Making new technologies work for human development

This Report, like all previous *Human Development Reports,* is about people. It is about how people can create and use technology to improve their lives. It is also about forging new public policies to lead the revolutions in information and communications technology and biotechnology in the direction of human development.

People all over the world have high hopes that these new technologies will lead to healthier lives, greater social freedoms, increased knowledge and more productive livelihoods. There is a great rush to be part of the network age—the combined result of the technological revolutions and globalization that are integrating markets and linking people across all kinds of traditional boundaries.

At the same time, there is great fear of the unknown. Technological change, like all change, poses risks, as shown by the industrial disaster in Bhopal (India), the nuclear disaster in Chernobyl (Ukraine), the birth defects from thalidomide and the depletion of the ozone layer by chlorofluorocarbons. And the more novel and fundamental is the change, the less is known about its potential consequences and hidden costs. Hence there is a general mistrust of scientists, private corporations and governments—indeed, of the whole technology establishment.

This Report looks specifically at how new technologies will affect developing countries and poor people. Many people fear that these technologies may be of little use to the developing world—or that they might actually widen the already savage inequalities between North and South, rich and poor. Without innovative public policy, these technologies could become a source of exclusion, not a tool of progress. The needs of poor people could remain neglected, new global risks left unmanaged. But managed well, the rewards could be greater than the risks.

At the United Nations Millennium Summit, world leaders agreed on a set of quantified and monitorable goals for development and poverty eradication to achieve by 2015. Progress the world has made over the past 30 years shows that these goals are attainable. But many developing countries will not achieve them without much faster progress. While 66 countries are on track to reduce under-five mortality rates by two-thirds, 93 countries with 62% of the world's people are lagging, far behind or slipping. Similarly, while 50 countries are on track to achieve the safe water goal, 83 countries with 70% of the world's people are not. More than 40% of the world's people are living in countries on track to halve income poverty by 2015. Yet they are in just 11 countries that include China and India (with 38% of the world's people), and 70 countries are far behind or slipping. Without China and India, only 9 countries with 5% of the world's people are on track to halve income poverty. New technology policies can spur progress towards reaching these and other goals.

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1. The technology divide does not have to follow the income divide. Throughout history, technology has been a powerful tool for human development and poverty reduction.

It is often thought that people gain access to technological innovations—more effective medicine or transportation, the telephone or the Internet—once they have more income. This is true—economic growth creates opportunities for useful innovations to be created and diffused. But the process can also be reversed: investments in technology, like investments in

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education, can equip people with better tools and make them more productive and prosperous. Technology is a tool, not just a reward, for growth and development.

In fact, the 20th century's unprecedented gains in advancing human development and eradicating poverty came largely from technological breakthroughs:

- In the late 1930s mortality rates began to decline rapidly in Asia, Africa and Latin America, and by the 1970s life expectancy at birth had increased to more than 60 years. In Europe that same gain took more than a century and a half starting in the early 1800s. The rapid gains of the 20th century were propelled by medical technology—antibiotics and vaccines—while progress in the 19th century depended on slower social and economic changes, such as better sanitation and diets.
- The reduction in undernutrition in South Asia from around 40% in the 1970s to 23% in 1997—and the end of chronic famine—was made possible by technological breakthroughs in plant breeding, fertilizers and pesticides in the 1960s that doubled world cereal yields in just 40 years. That is an astonishingly short period relative to the 1,000 years it took for English wheat yields to quadruple from 0.5 to 2.0 tonnes per hectare.

These examples show how technology can cause discontinuous change: a single innovation can quickly and significantly change the course of an entire society. (Consider what an affordable vaccine or cure for AIDS could do for Sub-Saharan Africa.)

Moreover, technology-supported advances in health, nutrition, crop yields and employment are usually not just one-time gains. They typically have a multiplier effect—creating a virtuous cycle, increasing people's knowledge, health and productivity, and raising incomes and building capacity for future innovation—all feeding back into human development.

Today's technological transformations are more rapid (the power of a computer chip doubles every 18–24 months without cost increase) and more fundamental (genetic engineering breakthroughs) and are driving down costs (the cost of one megabit of storage fell from $5,257 in 1970 to $0.17 in 1999). These transformations multiply the possibilities of what people can do with technology in areas that include:

- *Participation.* The Internet, the wireless telephone and other information and communications technology enable people to communicate and obtain information in ways never before possible, dramatically opening up possibilities to participate in decisions that affect their lives. From the fax machine's role in the fall of communism in 1989 to the email campaigns that helped topple Philippine President Joseph Estrada in January 2001, information and communications technology provides powerful new ways for citizens to demand accountability from their governments and in the use of public resources.
- *Knowledge.* Information and communications technology can provide rapid, low-cost access to information about almost all areas of human activity. From distance learning in Turkey to long-distance medical diagnosis in the Gambia, to information on market prices of grain in India, the Internet is breaking barriers of geography, making markets more efficient, creating opportunities for income generation and enabling increased local participation.
- *New medicines.* In 1989 biotechnological research into hepatitis B resulted in a breakthrough vaccine. Today more than 300 biopharmaceutical products are on the market or seeking regulatory approval, and many hold equal promise. Much more can be done to develop vaccines and treatments for HIV/AIDS and other diseases endemic in some developing countries.
- *New crop varieties.* Trangenics offer the hope of crops with higher yields, pest- and drought-resistant properties and superior nutritional characteristics—especially for farmers in ecological zones left behind by the green revolution. In China genetically modified rice offers 15% higher yields without the need for increases in other farm inputs, and modified cotton (Bt cotton) allows pesticide spraying to be reduced from 30 to 3 times.
- *New employment and export opportunities.* The recent downturn in the Nasdaq has quieted the hyperbole, but the long-term potential for some developing countries remains tremendous as electronic commerce breaks barriers of distance and market information. Revenues

from India's information technology industry jumped from $150 million in 1990 to $4 billion in 1999.

All this is just the beginning. Much more can be expected as more technologies are adapted to the needs of developing countries.

2. The market is a powerful engine of technological progress—but it is not powerful enough to create and diffuse the technologies needed to eradicate poverty.

Technology is created in response to market pressures—not the needs of poor people, who have little purchasing power. Research and development, personnel and finance are concentrated in rich countries, led by global corporations and following the global market demand dominated by high-income consumers.

In 1998 the 29 OECD countries spent $520 billion on research and development—more than the combined economic output of the world's 30 poorest countries. OECD countries, with 19% of the world's people, also accounted for 91% of the 347,000 new patents issued in 1998. And in these countries more than 60% of research and development is now carried out by the private sector, with a correspondingly smaller role for public sector research.

As a result research neglects opportunities to develop technology for poor people. For instance, in 1998 global spending on health research was $70 billion, but just $300 million was dedicated to vaccines for HIV/AIDS and about $100 million to malaria research. Of 1,223 new drugs marketed worldwide between 1975 and 1996, only 13 were developed to treat tropical diseases—and only 4 were the direct result of pharmaceutical industry research. The picture is much the same for research on agriculture and energy.

Technology is also unevenly diffused. OECD countries contain 79% of the world's Internet users. Africa has less international bandwidth than São Paulo, Brazil. Latin America's bandwidth, in turn, is roughly equal to that of Seoul, Republic of Korea.

These disparities should come as no surprise. After all, electric power generation and grid delivery were first developed in 1831 but are still not available to a third of the world's people. Some 2 billion people still do not have access to low-cost essential medicines (such as penicillin), most of which were developed decades ago. Half of Africa's one-year-olds have not been immunized against diphtheria, pertussis, tetanus, polio and measles. And oral rehydration therapy, a simple and life-saving treatment, is not used in nearly 40% of diarrhoea cases in developing countries.

Inadequate financing compounds the problem. High-tech startups in the United States have thrived on venture capital. But in many developing countries, where even basic financial services are underdeveloped, there is little prospect of such financing. Moreover, the lack of intellectual property protection in some countries can discourage private investors.

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The global map of technological achievement in this Report shows huge inequalities between countries—not just in terms of innovation and access, but also in the education and skills required to use technology effectively. The Report's technology achievement index (TAI) provides a country-by-country measure of how countries are doing in these areas.

Technology is also unevenly diffused within countries. India, home to a world-class technology hub in Bangalore, ranks at the lower end of the TAI. Why? Because Bangalore is a small enclave in a country where the average adult received only 5.1 years of education, adult illiteracy is 44%, electricity consumption is half that in China and there are just 28 telephones for every 1,000 people.

3. Developing countries may gain especially high rewards from new technologies, but they also face especially severe challenges in managing the risks.

The current debate in Europe and the United States over genetically modified crops mostly ignores the concerns and needs of the developing world. Western consumers who do not face food shortages or nutritional deficiencies or work in fields are more likely to focus on food safety and the potential loss of biodiver-

sity, while farming communities in developing countries are more likely to focus on potentially higher yields and greater nutritional value, and on the reduced need to spray pesticides that can damage soil and sicken farmers. Similarly, the recent effort to globally ban the manufacture of DDT did not reflect the pesticide's benefits in preventing malaria in tropical countries.

Moreover, while some risks can be assessed and managed globally, others must take into account local considerations. The potential harms to health from mobile phones or to unborn children from thalidomide are no different for people in Malaysia than in Morocco. But gene flow from genetically modified corn would be more likely in an environment with many corn-related wild species than in one without such indigenous plants.

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Environmental risks in particular are often specific to individual ecosystems and need to be assessed case by case. In considering the possible environmental consequences of genetically modified crops, the example of European rabbits in Australia offers a warning. Six rabbits were introduced there in the 1850s. Now there are 100 million, destroying native flora and fauna and costing local industries $370 million a year.

If new technologies offer particular benefits for the developing world, they also pose greater risks. Technology-related problems are often the result of poor policies, inadequate regulation and lack of transparency. (For instance, poor management by regulators led to the use of HIV-infected blood in transfusions during the 1980s and to the spread of mad cow disease more recently.) From that perspective, most developing countries are at a disadvantage because they lack the policies and institutions needed to manage the risks well.

Professional researchers and trained technicians are essential for adapting new technologies for local use. A shortage of skilled personnel—from laboratory researchers to extension service officers—can seriously constrain a country's ability to create a strong regulatory system. Even in developing countries with more advanced capacity, such as Argentina and Egypt, biosafety systems have nearly exhausted national expertise.

The cost of establishing and maintaining a regulatory framework can also place a severe financial demand on poor countries. In the United States three major, well-funded agencies—the Department of Agriculture, Food and Drug Administration and Environmental Protection Agency—are all involved in regulating genetically modified organisms. But even these institutions are appealing for budget increases to deal with the new challenges raised by biotechnology. In stark contrast, regulatory agencies in developing countries survive on very little funding. Stronger policies and mechanisms are needed at the regional and global levels, and should include active participation from developing countries.

4. The technology revolution and globalization are creating a network age—and that is changing how technology is created and diffused.

Two simultaneous shifts in technology and economics—the technological revolution and globalization—are combining to create a new network age. Just as the steam engine and electricity enhanced physical power to make possible the industrial revolution, digital and genetic breakthroughs are enhancing brain power.

The industrial age was structured around vertically integrated organizations with high costs of communications, information and transportation. But the network age is structured along horizontal networks, with each organization focusing on competitive niches. These new networks cross continents, with hubs from Silicon Valley (United States) to São Paulo to Gauteng (South Africa) to Bangalore.

Many developing countries are already tapping into these networks, with significant benefits for human development. For instance, new malaria drugs created in Thailand and Viet Nam were based on international research as well as local knowledge.

Scientific research is increasingly collaborative between institutions and countries. In 1995–97 scientists in the United States co-wrote articles with scientists from 173 other countries, scientists in Brazil with 114, in Kenya with

81, in Algeria with 59. Global corporations, often based in North America, Europe or Japan, now typically have research facilities in several countries and outsource production worldwide. In 1999, 52% of Malaysia's exports were high-tech, 44% of Costa Rica's, 28% of Mexico's, 26% of the Philippines's. Hubs in India and elsewhere now use the Internet to provide real-time software support, data processing and customer services for clients all over the world.

International labour markets and skyrocketing demand for information and communications technology personnel make top scientists and other professionals globally mobile. Thus developing country investments in education subsidize industrial country economies. Many highly educated people migrate abroad even though their home country may have invested heavily in creating an educated labour force. (For instance, 100,000 Indian professionals a year are expected to take visas recently issued by the United States—an estimated resource loss for India of $2 billion.) But this migration can be a brain gain as well as a brain drain: it often generates a diaspora that can provide valuable networks of finance, business contacts and skill transfer for the home country.

5. Even in the network age, domestic policy still matters. All countries, even the poorest, need to implement policies that encourage innovation, access and the development of advanced skills.

Not all countries need to be on the cutting edge of global technological advance. But in the network age every country needs the capacity to understand and adapt global technologies for local needs. Farmers and firms need to master new technologies developed elsewhere to stay competitive in global markets. Doctors seeking the best care for their patients need to introduce new products and procedures from global advances in medicine. In this environment the key to a country's success will be unleashing the creativity of its people.

Nurturing creativity requires flexible, competitive, dynamic economic environments. For most developing countries that means building on reforms that emphasize openness—to new ideas, new products and new investment, especially in telecommunications. Closed-market policies, such as telecommunications laws that favour government monopolies, still isolate some countries from global networks. In others a lack of proper regulation has led to private monopolies with the same isolating effects. In Sri Lanka competition among providers of information and communications technology has led to increased investment, increased connectivity and better service. Chile offers a successful model for pursuing privatization and regulation simultaneously.

But open markets and competition are not enough. At the heart of nurturing creativity is expanding human skills. Technological change dramatically raises the premium every country should place on investing in the education and training of its people. And in the network age, concentrating on primary education will not suffice—the advanced skills developed in secondary and tertiary schools are increasingly important.

Vocational and on-the-job training also cannot be neglected. When technology is changing, enterprises have to invest in training workers to stay competitive. Smaller enterprises in particular can benefit from public policies that encourage coordination and economies of scale and that partly subsidize their efforts. Studies in Colombia, Indonesia, Malaysia and Mexico have shown that such training provides a considerable boost to firm productivity.

Market failures are pervasive where knowledge and skills are concerned. That is why in every technologically advanced country today, governments have provided funding to substitute for market demand with incentives, regulations and public programmes. But such funding has not been mobilized to do the same for most developing countries, from domestic or international sources.

More generally, governments need to establish broad technology strategies in partnership with other key stakeholders. Governments should not try to "pick winners" by favouring certain sectors or firms. But they can identify areas where coordination makes a difference because no single private investor will act alone (in building in-

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frastructure, for example). Costa Rica has been successful in implementing such a strategy.

6. National policies will not be sufficient to compensate for global market failures. New international initiatives and the fair use of global rules are needed to channel new technologies towards the most urgent needs of the world's poor people.

Policy, not charity, will determine whether new technologies become a tool for human development everywhere

No national government can single-handedly cope with global market failures. Yet there is no global framework for supporting research and development that addresses the common needs of poor people in many countries and regions.

What is the research needed for? The list is long and fast changing. Some top priorities:

- Vaccines for malaria, HIV and tuberculosis as well as lesser-known diseases like sleeping sickness and river blindness.
- New varieties of sorghum, cassava, maize and other staple foods of Sub-Saharan Africa.
- Low-cost computers and wireless connectivity as well as prepaid chip-card software for ecommerce without credit cards.
- Low-cost fuel cells and photovoltaics for decentralized electricity supply.

What can be done? Rich countries could support a global effort to create incentives and new partnerships for research and development, boosted by new and expanded sources of financing. Civil society groups and activists, the press and policy-makers could nurture public understanding on difficult issues such as the differential pricing of pharmaceuticals and the fair implementation of intellectual property rights. The lesson of this Report is that at the global level it is policy, not charity, that will ultimately determine whether new technologies become a tool for human development everywhere.

Creative incentives and new partnerships. At a time when universities, private companies and public institutions are reshaping their research relationships, new international partnerships for development can bring together the strengths of each while balancing any conflicts of interest. Many approaches to creating incentives are possible—from purchase funds and prizes to tax credits and public grants.

One promising model is the International AIDS Vaccine Initiative, which brings together academics, industry, foundations and public researchers through innovative intellectual property rights agreements that enable each partner to pursue its interests while jointly pursuing a vaccine for the HIV/AIDS strain common in Africa.

Dedicated funds for research and development. At the moment it is not even possible to track how much each government or international institution contributes to research and development to deal with global market failures. For instance, it is relatively easy to find out how much a donor spends to promote health in a given country—but much harder to determine how much of that goes for medical research. A first step towards increased funding in this area would be establishing a mechanism for measuring current contributions.

Private foundations, such as Rockefeller, Ford and now Gates and Wellcome, have made substantial contributions to research and development targeted at the needs of developing countries. But these contributions are far from sufficient to meet global needs, and at least $10 billion in additional funds could be mobilized from:

- *Bilateral donors.* A 10% increase in official development assistance, if dedicated to research and development, would put $5.5 billion on the table.
- *Developing country governments.* Diverting 10% of Sub-Saharan Africa's military spending in 1999 would have raised $700 million.
- *International organizations.* In 2000 about $350 million of the World Bank's income was transferred to its interest-free arm for lending to the poorest countries. A much smaller amount dedicated to technology development for low-income countries would go a long way.
- *Debt-for-technology swaps.* In 1999 official debt service payments by developing countries totalled $78 billion. Swapping just 1.3% of this debt service for technology research and development would have raised more than $1 billion.
- *Private foundations in developing countries.* Developing countries could introduce tax incentives to encourage their billionaires to set up foundations. Rich individuals from Brazil

to Saudi Arabia to India to Malaysia could help fund regionally relevant research.

- *Industry.* With their financial, intellectual and research resources, high-tech companies could make bigger contributions than they do now. The head of research at Novartis has proposed that these companies devote a percentage of their profits to research on non-commercial products.

Differential pricing. From pharmaceuticals to computer software, key technology products are in demand worldwide. An effective global market would encourage different prices for them in different countries, but the current system does not.

A producer seeking to maximize global profits on a new technology would ideally divide the market into different income groups and sell at prices that maximize profits in each. With technology, where the main cost to the seller is usually research rather than production, such tiered pricing could lead to an identical product being sold in Cameroon for just one-tenth—or one-hundredth—the price in Canada.

But in the network age segmenting the international market is not easy. With increasingly open borders and growing Internet sales, producers in rich countries fear that re-imports of heavily discounted products will undercut the higher domestic prices charged to cover overhead and research and development. And even if products do not creep back into the home market, knowledge about lower prices will—creating the potential for consumer backlash. Without mechanisms to deal with these threats, producers are more likely to set global prices (for AIDS drugs, for instance) that are unaffordable for the citizens of poor countries.

Part of the battle to establish differential pricing must be won through consumer education. Civil society groups and activists, the press and policy-makers could help the citizens of rich countries understand that it is only fair for people in developing countries to pay less for medicines and other critical technology products. Without higher prices in rich countries, companies would have far less incentive to invest in new research and development.

The broader challenge for public, private and non-profit decision-makers is to agree on ways to segment the global market so that key technology products can be sold at low cost in developing countries without destroying markets—and industry incentives—in industrial countries. This goal should be high on the agenda in upcoming international trade negotiations.

Fair use of intellectual property rights and fair implementation of TRIPS. Intellectual property rights are being tightened and increasingly used worldwide. The World Intellectual Property Organization's Patent Cooperation Treaty accepts a single international application valid in many countries; the number of international applications rose from 7,000 in 1985 to 74,000 in 1999. In the midst of this boom, there are two new hurdles for developing countries and poor people.

First, intellectual property rights can go too far. Some patent applications disclose their innovations with great obscurity, stretching patent officers' capacity to judge and the ability of other researchers to understand. In 2000 the World Intellectual Property Organization received 30 patent applications over 1,000 pages long, with several reaching 140,000 pages. From patents on genes whose function may not be known to patents on such ecommerce methods as one-click purchasing, many believe that the criteria of non-obviousness and industrial utility are being interpreted too loosely.

In particular, patent systems lay open indigenous and community-based innovation to private sector claims. Ill-awarded patents, granted despite prior art, obviousness or lack of innovation—such as a US patent on the Mexican enola bean—are contributing to the silent theft of centuries of developing country knowledge and assets.

Second, current practices are preventing the fair implementation of the World Trade Organization's agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). As signatories to the 1994 TRIPS agreement, developing countries are implementing national systems of intellectual property rights following an agreed set of minimum standards, such as 20 years of patent protection. A single set of minimum rules may seem to create a level playing field, since one set of rules applies to all. But as currently practiced, the game is not fair be-

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cause the players are of such unequal strength, economically and institutionally.

For low-income countries, implementing and enforcing intellectual property rights put stress on scarce resources and administrative skills. Without good advice on creating national legislation that makes the most of what TRIPS allows, and under intense external pressure to introduce legislation beyond that required by TRIPS, countries can legislate themselves into a disadvantageous position. Moreover, the high costs of disputes with the world's leading nations are daunting, discouraging developing countries from asserting their rights.

Commitments under TRIPS to promote technology transfer to developing countries are paper promises, often neglected in implementation. They must be brought to life.

If the game is to be played fairly, at least two changes are needed. First, the TRIPS agreement must be implemented in a way that enables developing countries to use safeguard provisions that secure access to technologies of overriding national importance.

For instance, under a range of special conditions TRIPS allows governments to issue compulsory licenses for companies to manufacture products that have been patented by others. Such licenses are already in use from Canada and Japan to the United Kingdom and the United States for products including pharmaceuticals, computers and tow trucks. They are used particularly as antitrust measures to prevent reduced competition and higher prices. But so far these provisions have not been used south of the equator. Developing countries, like other countries, should be able to do in practice what TRIPS allows them to do in theory.

Second, commitments under TRIPS and many other multilateral agreements to promote technology transfer to developing countries are paper promises, often neglected in implementation. They must be brought to life.

The heart of the problem is that although technology may be a tool for development, it is also a means of competitive advantage in the global economy. Access to patented environmental technologies and pharmaceuticals, for example, may be essential for combating global warming and for saving lives worldwide. But for countries that own and sell them, they are a global market opportunity. Only when the two interests are reconciled—through, say, adequate public financing—will fair implementation of the TRIPS agreement become a real possibility.

Policy—not charity—to build technological capacity in developing countries

Global arrangements can only be as effective as national commitments to back them. The first step is for governments to recognize that technology policy affects a host of development issues, including public health, education and job creation.

There are many successful examples of international corporate philanthropy involving technology. For instance, in-kind donations by pharmaceutical companies have saved many lives, and the agreement to give poor farmers access to vitamin A–enhanced rice could help reduce global malnutrition. These initiatives have tremendous appeal—they can be a win-win proposition in which a country gets access to vital new technologies and a company get good public relations and sometimes tax incentives.

But these kinds of industry initiatives are no substitute for structural policy responses from governments. High-profile projects may gain such support from industry, but less newsworthy research cannot depend on it. When HIV/AIDS drugs and golden rice are no longer in the news every day, will Chagas disease and mosaic virus–resistant cassava motivate the same global public support?

Developing countries should not forever be held hostage to the research agendas set by global market demand. If any form of development is empowering in the 21st century, it is development that unleashes human creativity and creates technological capacity. Many developing countries are already taking up the challenge to make this happen. Global initiatives that recognize this will not only provide solutions to immediate crises but also build means to cope with future ones.

The ultimate significance of the network age is that it can empower people by enabling them to use and contribute to the world's collective knowledge. And the great challenge of the new century is to ensure that the entire human race is so empowered—not just a lucky few.