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A framework for a common vision for the future contribution of science and technology for development: elements of change and possible responses

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Preface

The objective of this contribution[1] is to describe the framework within which a common vision for the future contribution for science and technology for development may be formulated. Given the multitude and complexities of issues relevant in this context, the paper is set out in a sketchy fashion to stimulate discussion rather than to fully cover each aspect. Beyond the elements of change that rule today=s world, this paper indicates some of the aspects which the common vision may contain. The reader is also referred to the work of the Panel on a common vision established by the Commission on Science and Technology for Development (CSTD) and to related documents prepared under this item for the Commission=s fourth session and on which the consultant has drawn.[2]

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[1] The views expressed in this paper are those of the author and do not necessarily represent the views of the UNCTAD secretariat. The paper is reproduced without editing.

[2] See UNCTAD (1999), *Expert group meeting on a common vision for the future contribution of science and technology for development: Summary report by the UNCTAD secretariat* (E/CN.16/1999/ Misc. 1); UNCTAD (1999), *A common vision on science and technology for development: A note by the UNCTAD secretariat* (E/CN.16/1994/4); UNCTAD (1999), R. Engelhard, L. Box, *Making North-South Research Networks Work. A contribution to AA Common Vision for the Future of Science and Technology for Development@* (E/CN.16/1999/Misc.5). Additionally, for data on trade and investment the author used such UNCTAD publications as *the Trade and Development Report and World Investment Report* and for data on education, the UNDP publication *Human Development Report*, for different years.

I. THE CHALLENGE OF CHANGE IN A GLOBALIZED WORLD

Globalization, reflecting the combined effects of technological change, liberalization, and growing competitive pressures have altered the context for thinking about the role of science and technology for development from what it was in Vienna in 1979. The revolution in microelectronics and communication has transformed the way in which society=s relations are structured. The best practice rules for organizing production are no longer those first laid down in the factories of Henry Ford. In the industrialized countries employees are increasingly multi-skilled and organizational structures are becoming less hierarchical and more de-compartmentalized. Instead of straightforward contractual relationships between clients and sellers there is a growing tendency to cooperate on many levels. Professionals, skilled and semi-skilled personnel are choosing to earn their living at home, as enterprises of all sizes are beginning to find it profitable to engage in subcontracting and outsourcing of a part of their activities. Central to these trends is the vastly increased knowledge content of production, distribution and consumption of goods and services. Moreover, it is now recognized that the building of technological capabilities is not a linear process that proceeds sequentially from the importation of foreign technology, followed by its absorption, assimilation and mastery, leading through Research and Development to new product and process innovations. It is messy, iterative, experimental - involving learning, correction of mistakes, feedback loops, cooperation between design, engineering and marketing functions and between suppliers and customers. The ability to acquire knowledge, to put it into new uses and to solve a succession of never-ending new problems is replacing pure cost of production as the crucial element in the competition for markets as we approach the 21st century.

The knowledge-based mode of competition is part and parcel of the widening and deepening of international trade, finance and information in a single, integrated global market. Underlying the concept of globalization is a concerted effort to liberalize national and international markets in the belief that the free flow of trade, finance and information will accelerate economic growth and improve well-being.[3] But not everyone stands to share equally in these benefits. In part this has been because liberalization has been applied selectively. There has been no liberalization of the global market for unskilled labor as there has been for exports and capital. Nor have agriculture and textiles - on which developing countries are highly dependent - been fully freed from subsidies and trade restrictions. The overwhelming gains to the global economy as a whole mask projected losses for certain parts of the world from the trade agreements - notably, the least developed countries (LDCs)[4] and Sub-Saharan Africa[5]. Poor countries whose share of world population has been on the rise have not experienced a significant increase in the share of world trade. The rising shares of Asian countries as a whole are offset by declines in other regions and groupings, such as the LDCs. The flow of finance has also been uneven. In 1997, 58 per cent of foreign direct investment flows went to the United States, European Union and Japan. Of the 37 per cent received by developing countries, 21 per cent was accounted for by South, East and South-East Asia and scarcely more than one per cent by Africa. In so far as

[3] Thus the overall increase in global income resulting from the efficiency and trade expansion effects of the Uruguay round of multilateral trade negotiations concluded in Marrakech has been estimated at between $212 and $510 billion 1995 and 2001.

[4] Which stand to lose up to $600 million.

[5] Which has been projected to lose $1.2 billion over the same 1995 to 2001 period.

investment brings with it skills and knowledge, a large part of the world=s population, especially women, is excluded from this source of technological progress. The implications for human poverty, which has been growing in absolute terms, and for environmental degradation is disturbing. Inequality is also on the rise. Statistics relating to nutrition, medical care and education testify to the growing gap between rich and poor both within and between countries.

The skewness of the flows of foreign direct investment (FDI) and of their corresponding social impact is due in large part to a lengthy combination of well-known factors - domestic and external - that chronically afflict developing countries and deter trade and investment. Among the former are poor macroeconomic policies, over-protection of local producers and insufficient resources for investment in people and in infrastructure. Among the latter are biases in the international trading and financial system which work against developing countries. In addition to the biases already noted, developing countries are highly vulnerable to external shocks originating from commodity price instability, high volatility of financial flows and natural and man-made catastrophes.

Although these asymmetries in the distribution of benefits from globalizing change are not likely to disappear overnight, their importance will diminish for those countries that manage to put themselves onto the path of sustainable economic growth and development. Central to development is production. A major issue for the 21st century that should be stressed, therefore, is how science and technology can be made to contribute effectively to the capacity of developing countries to produce goods and services. One of the problems with the reform agenda introduced by the IMF over the last two decades is precisely its failure to give serious attention to the supply side in its attempt to revive depressed sub-Saharan economies. There is a virtuous circle between enhancing the capacity to supply, mobilizing savings and investment and accelerating economic growth. Growth in turn generates the resources that governments require in order to give attention to meeting the basic needs of their people, diminishing social unrest and achieving social justice.

A. National systems of innovation

There are various ways governments have responded to the trend towards globalization and liberalization. One of them has been to develop national frameworks through integrated Asystems of innovation@ involving different Astakeholders@ of society.

Within a country the term Anational system of innovation@ (NSI) has been designated to characterize the network of institutions and public policies that shape firms= investment and innovative behavior. Governments do not necessarily set out consciously to create an innovation system - that is, a fully articulated set of institutions and policies towards investment in science, technology and innovation. But depending on its historical pattern of specialization and evolution of its enterprises, economic structure, and type of political institutions each country will have its own unique NSI. While in some it is adequate to satisfy the needs of an increasingly knowledge-based economy, in others, the direction and quality of its activities are unable to meet the society=s new and increasing demands.

Some of the stylized shortcomings of the NSI in developing countries that will need to be addressed in the early years of the coming century are: (1) lack of a clearly defined set of objectives for the development of science and technology (S&T) and for innovation; (2) absence of the integration of S&T in the country=s development policy objectives; (3) lack of networks of S&T institutions (such as universities, research institutes, standards institutions); (4) isolation of the preceding from the productive sectors of the economy; (5) insufficient horizontal

coordination between the main areas of public policy - fiscal and monetary, foreign investment, intellectual property, competition, trade, agricultural and industrial development, environment, health, etc. - that may be inter-related with investment in S&T development; (6) insufficient vertical coordination between S&T policies at the national, regional and community levels; and (7) failure of government decision makers to consult with or secure the participation of all main actors - such as government agencies, business, academia, science and technology institutions, consumers, labor and civic groups - in the formulation and implementation of S&T and innovation policies.

What this means is that whereas, on the eve of the new millennium firms in industrialized countries are increasingly imbedded in an interactive network of policies and institutions that promote competition, organizational change and the development of human resources, firms in most developing countries float in isolation from the articulated, trust-based relations and inter-activity required for innovation. How to re-shape the NSIs to meet the need for innovation and learning will be a major concern of their governments in the years ahead. This report reviews the main challenges they face in a selected number of specific areas of policy, including the social dimension, and advances a common vision of how to address them in the years to come.

B. Research and development

Part of the key to the ability of firms to innovate is a capacity for R&D and access to a well-trained labour force. R&D activity in the developing world is not up to meeting the challenges of the new millennium. In quantitative terms, disparities between country groupings in spending on R&D are greater than for per capita income. The relatively poor performance of developing countries is also reflected in patent statistics. Apart from this, a number of qualitative weaknesses characterize the R&D systems of most developing countries including, most notably, the fact that most of the R&D is publicly funded and the private sector does little itself (although its performance is improving) and that the public-sector R&D taking place has been insufficiently oriented to the needs of the productive sectors of the economy. On the eve of the new millennium the significance of this situation is not so much that developing countries are stillcontributing comparatively little to advancing the frontiers of knowledge but that R&D capacity will be increasingly essential to firms= abilities to keep up with global technological developments, access sources of existing scientific and technological information and expand their knowledge base through participation in joint R&D activities with other firms.

Developing countries= low level of participation in global R&D has the further consequence that the particular kinds of problems that they face **B** both in the productive sector and in the social sectors - do not get addressed. With the growing privatization of R&D and orientation of academic research in industrialized countries towards the needs of corporations, developing country problems do not attract interest unless they are of a size that can generate sufficient profits to justify the R&D investment. The innovations produced by the TNCs cater to the life styles and purchasing power of consumers in industrialized countries and are based on cost structures, climatic conditions and resource endowments of those rather than developing countries. Moreover, traditional adaptations to some of these factors which could benefit from upgrading risk disappearing because of neglect.

C. Education and training

Firms and countries that succeed in coping with rapid globalizing change will be those whose work forces can learn new skills and acquire new competencies to cope with emerging problems and challenges. The key to acquiring, adapting, spreading and creating knowledge is education. The importance of education extends beyond the firm to society as a whole, to the

family, community and nation. Basic education increases peoples capacity to learn and to interpret information. Although developing countries have made notable progress in reducing illiteracy, the lag with industrialized countries is still substantial.

Gender-related discrepancies in literacy and levels of education generally persist. The adult literacy rate for females in least developed countries was still only 35 per cent in 1994 compared with 57 per cent for males in those countries and 98 and 60 per cent for females in industrialized and developing countries respectively as a whole. The role of women in the social spheres of health and nutrition and in agricultural production and in the informal economic sectors is overwhelming. The gender gap in basic education constitutes a formidable obstacle to the improvement of human welfare and to narrowing the development gap in the 21st century.

As crucial as it is, basic education is not sufficient. To build up the labor force that will be needed in the years ahead to keep up with the constant stream of technological advances which compress product cycles and make knowledge obsolete also requires higher education and technical training. Apart from teaching new skills, higher education creates the pool of engineers, managers and scientists who can monitor and assess technological trends and help to develop appropriate national technology strategies. Here too developing countries face a challenge to educate and train the highly qualified, multi-skilled personnel for solving the wider range of problems in the information age that has dawned. And here as well the gender gap will be a critical obstacle to be overcome in the early years of the next century.

D. Making markets work better

The debate on the role of the state in the economic development that has taken place in the latter half of this century has made us realize that while attention to price signals and the maintenance of a semblance of price stability are essential to growth, there remains a need for institutions and policies in order to make markets work. In particular, state intervention will continue to be important in reinforcing the kinds of incentives needed in order to maintain a high rate of investment in capital formation and innovation in the new millennium. Innovation is the bringing of new goods and services, processes and forms of organization into productive use. Investment and innovation are the primary determinants of growth of all economies. Today, both of them take place primarily in the profit-seeking enterprise, a trend that is unlikely to reverse itself. But in a world of constant product turnover, instant communication and rapid technological obsolescence, to remain profitable and survive, firms must compete. Competition means sustained investment in best-practice production methods, new modes of organization and, above all, in the development of its human resources. Managers may argue that the decisions connected with such investment should be left up to them, depending on the signals emanating from the market place. Pressures from the market are the main incentive to invest in change. But the state has a major function to fulfill in ensuring that the pressures are being produced by markets and perceived by firms, by eliminating or mitigating market imperfections. The role of the state in the 21st century will be to devise policies and institutions to facilitate investment in learning and adaptation to change and to provide for those members of society - such as women, the infirm and the rural poor who may be excluded from the benefits of such investment.

E. International Trade

Given their more limited human and material resources, developing countries and their enterprises have fewer options than industrialized counterparts in choosing between investment in the expansion of the domestic knowledge base and tapping into knowledge developed elsewhere. As the liberalization of trade and regulatory regimes in many countries and falling transportation and communications costs make the world more interconnected, acquiring imported knowledge through international trade in goods and services, FDI, technology licensing, partnerships, networks and other means seems almost limitless. And yet developing countries face challenges in tapping into these flows. As the industrial accomplishments of the East Asian NICs since the 1960s and 1970s have demonstrated, international trade can contribute to technological development in a number of ways. Through information supplied by buyers and sellers, trade increases awareness of the constant improvements in ways of doing things. Measured exposure to competition from imports encourages efforts to meet global standards of quality and design. Competition in export markets drives firms to master the complex of human skills associated with organizational, marketing and design competence. Exports give scope for achieving economies of scale beyond what is possible in domestic markets. Growing export receipts contribute to the mobilization of foreign exchange and savings that can be used for investment in new equipment and other imported inputs embodying knowledge from other parts of the world. But as was pointed out above, not all developing countries have been able to participate in the expansion of international trade associated with globalization, in part because of underdevelopment itself and in part because of persistent biases in the international trading system against the agricultural and labor-intensive exports in which many of them have a competitive advantage. Increasing resort to anti-dumping and safeguard measures are creating barriers even to exports of more sophisticated products in the electronics sector in which a number of developing countries have sought to gain a foothold. Ways will have to be found to overcome these and other impediments to trade if developing countries are to be able to share more fully in the benefits of globalization in the next century.

F. Foreign direct investment

The leading role that large transnational corporations play as leaders in innovation makes them an important potential source of knowledge to developing countries wishing to keep abreast of changes taking place in the global economy in the 21st century. Two important, interrelated issues stand out. First, most of the FDI going to developing countries is concentrated in only a few of them, whereas least-developed and lower income countries generally - especially south of the Sahara - have been unable to attract it to any significant extent. Secondly, with the dramatic rise of FDI flows in recent decades, municipalities, regional authorities and national governments have been engaging in ›bidding wars‹ - vying with each other to offer the best terms and conditions - to attract TNCs to their territories. With regard to the first point it appears that TNCs are deterred from investing in many developing countries quite simply because of more profitable opportunities elsewhere - in dynamic, rapidly growing markets with good communications and transportation infrastructure, political and economic stability and access to low cost resources. Even when these conditions are present, TNCs' decisions to site their production in particular locations are also influenced by long-term strategic considerations such as market positioning, exploitation of firm-specific assets and inter-affiliate division of labor. As many countries have discovered over the last few decades, liberalization of foreign investment regimes may be a necessary but not a sufficient condition for attracting inward FDI. This raises the second point relating to competition between countries to entice TNCs to locate facilities on their territories. The main purpose of such locational ›tournaments‹ for FDI is to create local jobs. Competition for FDI takes the form of capital grants, reductions and exemptions from taxes, funding of training activities, subsidization of equipment purchases for R&D, reduced energy and land charges and exemptions from employers' social charges. There is a question as to whether the purported employment and other benefits can be covered by the social costs of the incentives offered by the governments and agencies trying to attract these investments. This is particularly relevant to developing countries that are likely to be drawn into these tournaments in the hope of benefiting from globalization, and are less able to afford the costs.

G. Intellectual property rights protection

The transfer of technology through licensing of patents and know-how can be an important channel for gaining access to proprietary technology in the next century. The learning that takes place from using more advanced technology can contribute to closing the knowledge gap and preparing developing country firms to adapt to global technological change in the 21st century . The cost of licensing and the terms and conditions of transfer of technology agreements may be influenced by a country's regime for the protection of intellectual property rights (IPRs). Protection of IPRs through the granting of monopoly rights for their exploitation is considered an important condition for the promotion of invention and creative activity. It is also a necessary condition for obtaining the willingness of TNCs as IPR holders to license their patents as well as to invest capital in technology importing countries. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) which came into force as part of the WTO agreement, set forth minimum international standards for the protection of IPRs. Signatories to the Agreement are obliged to revise their national legislation to make it conform with the strengthened standards. Such a revision, however, must take into account the opposing interests between IPR holders who are located mainly in industrialized countries and IPR users many of whom are located in developing countries. Whereas the exploitation of monopoly rights may permit IPR holders to obtain higher royalties and other compensation than under competition, such benefits are at the expense of users, and ultimately consumers who will have to pay a higher price. The way in which developing countries implement the Agreement, which many will already have to have completed by the year 2000, may have strong implications for their access to and use of proprietary technology and for their economic and social development. Unfortunately, most developing

countries still lack the expertise in drafting legislation and modifying policies to fit their own needs in striking an appropriate balance between encouraging the future production of knowledge and the free flow of information. One important area in which the TRIPS agreement has generated debate is in relation to drug patents. On the one side are those who argue that the increased protection of pharmaceutical innovations through patents should lead to a greater flow of technology transfer and FDI to the benefit of developing countries and to the development of a wider range of better quality products internationally. On the other are those who suggest that the prices of patented drugs and the amount of payment royalties will increase with the strengthening and prolongation of the patent holders= monopoly written into the Agreement, and that pharmaceutical TNCs will be free to export finished or semi-finished products instead of transferring the technology to investing in developing countries. Moreover, with the elimination of non-patentability of pharmaceutical products (as distinct from processes) under the Agreement, developing country firms would no longer be permitted to deepen their knowledge through investment in reverse engineering. Thus, public health may very well be one area in which those living in poor countries could suffer adversely from globalization in the next century. The extent to which developing countries will be able to implement the reforms required under the TRIPs may determine whether some of these potentially adverse effects in the field of public health can be mitigated.

H. Partnerships and networking[6]

In response to increasing competition associated with globalization, rapid obsolescence, short product cycles and the rising costs of many types of R&D and other in-house sources of knowledge, firms have increasingly given consideration to a broad range of external sources for obtaining access to technologies that they need for conducting their manufacturing and services activities. New forms of partnership among firms and between firms and R&D organizations and academic institutions have emerged worldwide. Such arrangements offer a means of engaging in new forms of technology cooperation involving two-way relationships and an attempt to share knowledge and collaborate on R&D as well as on training, manufacturing and marketing. Through this collaboration firms are able to benefit from the particular knowledge, skills and experience that has already been acquired by their partners, be they domestic or foreign. The collaboration may be vertical - that is, taking place along the chain of activities that go from the accessing of raw materials, through distribution and provision of after-sales service; or it may be horizontal - that is, involving the pooling of knowledge and skills between firms producing the same good or service.

A number of observations have emerged from the experience to date with technological partnerships. First, they are for the most part confined to industrialized country partners, although the number of developing country participants, particularly those from the more advanced developing countries, is growing. The most important single example of partnerships between industrialized and developing countries are those involving outsourcing arrangements between electronics firms in industrialized countries (mainly the United States and Japan) and

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[6] For more detailed coverage of this topic, see also UNCTAD (1999), *Working Group on Science and Technology Partnerships and Networking for National Capacity-Building: Report by the UNCTAD secretariat* (E/CN.16/1999/2) and the above paper by R. Engelhard and L. Box.

components suppliers in East Asia where the level of technological capabilities is quite high. Another area that will continue to be of growing significance in the years ahead is outsourcing of software. Others include pharmaceuticals, chemicals and automotive industry. Secondly, the nature of the partnerships between exclusively industrialized country participants and those involving developing country firms differ. The former have tended to be of a more strategic nature, aimed at achieving important competitive breakthroughs in the development of new products or processes; whereas the latter have been confined primarily to the achievement of improved productive efficiency with existing technologies. Thirdly, firms in developing countries wishing to attract partners must have a minimum level of managerial, marketing and technological capabilities and operate in stable economies with a reasonably well-functioning business support system.

Partnerships in the 21st century will remain an effective mechanism for decreasing the isolation of SMEs in developing countries by creating access to knowledge from the outside. Like partnerships, networks are also a form of cooperation that is expected to increase in the next century. They differ from partnerships in that they involve multiple participants B and quite often individuals as well as firms and other types of organizations. Clusters, are a network of firms in geographical proximity to each other. As experience in a number of developing countries has shown, simply bringing firms in proximity with each other and with local support structures such as productivity centres, university research laboratories or standard-setting bodies will not guarantee that closer interaction between them will necessarily emerge. Yet it is precisely this interaction that will be needed to generate the kind of networks and partnerships that lead to innovation, stimulate productivity increases and sustain competitiveness.

I. Information and communication technologies

Advanced microelectronics-based information and communication technologies (ICTs) are at the heart of the economic and social transformation that has been taking place in both industrialized and some developing countries during the last two decades of the 20th century. Underlying this transformation are the expansion of computing power, the declining cost of transmitting information and the convergence of telecommunications and computing. The information technology market has been growing at a rate several times faster in real terms than world GDP. In the years ahead, developing countries will be in a position to take advantage of the new ICTs in increasing the spread of information. A few have already begun to ›leapfrog: the industrial countries by installing fully digitalized networks which require less investment than traditional wire-based systems and which are more cost-effective in harsh climates, sparsely populated zones and difficult terrains. The opportunities for benefiting from ICTs in the 21st century are quite significant. In the field of education they permit adults, including women, who never received an adequate education in their youth to make up for lost time at their own pace, while some costs in schools and universities can be lowered by sharing of educational materials through E-mail and over the Internet. The ICTs give opportunities to governments and NGOs to have greater access to women and to the poor in their programmes, including public health campaigns, specifically tailored to them, while empowering them to participate in their design and implementation. With access to the new ICTs, farmers and other small businessmen or businesswormen in remote areas can keep themselves up to date on prices and market opportunities. Finally, the opportunities for increasing inter-connectedness and knowledge-sharing through the promotion of partnerships and networking involving developing country firms, people and institutions can also be significantly enhanced through the deployment of the new ICTs.

The lion:s share of the growth in use of the new technologies has been in OECD countries. Although use of ICTs in developing countries has also been growing rapidly it remains low for the majority of them, where the number of personal computers and telephones per capita is a fraction of what it is in the OECD countries. The most frequently cited obstacles to a more rapid

diffusion of ICTs include low incomes and purchasing power, lack of training in the ICTs (low computer and Internet literacy) and weak infrastructure as well as competitive and regulatory environments as regards telecommunications in particular. These are the kinds of problems needing to be addressed if developing countries are to link into the vast opportunities for increasing the knowledge base of their populations through the exploitation of these new technologies in the 21st century.

J. Biotechnology

Biotechnology is one of the leading technologies of the future, opening new ways of exploiting knowledge of live biological material for a wide range of applications of benefit to humankind. It is the findings of molecular genetics that have given a boost to modern biotechnology since the 1970s. Applications in medicine include genetically produced drugs, products for medical diagnoses, vaccines, and techniques for identifying predispositions to certain diseases. The major ongoing project is to decipher the entire genetic make-up of the human being by the year 2005. The Human Genome Project, as it is called, is of enormous importance in pointing the way to the causes and, therefore, the treatment of many illnesses in which the patient=s genetic predisposition is involved. Biotechnology can also make important contributions to better treatment of infectious diseases such as AIDS or malaria through research on the molecular details of the interaction between the pathogen and the host.

In addition to medicine, modern biotechnology is mainly used in food production and processing. This includes primarily the development of vaccines and diagnostic tools for the enhancement of animal health, the production of disease-free planting material for horticultural crops and the achievement of modified plant quality, resistance to weed killers, resistance to pests and modified agronomic characteristics.

The development, introduction and diffusion of biotechnological innovations in developing countries offers a great potential to improve health conditions and expand the food base in developing countries. However, there are important issues to resolve concerning the ability of developing countries to benefit. Compared with innovations in the fields of chemical or mechanical engineering, advances in health and agriculture are not readily transplanted from one locale to another without considerable investment in adaptation to the unique natural and human environments in the host country. Lacking sufficient research scientists, infrastructures and resources for carrying out adaptive R&D, developing countries are handicapped in re-orienting their health care systems and expanding their plant and animal breeding capacities for applying modern biotechnology to the management of local diseases and pests. Moreover the relative decline in public funding of medical and agricultural research and the tightening of IPR legislation under the TRIPS agreement, may mean a diminished access to the genetic materials used as inputs to research in developing countries in the years to come.

It should be noted that there are complex legal problems concerning the exploitation of biotechnology and access to genetic materials that will need to be considered in the early years of the 21st century. One thing that biotechnology innovations all have in common is that they are derived from living matter. Historically, living matter was not considered patentable because of doubts as to whether it could satisfy the conditions that had to be satisfied by industrial inventions - namely that they be new, involve an innovative step and be capable of industrial application. The advances in knowledge of biological processes involving the fundamental components of living plant and animal material since the 1970s, however, have meant that modern biotechnological innovations have taken on the character of inventions in a similar sense to inventions in applied chemistry and physics. The United States, Japan and the European Union have led the way in adopting policies which, in different ways, allow for the patent protection of DNA and other genetic information contained in natural living matter. Genetically modified plants and animals, as well as parts from them, are now also patentable in many jurisdictions, often on the basis of

broadly defined claims. Private firms have in some instances succeeded in obtaining patents on products known and used for a long time by local and indigenous communities or on other resources collected in developing countries. On the other hand, despite specific provisions in the Convention on Biological Diversity, the implementation of the principle of sharing of benefits of genetic resources with the countries in which they originate, including scientific and technical knowledge associated with their use, is still largely unresolved.

More generally, where to draw the line as to what types of living matter or innovations derived from it deserve IPR protection will require considerable thought and reflection in view of the implications for the creation and dissemination of biotechnological innovations, for the preservation of biological diversity and for access to scientific knowledge in this domain. These are all questions that will need attention in the early years of the new century.

K. Impact of tomorrow=s technologies B Some critical issues

Whether driven by the pull of market forces or pushed by intellectual curiosity the ever-expanding cornucopia of new technologies in the late 20th century is generating enormous opportunities for the creation of wealth and for improving peoples= lives throughout planet. The changes, because of their speed and broad sweep of their sectoral and global impact are also posing complex problems for society. One of these, already discussed above, is the uneven access to the benefits of scientific advance and technological change. Among the many other types of issues relating to the impact of science- and technology-driven change on society, three are singled out for attention here. They are environmental degradation, the risk of technology >failures=, and challenges to moral and ethical values. As technologies have developed, the range of resources that can be exploited has widened and some technologies are used in ways that are unsustainable, not only in environmental but also in social terms. The proliferation of new techniques and the ever-increasing knowledge content of goods and services has reduced human control over the production system, making society more vulnerable to technological breakdowns. With the expansion of human knowledge come troubling questions about how it should be applied or whether it should be applied at all. The revolution taking place in ICTs and in biotechnology brings out the importance of these and related issues for scientific and technological development in the 21st century.

As the quantity of information and speed with which it can be handled increase, people=s consumption of an ever-larger proportion of basic services will depend on computers, networks and the software that drives them. The crashing of one small part of the system can bring to a standstill a large amount of activity. Highly vulnerable to catastrophic breakdowns and intentionally debilitating acts of sabotage are electric power grids, transit systems, air traffic control infrastructure, hospitals and water treatment facilities. The breakdowns could in some instances have adverse effects on the natural environment. Given their chronic shortage of qualified managerial, scientific and technical personnel, developing countries that do achieve some measure of progress in computerization will be the most vulnerable to such breakdowns in the next century.

Biotechnological innovations also have a destructive potential that can be powerful and difficult to control particularly as regards the environment. A case in point is the development of crops resistant to insects or which are able to tolerate herbicides. From an economic point of view, the rationale for such crops are the enormous annual losses in global food production on account of insect damage and the high cost of keeping weeds at bay. In so far as the planting of such crops increases agricultural productivity it may also be environment-friendly by reducing the plowing up of the world=s few remaining wild lands. Not surprisingly, the total acreage of engineered plants - cotton, soybeans, corn, rape seed, and potatoes - has been growing by leaps and bounds, particularly in the United States. There are, however, a number of difficulties which if they remain unresolved, could have potentially severe consequences for the environment and for

food production in the 21st century. Experience has shown that some engineered plants are capable of spreading herbicide resistance to surrounding weeds, thereby creating the risk of creating superweeds that would be costly to control. Insect-resistant plants have been known to kill not only targeted insects but also beneficial insects that normally kill plant pests. The recent development and patenting of herbicide-resistant seeds in which a gene has been inserted that makes the second generation of the seeds sterile is one answer to the promiscuity of herbicide-resistant plants. More important from the point of view of the company marketing the seed, is the fact that since the farmer is thus prevented from saving and re-using the seed the company is able to make more profits. On the other hand, the introduction of this technology in important food crops such as corn, wheat and soy beans, could create a threat to food security and the sustainability of agriculture, especially in the absence of mechanisms for monitoring the effects of dissemination of the trait in such crops. Given the more fragile environments, managerial shortcomings and poor transport and marketing systems in developing countries, the potential adverse effects there could be even worse. In more general terms the fragmentary knowledge of what genetically engineered crops might do to ecosystems or - if consumed over a long enough period of time - to human health, makes their production a risky business which calls for further research and reflection.

Social, ethical and moral issues are particularly troublesome in connection with applied research in biotechnology. The most dramatic potential benefits for modern biotechnology are in the field of medicine, some of which have already begun to be realized. Since the conception of the first baby in vitro in 1978, for example, more than 200,000 children have been born as a result of this method which has also contributed to the happiness of many mothers and fathers unable to reproduce naturally. Continued progress in assimilating this and other biotechnology advances into obstetrics has made it possible to screen for genetically inherited diseases in the implanted embryos and to detect and even determine sex and an increasing number of other desired traits such as hair and eye color in one=s progeny. Biotechnology is already assisting in the diagnosis of disease. With the eventual isolation of all of the genes of the human body, it is expected sometime in the next century to become possible not only to predict in advance the onset of heart ailments, Alzheimers and other diseases, but also to detect, prevent, treat and ultimately cure them. A large number of ethical, biological and social questions is emerging in the wake of such discoveries which seem to be giving human beings power over what previously belonged to the realm of nature. A sample would include, for example, whether assisted reproduction should be guided principally by the rights of children or the rights of parents to have children; what should be the limits if any to the use of created human embryos for research; the risk of turning women=s bodies into instruments for the production of commercial commodities; the danger that new forms of discrimination could in a subtle way grow out the idea of designating some genes as being pathogenic; and the right to privacy and the fair use of genetic information.

To a great extent, these kinds of social and ethical issues will be relevant to a wide range of countries in the 21st century. It should be noted, however, that vast segments of the female population of child-bearing age are without access to primary health care, especially pre-natal care (that has also found to be an important component of birth control programs). From a social perspective, therefore, one may question whether elaborate programmes of medically assisted procreation and the ethical questions associated with them will not be a luxury in poor countries where resources will continue to be desperately needed for prenatal and maternal health care.

Equally important are various social, ethical and moral issues associated with the development and use of ICTs and biotechnology. How they are going to be resolved in the next century will depend very much on the historical and cultural context. Hence, while sharing knowledge with one another, each country - developed and developing alike - will have to find its own way. There are three main concerns regarding ICTs. First, by abolishing geographical distance ICTs, especially the Internet, have the capacity to bring people together that would otherwise have been remote from one another. At the same time, they are relegating to oblivion

existing people-to-people contacts of the kind that have been traditional within given localities - at the workplace and in neighborhoods, shops, schools and doctors' offices. Whether on balance these two tendencies will make for greater conviviality or lead to social alienation and exclusion

will affect the rate of diffusion of ICTs and the benefits that they will bring. Second, is the question of whether individuals and organizations will be able to cope with the vastly increased access to knowledge made possible by the ICTs or whether some - especially those with less education - will simply be overcome by Ainformation overload.@ Thirdly, there is the very real risk that the spread of ICTs will make it easier to violate peoples= basic privacy or civil rights and to engage in criminal activities such as fraud and theft.

II. TOWARDS A COMMON VISION

The above discussion leads to a number of issues that should be part of any ACommon Vision for the Future Contribution of Science and Technology for Development@. These issues are being outlined in the following chapter; this is again done with the purpose of stimulating discussion of the CSTD rather than fully addressing each issue.

A. The global entitlement to knowledge

As we approach the new millennium, individuals, firms, governments and society in general are facing a challenge in finding how best to respond to the pressures imposed by the acceleration of technical change and increasingly fierce competition in a globalized economy. The central question that the CSTD wishes to address is what needs to be done to build the capacity in developing countries to adapt to the twin challenges of competition and constant change. Given these pressures, the key to successful adaptation is knowledge B the combination of skills, learning and ability to use information. We focus on a particular sort of knowledge that is fundamental for developing countries, namely science and technology. The CSTD is committed to the common vision of a global entitlement to scientific and technological knowledge. Let us look at what this means. It means, on the one hand, universal access to information embodied in the written word - instructions, explanations or descriptions of processes and ways of doing things, including intellectual property as well as in machinery and equipment which has been called codified knowledge. It means, on the other hand, access to the ability to use such information effectively, to organize knowledge-using and knowledge-generating activities to make life better and more predictable which has been called tacit knowledge. Increased economic growth and expanded international trade and capital flows do not necessarily translate into >development= unless in addition every child, including every girl-child, has access to benefits of science and technology such as better nutrition, shelter, clothing and medicines and to improved basic understanding of its surrounding environment. The vision of a global entitlement to science and technology aims at sustainable development in the largest sense of economic, ecological and social sustainability. Economic sustainability implies investment in the future to maintain the stock of capital and achieve a rate of economic growth sufficient to give future generations a standard of living at least as good as that enjoyed by the present generation. It also implies sufficient investment in learning, R&D and human resource development today - to maintain or increase the ability to withstand future competition and adapt to change. Ecological sustainability is the maintenance of the carrying capacity of ecosystems, the protection of species including biological diversity and the conservation of natural resources. Social sustainability means doing something about disadvantaged firms and people, especially women, who are less able to adjust to globalizing change - through redistributive policies or, more importantly in the long run, by focusing science and technology polices on building up their learning capabilities. Thus, giving expression to the principle of global entitlement to science and technology for development in the 21st century inevitably points to the formulation of policies and establishment of arrangements that safeguard and protect the interests of all people on the planet including those of the yet unborn.

B. A framework for policy

The experience of countries as different as the United States and Japan and the Republic of Korea and Chile has shown the importance of the state in providing a framework of policies, institutions and guidelines for the promotion of science and technology. At a time of rapid global change and growing global interdependence and economic liberalization the state in the 21st century will be called upon to motivate, and interact with a larger number of actors making up the National System of Innovation (NSI) than in the past, including not only stakeholders from the scientific, R&D and business communities but also NGOs and representatives of civil society. Within the NSI the functions of government policy are to show the way forward, to coordinate, and to act at times as a catalytic agent and at times as an instigator. All countries should have a vision or strategy for the development of scientific and technological capabilities in an age of change and competition, in which the enterprise as a leading actor interacts with other stakeholders.

Government intervention is essential for encouraging productive enterprises of all sizes, including SMEs to join partnership and networking arrangements and for creating mechanisms where all stakeholders in science and technology - producers and users alike - can meet and interact. Increasing recognition of the dynamic nature of R&D, both within and outside of the enterprise, suggests the need for taking concrete steps to stimulate greater cooperation among enterprises and between enterprises - including SMEs and TNC subsidiaries - and local R&D institutions and universities. These include, for example, tax write-offs, R&D matching grants, putting a part of R&D institutes activities on a self-supporting basis and the creation of technology incubators and science parks. The growing importance of the private sector in R&D should not permit us to lose sight of the fact that public sector funding is essential for scientific research on subjects dealing with longer-term objectives, particularly where the results are expected to be of humanitarian significance. In a globalized society all participants benefit from international cooperation in science and technology. Developing country scientists and engineers should be given greater opportunity to participate in international networks, especially on issues of global importance such as climate change, biodiversity, and AIDS, with a capacity building component included in order to make their participation more effective. For the non-voluntary contributions that may be required in cash and in kind for the support of such capacity building, a "fairness principle" should be adopted whereby the equitable contribution of each participating country is related to its per capita income.

The growing importance of interaction between the different actors involved with or affected by innovation and change has induced a substantial number of OECD countries to carry out reviews of their NSIs. Analysis of NSIs must of necessity take a comparative perspective, since no two countries are likely to have the same pattern of specialization in trade and production, level of technological development or institutional set-up. UNCTAD, under the guidance of UNCSTD launched similar activities through Science, Technology and Innovation Policy Reviews in developing countries which are now being broadened to cover inter-related investment issues. It is to be hoped that this exercise will strengthen the capacity of participating countries to examine, with the participation of all stakeholders, NGOs and civil society, the effectiveness of their institutional set-ups and policy framework for promoting investment, innovation and change.

C. Investing in people

No single input in a country's NSI is more important to the ability to compete, to attract foreign investment and to move into advanced technologies including information technologies than abundant quantities of skilled labor. Priorities include more investment in higher education with an emphasis on the graduation of engineering and scientific specialists; the promotion of vocational training with the participation and financial support from the private sector; and the elimination of illiteracy. The goal of universal access to basic education for all women is

fundamental, in view of their critical role in education, child care, public health and agriculture and in light of the importance of education in human development. Measures are needed for overcoming the obstacles encountered by women in obtaining university educations, pursuing careers in science and participating in decision-making functions in science and technology. Education is also a priority in order to be able to adapt to the rapidity of technological change and to master information technology, in particular in connection with use of the Internet. Much can be said in favor of the creation of ›community colleges‹ involving the participation of local stakeholders in framing curricula. Such colleges, which have been particularly popular in the United States, are locally run and supported and respond to local needs. More informal than universities and more egalitarian in their selectivity, they provide an affordable means of transmitting marketable skills not necessarily covered elsewhere and an alternative channel for disadvantaged young people to qualify for tertiary education. Moreover, continuing education is a top-order need in today's world in view of the constantly changing requirements for skills and the opportunity they provide for school drop-outs, women and other neglected segments of society to upgrade their qualifications and realize more fully their aspirations. Day care centers and other initiatives which are targeted specifically to women must be part of the agenda in order to increase the opportunities for them to catch up educationally and become a part of the knowledge society.

D. Knowledge through trade

If there is one conclusion that can be drawn from East Asian countries' success in modernizing their economies it is that exporting experience is a highly effective means of acquiring technological capabilities. Countries should not exclude the possibility of their firms entering export markets without prior acquisition of production capabilities if the design and marketing know-how is present or can be accessed from overseas partners. It is not so much open as outward-oriented trade policy frameworks that have been instrumental in permitting firms to enter export markets. Implementation of the WTO agreement needs to be flexible enough to permit a certain amount of infant industry protection of limited duration for industries targeted as having export potential. The rhetoric of trade liberalization that has been directed towards developing countries should not be used to disguise the resort to non-tariff barriers (NTBs) in many western countries, including safeguard and anti-dumping measures. The justification for such measures, if it exists, should explicitly take account of effects on market competition. Since conditions for export-led development are less favorable today than those faced by East Asian
firms in the 1970s, developing countries should envisage not only exporting more technologically sophisticated products for OECD markets but also less sophisticated products for intra-regional markets following the promising examples set by the ASEAN and MERCOSUR trade groupings.

E. Linking into knowledge

Of particular interest in strengthening the capabilities of developing countries, are research networks which permit pooling of resources devoted to research and allow for an improved global access to research results available in the industrialized countries. Individuals and/or their institutes, associate voluntarily in a non-hierarchical relationship to exploit a common interest in exchanging information, render mutual research in research programmes, or in actively collaborating in specific joint research activities. A key feature of these networks is the economies that are achieved because the participating agents do not need to travel as much, sharing information is less costly than through other means such as professional journals, and the contact is more frequent. One of the factors responsible for the growing importance of research networks is the decline of bilateral aid and shift in donor policies away from technical assistance involving transactions between the dominant aid-giver and passive aid-recipient towards collaborative equal research partnerships between participants in the North and South. The fact that participants are

still accountable to the funding agency means that the relationship between them remains asymmetrical, a tendency that needs to be examined in the light of its effect on development. A further characteristic of research networks involving developing countries is their concentration on traditional areas of co-operation, such as agriculture and food security, primary health care, environmental management, gender and social sciences. The question to consider is what conditions will have to be fulfilled in the future to facilitate the participation of researchers from developing countries in the less traditional areas, such as biotechnology and information and communication technologies. This is of some relevance because research by TNCs in the new technologies tends to neglect the special needs and conditions prevailing in developing countries. Moreover accessibility to the results, which are subject to intellectual property protection, is relatively more limited for developing country actors who are unlikely to have commercially marketable proprietary rights to offer in exchange.

Ideally, foreign direct investment should be looked upon as an important channel for obtaining access to capital, the latest machinery and equipment and managerial know-how. It should not be a substitute but rather a complement to domestic efforts to master technological capabilities including the full range of knowledge ranging from that which is needed for planning and executing investment projects to engineering know-how, marketing and ultimately various levels of design capability. But since a minority of developing countries have succeeded in attracting significant inflows of FDI, attention should be given to a number of alternative channels for acquiring know-how from external sources as exemplified by the experience of the Southeast Asian NICs. These include the well-know option of licensing of patented know-how and the use of copyrights. But they also include consultancy assistance in such areas as project preparation, engineering, design, marketing and management which can be obtained at zero or low cost from machinery and equipment suppliers, component suppliers and customers. As already noted in this report, there has been a proliferation of various types of international linkages between firms that circumvent equity investment in favor of alliances, partnership arrangements and networks for joint research and development, marketing and distribution - many which entail an exchange and sharing of both indigenous and imported know-how. The international community has a role to play in all of these domains by improving knowledge of the kinds of factors needing to be considered in making the host country more attractive to foreign investment and designing measures to improve the knowledge and access in developing countries - particularly of small and medium-sized enterprises - to the various alternative channels for sourcing technology. For example, the potential for different forms of technological partnership are worth examining with a view to raising the technical competence of developing country firms, facilitating access to technical information and to information about opportunities for partnerships including the organization of pilot projects involving partnerships that could well serve as models for other partners, and monitoring existing partnerships in order to diminish bottlenecks. It should be borne in mind that the conclusion of any international initiative aimed at promoting the international flow of FDI, must be sensitive to the desire of developing countries to attract FDI in the context of strengthening the technological capabilities and international competitiveness of their enterprise sectors.

F. IPRs and the public interest

The TRIPS Agreement gives signatories considerable leeway in adopting IPR legislation to suit their national requirements in terms of the transfer and development of technology. There are a vast number of areas relating inter alia to patent provisions (such as the concept of ›invention:, criteria of patentability, rights conferred, disclosure requirements and compulsory licenses) and anti-competitive practices associated with licensing agreements, in which countries are given a degree of freedom which they should exploit in adopting their legislation according to their national interests. The World Intellectual Property Organization and the international community in general should offer those governments that need it, assistance in drafting IPR

legislation in conformity with the TRIPS Agreement that is tailored to their needs. At the same time, there is a need for an ongoing review and evaluation of the TRIPS Agreement in the light of its development impact. The issues that need to be examined include: (1) to what extent, by making it more difficulty to carry out what was formerly considered legitimate imitation and reverse-engineering, does the TRIPS Agreement discourage certain types of new innovation, (2) what the trade-offs are between increasing the rewards for innovation and making the diffusion of technology more costly and (3) what industries are most affected. Among the development impacts that need to be seriously considered are those that relate to health, owing to the possibility of TRIPs-induced rises in the costs of medicines. As the coverage of patent and copyright protection expands ever more widely to include even forms of life, and data banks, there is a need to raise the legitimate question of whether the tradition of openness and free exchange of scientific information - so important to scientific progress, from which everyone benefits - is not being threatened. In this connection, although scientists do not oppose reasonable measures to encourage investment in the compilation of commercial databases if a demonstrable need should arise, they do question any attempt to create an absolute exclusive property right in the contents of databases. In so far as the broadening of IPR protection is unavoidable - in light of the trend towards the privatization of R&D - developing countries should also benefit from it. Developing countries have a legitimate claim, therefore, to intellectual property rights of local knowledge that has generated plant and animal varieties particularly suited to local conditions and based not on laboratory experimentation, but on the results of trial and error handed down from generation to generation. In addition, the principle that developing countries should benefit whenever samples of wild plant or animal species are taken from their environments and used in the generation of new or improved varieties, also needs to be formally incorporated into international intellectual property rights protection legislation.

G. ICTs in the 21st century

It is imperative that developing country governments, assisted by the international community, take all possible measures to prepare their citizens, especially young people, to take advantage of the opportunities presented by ICTs. This requires a willingness to open up to the outside world and a commitment to invest in the necessary infrastructure and in schools - both to raise literacy and over-all educational levels of both sexes, as well as to impart the specific skills for making the best use of ICTs. Not everyone can afford a personal computer but following Moore=s law - computer prices should continue to fall until well into the next century. Moreover, the cost of telecommunications is also falling and a number of service providers are already providing free Internet access to comers all over the world. This means that with a relatively few strategically-sited computers governments even now have the possibility of putting vast segments of their educated populations in touch with the world=s intellectual resources and of increasing the opportunity for their scientists and engineers to network with their counterparts within and outside their countries.

H. Biotechnology in the 21st century

The early years of the 21st century should see an increased focus on the generation and use of biotechnology aimed at bringing about sustainable development in medicine and agriculture. Building national capacity in biotechnology is essential. It involves an examination of the role of biotechnology research in NSIs, including the formulation of policies, support for relevant networks and establishment of infrastructure; the integration of biotechnology into existing medical and agricultural research and strengthening of linkages with medical and agricultural research. In medicine there is a specific need to form partnerships between and among private and public institutions from developed and developing countries with the aim of developing and applying biotechnology to the health needs of developing countries. This could take place

through, inter alia, the development of affordable diagnostic technologies and low cost, easy-to-administer vaccines and medicines for combating the major infectious diseases afflicting the people of developing countries, including especially women and children. Similar partnerships are called for in food and agriculture for the purpose of developing and applying biotechnology techniques for the improvement of traditional food crops adapted to conditions in developing countries and which are used as primary sources of carbohydrates, proteins and other nutrients by the mass of the local population.

I. The social perspective

The consequences of any technological innovation can no longer be viewed in terms of benefits to isolated groups or selected organizations but should be assessed in terms of their full economic, social and environmental impact on society at large. Particular importance attaches to effects on the satisfaction of basic needs and on the well-being of disadvantaged groups such as rural women, landless peasants and the elderly. The principle of knowledge entitlement extends to access to information about the potential consequences of new technologies. The scientific community has an important social responsibility to keep the public informed about the nature of such impacts, including the extent of uncertainty over future impacts and the possible risks that they may pose for individuals and for society. As developing country scientists, including social scientists, lack the capacity to carry out systematic, multidisciplinary impact analysis and risk assessment, international cooperation can fulfill a useful function in providing assistance in this domain, including capacity building. There are many science- and technology-related topics that are likely to occupy decision-makers in the early years of the 21st century about which the public has a right to be enlightened and heard. Among these are climate change and the respective consequences of advances in genetic engineering and the diffusion of ICTs. How to slow down global warming and attenuate its impact on different population groups and countries in an equitable manner will have serious implications both with respect to technological and other areas of public policy in the early years of the 21st century. Advances in genetic engineering raise both legal issues concerning the patentability of ›forms of life‹ and serious social, ethical, and environmental issues associated, for example, with the creation of transgenic plant and animal varieties, the use of genetics in predicting and treating disease and medically assisted reproduction. Finally, the social transformations stemming from the spread of the Internet and other ICTs and the possibly increased vulnerability of society to the risk of physical breakdowns of control systems driven increasingly by computers will also have to be confronted. Substantial rewards can be reaped if all those who are affected by policy decisions in the field of science and technology can be made aware of all the implications and consulted beforehand. In this connection, governments should consider establishing appropriate mechanisms similar to that of Denmark‹s consensus conferences in which not only business, government and the scientific community, but also NGOs, representatives of women‹s groups and minorities, and the public-at-large are invited to exchange views on the scientific, social and ethical dimensions of issues of major concern.

J. Policy conclusions

Under a holistic strategy, a common vision reflected in national systems of innovation would encompass three main areas of policies for innovation and change: (1) policies that help create an enabling environment and affect the pressure for change and innovation (general macroeconomic policy and trade and competition policies); (2) policies that affect the ability to accumulate knowledge, adapt to change and innovate (education and training, R&D, technology transfer, intellectual property, procurement and standards and certification policies); and (3) policies that affect the social and environmental dimension of sustainable development (environment and resource conservation policies, income transfers and targeted human resource

development measures for women and other disadvantaged groups). There is a need to coordinate the three areas of policy to ensure that they are not at cross-purposes. Coordination is also necessary to ensure coherence between national, regional and local level policies.

Finally, science and technology and the benefits societies may achieve in applying them are a global concern. While it has been debated if a generic issue like science and technology could be addressed in international relations and related policy at all, it is also an issue that will remain on the international agenda. Thus, many of the conclusions and agreements of the 1992 U.N. Conference on Environment and Development (UNCED) explicitly referred to the need of technology cooperation. So do recent statements made by several states members at UNCTAD in preparation for UNCTAD X. No doubt, a ACommon Vision@ of A1999@ will be different from that of A1979@ which was part of the debate over a new international economic order. On the eve of the twenty-first century, this new vision may aim at ensuring a more balanced participation of all countries in the benefits of science and technology.