Poor countries—and poor people—suffer not only because they have less capital than rich countries. They also suffer because they have less scientific and technical knowledge. Without skills and information, it is difficult to combat disease, raise crop yields, improve general welfare, and get credit at fair interest rates. If countries don't narrow this "knowledge gap," they could wind up stuck with lower living standards.

All countries benefit from science and technology—in vaccines, antibiotics, and better seeds and fertilizers. But many new technologies are too expensive for widespread application in poor countries. Technological solutions to many of their problems will not come easily or quickly, so they need to be selective in how they invest in science and technology. And to reduce poverty, they need policies that take advantage of science and technology the world over—opening the door to eventually improving capacity and developing their own solutions.

Technological innovation, often fueled by government-led research and development, has been the driving force for industrial growth around the world. It has paid off handsomely in high-income countries. The evidence for the same returns in developing countries is not so clear. Even so, the best opportunities to improve living standards—including new ways of reducing poverty—will come from science and technology. The more science and technology capacity a country has, the more able it is to take advantage of emerging opportunities. Poor countries thus need to continue to find ways to make increasing science and technology capacity part of their development strategy. Building alliances with private, public, national, and international actors is essential in this, especially to overcome market failures—when private investors do not expect to recover costs and make a profit, as for vaccines for tropical diseases.

Science and technology—applied well—can reduce poverty

Science and technology—applied wisely and well—hold great promise for eradicating the worst forms of human poverty.

Improving health

The health of people in developing countries is better than ever, with life expectancy up from 60 years to 65 since 1980. But in most developing countries child mortality is still 10 times that in high-income economies. About half the deaths result from such preventable ailments as diarrhea, malnutrition, and

respiratory illness. And some 3 million children die each year because they lack access to existing vaccines.

Most deaths in developing countries are preventable with improvements in low-technology health delivery systems. Oral rehydration therapy, for example, now treats half of all diarrhea cases in the world's poorest countries. But there still is an urgent need to make this therapy—a simple combination of salts, glucose, and water—more widely accessible.

Increasing farm output

Agriculture is the main source of income for around 60 percent of the labor force in developing countries, so increasing agricultural output will affect more people than advances in any other economic sector. As Collins, Frison, and Sharrock (1997) note, one of the main challenges of agricultural research is to increase food production and food security in a sustainable manner—and at the same time to improve farm income while conserving natural resources. With the global population expanding rapidly, more scientists around the world recognize that biotechnology, with the right ethical and safety standards, offers important new tools to help feed the world's 6 billion people (box 5a).

Connecting people

New communications technology offers opportunities for informing and empowering the poor—and for serving the towns, small cities, and rural areas of many developing countries. In parts of Asia and Africa rural telephone density is a fifth that in the largest cities, so small entrepreneurs and others in remote areas typically lack information about prices and market opportunities. But new access to telecommunications—telephones (especially mobile phones, which have helped to reduce the urban-rural gap in telephone density), email, and the Internet—can strengthen their voices, whether to advocate policies or to market village handicrafts.

Box 5a

What can biotechnology do?

Biotechnology uses living organisms to make and modify products, improve plants and animals, and develop microorganisms for specific uses. It mixes disciplines—genetics, molecular biology, biochemistry, embryology, and cell biology (Doyle and Persley 1996). How has biotechnology been applied?

- *Eliminating disease.* Dr. Walter Plowright received the World Food Prize in 1999 for a vaccine that eliminated rinderpest—one of the deadliest animal diseases, commonly known as cattle plague—from much of the developing world. Rinderpest control has saved farms, increased milk supplies, and boosted agricultural output and meat and hide production (World Food Prize 2000).
- *Improving crops.* Many countries are using biotechnology to improve crops and develop biofertilizers and forestry biopesticides.
- *Conserving resources.* Two research centers—the International Rice Research Institute in the Philippines and the International Water Management Institute in Sri Lanka—are leading the effort to research new water-saving techniques for cultivating rice in Asia. The techniques include wet-seeding, intermittent irrigation, land leveling, weed management, and ways to cultivate cracked soils.

Absorbing knowledge

The key to absorbing knowledge is education. Schooling at all levels is important—from basic education to technical training that helps to build a labor force that can keep up with technology's advances. Among developing countries there is a wide range in the number of trained scientists and engineers, from around 3 per million people in Senegal to more than 1,900 per million people in Croatia (table 5.12). Technical literacy is needed for successful technology transfer and to develop indigenous technological capabilities. But achieving it is far from automatic. Needed in addition is a long-term strategy for human resource development and for continually investing in a country's education system. The information technology revolution has the potential to improve the quality of life around the world, but the "digital divide"—between those connected to the Internet and those not—can be closed only by making education a top priority.

Technology is contributing to the growth of distance education and virtual universities—and helping to build cadres of professionals with internationally competitive skills. Virtual universities use satellites and the Internet to deliver courses, allowing people in scattered locations to share resources. The Virtual University of Mexico's Monterrey Institute of Technology—a consortium of collaborating universities, including 13 outside the country—delivers courses through printed texts and live and prerecorded television broadcasts, and Internet connections facilitate communication between students and faculty. In China half the 92,000 engineering and technology students who graduate each year do so through distance education. Between 1981 and 1995 China's scientists increased the number of scientific and technical articles they published in internationally recognized journals from about 1,100 a year to more than 6,000 (table 5.12).

Improving national capacity to absorb and create science and technology

Many developing countries spend less than one-hundredth of 1 percent of GNP on research and development, while others, such as the Czech Republic and Slovenia, spend more than 1 percent (table 5.12). Even with large investments in research and development there is no guarantee of progress, so governments need to evaluate programs to make sure they are effective.

For developing countries to have the resources for extensive research and development, they must acquire technical knowledge from the rest of the world and adapt it to their needs. In this, the key task of governments is to provide a policy and regulatory environment that stimulates private firms to develop technology. Governments must also enhance firm-specific and national technological capabilities in production, investment, and innovation.

National innovation systems, especially their private components, are essential for economic growth. Such systems have different characteristics in countries at different levels of development, but the common elements include:

- *A vital and self-renewing research community.* Whether in universities or in public and private laboratories, the research community must collaborate with international peers, balance

basic and applied research, and train the next generation of researchers.

- *Sound public policy and selective public support for research.* Governments must implement effective policies in science education—and fund or purchase basic research in sectors where knowledge is a public good.
- *Proper incentive structures.* The government must be receptive to foreign technology—through licensing laws, legal protection of intellectual property, tax codes that promote research and development, and policies that encourage technological entrepreneurship.

Public and private partnerships to overcome market failures that hurt the poor

Despite huge advances in biotechnology, there has been little investment by the industrial world in research and development for products that help developing countries. New vaccines for tropical diseases are not developed at anywhere near the rate for vaccines demanded by rich-country markets—in part because of the science, but often because of market failure. Of the 1,233 new drugs licensed worldwide between 1975 and 1997, only 13 were for tropical diseases.

That could soon change. Developing country governments working in partnership with the private sector and with wealthy governments and international organizations show the potential for mobilizing science and technology to address the problems of the poor (box 5b). Universities, research institutes, and industry are cooperating more closely—and financing for science and technology projects is being promoted to advance knowledge and strengthen science-based industries.

Where do we go from here? Looking to the 21st century

Many types of knowledge are international public goods. No one country or private organization has the incentive to do the research to create this knowledge, and international institutions can help fill the gap. The World Bank, working within its new Comprehensive Development Framework, seeks to provide coordinated and targeted assistance. This requires:

- Conducting more dialogue with countries to get a consensus on the importance of knowledge for development.
- Identifying successful policy approaches and practices.
- Providing advice on human resource development, technology development, national innovation systems, and legal and regulatory issues in the knowledge sector.
- Lending in new and innovative ways to support knowledge-based development.

The World Bank is also exploring new mechanisms to increase the global coordination of research. It is developing partnerships with other donors to fund new global and regional research programs. It is creating new lending instruments to encourage international science and technology cooperation. And it is institutionalizing links among researchers across project and national boundaries. A new tool to promote cooperation in development is the Global Development Gateway, an initiative by international organizations, governments, businesses, universities, and nongovernmental organizations to produce the premier portal on the World Wide Web for supporting sustainable development and the alleviation of poverty.

Establishing centers of excellence

Among the new instruments for stimulating science and technology's contribution to development is the Millennium Science Initiative. A series of projects—the first in Latin America—will support research excellence and collaboration between top researchers from the developing and developed worlds. As part of the initiative, the World Bank is working with client countries to improve their systems for funding research and advanced training.

Dealing with intellectual property rights

To acquire knowledge through trade, foreign direct investment, or licensing, firms must often be encouraged to engage in a conscious, ongoing effort to learn and adapt technology. And if countries are to deal with new global rules for intellectual property rights, they must strike a compromise between preserving incentives to create knowledge and disseminating knowledge at little or no cost.

Disseminating vaccines and developing new ones

The Global Alliance for Vaccines and Immunization (GAVI)—launched on 31 January 2000 in Davos, Switzerland—brings together the World Bank, the World Health Organization, wealthy donor countries, poor recipient countries, philanthropic organizations, and the drug industry to improve access to existing vaccines and develop new ones.

Blending past and present

Technologies of the future can combine traditional and cutting-edge technology. In partnership with Nigerian collaborators, Shaman Pharmaceuticals, a California company, has begun to discover and develop new pharmaceuticals from plants with a history of local use. Some of the benefits: support for a medicinal plant reserve and new training programs on public health, botany, conservation, and ethnobotany.

Box 5b

Bridging knowledge and policy

A four-day meeting in Bonn in December 1999—on bridging knowledge and policy—brought together 28 donor agencies and more than 300 organizations in 111 developing countries to create the Global Development Network. The network will link policy-oriented think tanks in developing countries with their counterparts in industrial countries.

The World Bank believes that the network can evolve into a self-governing organization with financial support from a variety of donors. The Bank provided $10 million to help set up the regional development networks that make up the global network and will provide another $10 million in the next few years. Major bilateral donors have offered to fund an on-line network (Germany), development prizes (Japan), an evaluation exercise (Switzerland), a data initiative (Norway), and a global research project (Sweden).