solar energy, and water purification (3, 4).


Clearly, those who have the resources have placed their bets on this next new thing. Will such heavy investments lead to a North-South nanodivide comparable to the divide that has characterized biotechnology and global information technologies? The answer appears to be no.

In fact, nanoscience and nanotechnology may prove to be the first cutting-edge field to reflect the new realities of global science in the 21st century for two reasons. First, the capabilities and accomplishments of scientists and technologists from the developing world who choose to continue to work in their home countries are growing. Second, a number of governments in the South are devising ever more sophisticated and effective science and technology policies. On the downside, there is a disturbing emergence of a South-South gap in capabilities between scientifically proficient countries (Brazil, China, India, and Mexico, for example) and scientifically lagging countries, many of which are located in sub-Saharan Africa and in the Islamic world (8).

Between 2003 and 2007, China's central government will invest some US$240 million in nanoscience and nanotechnology and the nation's local governments, by some estimates, will provide US$360 million more. Brazil plans to invest more than US$25 million between 2004 and 2007, and India US$23 million between 2004 and 2009. Last year, South Africa invested an estimated US$6 million in this endeavor, and Argentina recently announced that that it will invest US$10 million over the next 5 years. Chile and Mexico are also pursuing modest but growing programs (9, 10).

Smaller and poorer developing countries have also decided that this represents a strategic investment in future economic and social well-being that they cannot afford to ignore. Thailand and the Philippines, for example, are both devoting a portion of their small science and technology budgets to nanoscience and nanotechnology (11).

Such investments seem to be paying off. In 2004, scientists in China published more articles on nanoscience and nanotechnology in international peer-reviewed science journals than scientists in the United States, and it now ranks third behind the United States and Japan in nanotechnology patents. In a 2004 listing on nanotechnology and nanoscience literature, two developing countries (China and India) were among the top 10 nations in the publication of peer-reviewed articles (12).

What accounts for this dramatic change is the anticipated return on investment. The U.S. National Science Foundation (NSF) estimates that nanotechnology will represent a US$1 trillion global market by the end of this decade (13). That market would likely remain the sole domain of developed countries except for several interrelated factors.

First, the developing world's interest in nanoscience and nanotechnology parallels a trend in global science that has been unfolding over the past 20 years. This trend is highlighted by a number of developing countries that have embraced science and technology as critical elements in their overall economic development strategies.

China, for example, now devotes ~1.1% of its gross domestic product (GDP) to science and technology (it has recently become the world's third-largest investor in research and development in absolute terms). Meanwhile, the budget for China's National Natural Science Foundation (modeled on the NSF) has skyrocketed from US$10 million in 1986 to US$300 million in 2003. India, likewise, now invests ~1.2% of its GDP in science and technology and has emerged as one of the world's leading countries in the application and, increasingly, the development of information technology (14). Brazil now spends an estimated ~1.1% of GDP on science and technology (15, 16) and graduates some 7000 Ph.D. students in a broad range of scientific disciplines each year (17).

Second, the investment in nanoscience and nanotechnology represents a paradigm shift in science-based development strategies. As Turner T. Isoun, Nigeria's Federal Minister of Science and Technology, recently
noted, “developing countries will not catch up with developed countries by investing in existing technologies alone. [In order] to compete successfully in global science today, a portion of the science and technology budget of every country must focus on cutting-edge science and technologies” (18).

This change in strategy explains, in part, China’s extensive investments in biotechnology and information technologies. It explains the recent decision by the Brazilian parliament to allow stem cell research. It explains Nigeria’s launch of a remote-sensing satellite in 2003 to improve resource management. And it explains South Africa’s decision to become the chief sponsor of the Southern African Large Telescope, which will be the largest such instrument in the Southern hemisphere when it opens this autumn (19).

The participation of developing world scientists at the highest levels of research is likely to quicken the pace of global progress. Equally important, it is likely to help avoid a repetition of one concern that has hampered the development of genetically modified crops; namely, that monopolization of research and development by corporations in the United States has protected their commercial interests at the expense of the rest of the world (20).

If the development of nanoscience and nanotechnology becomes a truly global phenomenon and if scientists engage their fellow-citizens in an open dialogue on the risks and benefits (2, 21), then the public is likely to be more accepting.

Some nongovernmental organizations (NGOs) in the North, led by the Canadian-based ETC Group (22) have argued that nanotechnologies, by increasing the efficient use of raw materials and creating substitutes for them, could damage the commodities-dependent economies of developing countries. Although this could pose a problem in the short run, developing countries have no choice but to embrace nanoscience and nanotechnology if they hope to build successful economies in the long term.

As advances continue on a global scale, there are some ominous trends. Although increased investments in a number of developing countries have narrowed the North-South nanodivide, such investments have widened the South-South divide. Today, the environment for research and development in nanoscience and nanotechnology in Brazil, China, India, and South Africa bears closer resemblance to the research environment in Europe, Japan, and the United States than it does, for instance, to the research environment in the Dominican Republic, Laos, or Rwanda.

This is no small matter, for two reasons. First, having closer ties between scientists and technologists in the North and South increases the chances that the research and development agenda will be dictated by the North. Nanoscience and nanotechnology raise many intriguing questions from a research perspective. At the same time, they have many potentially valuable societal applications for poor people, including the creation of more efficient filtering systems for producing clean drinking water (through the creation of filters that prevent viruses and toxins from entering the water supply) and the provision of cheap and clean energy (through more efficient solar cells). But there remains the possibility that the majority of resources and expertise (in the North and South) may be applied to products and services that hold the most promising market potential in the North where the richest consumers live. To avoid this pitfall, governments throughout the developing world must focus on and support national policies that address critical social and environmental concerns in their own countries.

Specifically, the governments of those developing countries now investing heavily in nanotechnology should avoid “hitching” their research and development programs to those in the North. To prevent the creation of a South-South nanotechnology divide, such developing countries should devise broad-based strategies that include ample investments in South-South cooperation. In the long term, this could advance the use of these technologies worldwide and spur progress on many of the Millennium Development Goals (23).

It is for this reason that the global scientific community should pursue the following policies for the advancement of nanoscience and nanotechnology:

(i) establish nanotechnology centers of excellence in sub-Saharan Africa and other least-developed regions within existing competent institutions capable of partnering with other centers both in the South and North on joint projects;

(ii) forge networks between universities and research centers in scientifically proficient developing countries and universities and research centers in scientifically lagging countries, particularly those in the least developed countries;

(iii) develop national policies that explicitly call for investments in research projects that focus on issues of critical importance in the developing world, including access to safe drinking water; the development of low-cost yet efficient sources of renewable energy; and the creation of gels that can reduce the risk of HIV/AIDS transmission.

Proponents of nanoscience and nanotechnology claim that this transformative field could radically alter fundamental aspects of our global society. If the research is organized in an effective manner, the pursuit of these larger social and environmental goals could also help build the capacities of nations that have been excluded. Of all the benefits promised by nanoscience and nanotechnology, the potential to lift the quality of science and technology on a global scale may be the most important benefit of all.

References and Notes

4. E. Court et al., Nanotechnol. Soc. (January 2004); available at www.nanotechweb.org/articles/societ y/3/1/1/1/.
13. A recent survey of scientists in the developing world on potential applications of nanotechnology showed strong support for applications closely in line with the UN’s Millennium Goals. Whether research agendas and funding and investment patterns will reflect these survey results remains an open question. See (7).
Small Things and Big Changes in the Developing World
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