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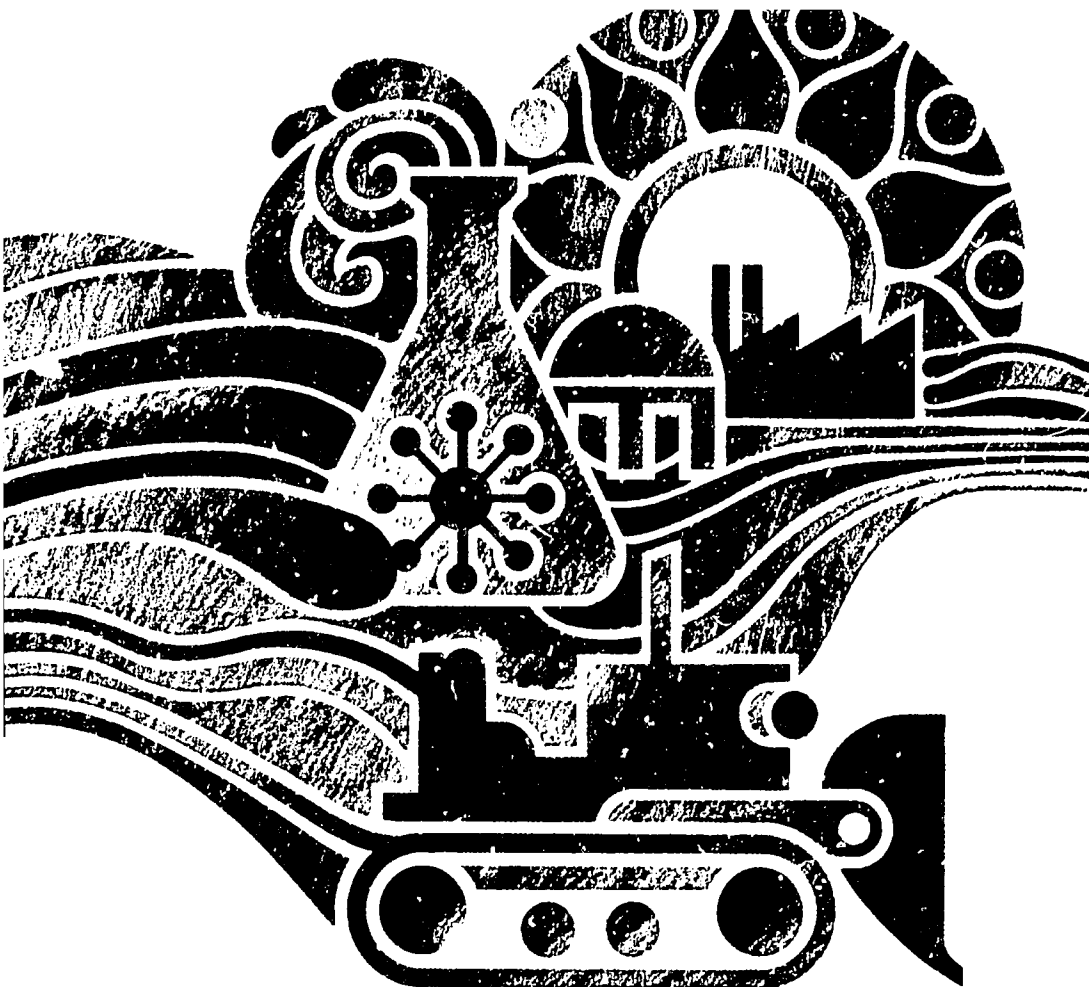
SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

United Nations Conference 1979



U.S. NATIONAL PAPER

For the rest of this century, the greatest potential for growth is in the developing world. To become more self-reliant, developing nations need to strengthen their technological capabilities. . . we can make technical and scientific cooperation a key element in our relationship.

President Carter
March 29, 1978
Caracas, Venezuela

We hope that the U.N. Conference on Science and Technology for Development will focus attention on how all countries can contribute their knowledge to global development. It will be particularly important to find ways for developing nations to enhance their capacity to generate, select, and apply technology for their own development priorities. We will contribute to the work of the conference, and we hope to benefit from it.

Secretary Vance
September 29, 1978
U.N. General Assembly

. . . there is a growing recognition of the importance of science and technology to development. Almost all the problems developing nations face today—those of agriculture, health, environment, resources, industrialization, employment, education and so forth–can be greatly alleviated by the transfer and proper application of new knowledge and technology.

Dr. Frank Press, Director
Office of Science and
Technology Policy and
Science and Technology
Adviser to the President
September 8, 1978

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SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

U.S. national paper prepared for the 1979 U.N. Conference on Science and Technology for Development by the Office of the Coordinator of that conference in the Department of State.

PREFACE

The compelling thing about the world conference that convenes in Vienna next August is inherent in its title: the United Nations Conference on Science and Technology for Development (UNCSTD). Those two words, "for development," are the keys. They mean that the governments of the world will be gathering to discuss science and technology not in an abstract or academic sense but in explicit relation to human welfare.

Science and technology are responsible, of course, for much of the rapid material progress of many societies in recent times. But we also have learned that indiscriminate application of some technologies can cause unintended damage to ecological systems. We have seen too much of the benefits of modern technology distributed inequitably or wasted for destructive and frivolous purposes. And only now have we begun to sense the magnitude of our failure to allocate adequate scientific and technological resources to meeting the fundamental needs of people and to fulfilling priority social goals.

Manifestly there are limitations as well as potentials to what science and technology can achieve in the realm of social action. But what is important here is that we are preparing to take up the urgent work of focusing the potential of world science and technology more directly, more deliberately, and more systematically on human needs and prospects.

The absolute numbers of hungry, sick, homeless, jobless people in this world continue to grow. The agenda of current problems that cannot be resolved by any state acting alone is still expanding. The pressure of time in this final quarter of the 20th century is increasingly insistent. And the need both for more self-reliance of nations and for more cooperation among nations becomes imperative.

As we approach the Vienna conference, my sense of optimism is fortified by a personal conviction. It is this: Religious and moral values, human compassion, political necessity, and pragmatic common sense are now all pointing in the same direction for action. These major motivational forces are converging in support of a freshly concerted and cooperative world effort to get on with the essential tasks of development, especially in the poorest countries and for the poorest in all countries.

The point of departure of U.S. preparation for UNCSTD is an assumption on which we invite discussion by industrialized countries and developing countries. This is: The overriding objective in the application of science and technology to development is to further the modernization of developing economies and simultaneously to meet the basic human needs of developing country populations.

This assumption rejects any implication that meeting basic human needs and modernization are mutually exclusive or incompatible development strategies. It asserts, instead, that the fulfillment of basic needs and the process of economic modernization can

proceed simultaneously in a mutually enforcing relationship.

Finally, there is no more important facet in our present joint effort than a more intensive application of human knowledge to the resolution of human problems. The United States delegation to the world conference in Vienna will be dedicated deeply to that purpose.

Ambassador Theodore Hesburgh
Chairman, U.S. delegation to
the U.N. Conference on Science
and Technology for Development

SUMMARY

The U.S. National Paper is a brief reflection on the American experience in applying science and technology to development. It analyzes the vital role they have played in the evolution of the U.S. economy and society and in the U.S. contribution to economic and social growth in the developing countries. The paper suggests steps which could be taken at various levels to improve the application of science and technology to problems of development.

The Challenge Ahead

The chief question before the U.N. conference is whether the peoples of the world have the will and can develop the means to harness scientific knowledge and technological skill for the benefit of all. We are faced with a challenge to meet the basic needs of more than 1 billion people who live in abject poverty and whose lot cannot be improved without the help of science and technology. We are faced, in addition, with a variety of common global problems such as protection of the environment, population growth, development of new energy sources, and alleviation of shortages of food and water—on all of which science and technology can have major impact.

Each country must reach its own decisions on how best to address these tasks. The United States is a major source of science and technology, but it also has needs in this common area which other countries can supply. President Carter has expressed the policy objective of making scientific and technical cooperation with developing countries a key element in our relationships. This policy is based on the premise that, although our material resources are limited, our resources of technical knowledge are inexhaustible. They must be employed more efficiently in the framework of international cooperation.

Such cooperation should be among and with upper- and middle-income developing countries as well as low-income countries. The issues and development circumstances vary widely from country to country, and many actors and factors must be involved in an effective developmental process. In particular the successful transfer of technology depends on the ability to put it to use, including effective collaborative efforts between governments and private sector institutions and cooperative relationships among countries faced with similar problems. And finally, all parties must recognize that, as helpful as science and technology may be in addressing these problems, they are not the total solution. Many other factors are involved, and there is no "quick fix" to many issues of long duration.

U.S. Approaches

Over the past 30 years, the U.S. Government has made outlays for economic assistance in excess of $100 billion. The U.S. approach, in close consultation with developing countries, has been:

- To provide technically skilled personnel and scientific knowledge;
- To facilitate direct transfer of capital goods that embody new technologies; and
- To help build the necessary infrastructures to implement the transfer of new technologies, both on an international basis and within the recipient countries.

U.S. efforts have included the use of American experts in advisory and operational roles; the use of radio, television, remote sensing, and other technologies; the training of experts in recipient countries; and the support of research efforts that have direct and favorable impact on the major problem areas of public works and transportation, communications, housing, public administration, agriculture, health, manpower training, and mineral and water resources development.

The United States holds strongly to the view that the success of the economic and social development of other nations is very much in the U.S. interest. Although concern is sometimes raised that the transfer of technology can have adverse effects on domestic employment in the United States, as well as other negative short-term economic impact, in the long run such transfer provides important opportunities and benefits to the U.S. economy, its businesses, and overall employment. All countries can benefit from

economic growth in developing nations and from the worldwide expansion of trade.

The transfer and diffusion of science and technology is a complex process of adaptation. No particular country can claim to be the model for scientific and technological development. Historical circumstances, economic conditions, and cultural patterns differ. Therefore, the evaluation of the U.S. experience is not to be taken as prescriptive but descriptive of the evolution of U.S. policies and practices in the application of science and technology for development.

Findings

The United States offers the following preliminary findings on the central issues relating to science and technology for development in the evolving international economic system.

Indigenous Capacity Building. It is necessary to improve the technologies and mechanisms of industrialized countries for assisting developing countries in upgrading their scientific and technological skills and resources. This would enable the developing countries better to generate, select, adapt, and apply science and technology in pursuit of their own economic and social goals.

Education and Training. Manpower needs must be critically surveyed, evaluated, and updated as an integral part of national and regional economic development plans. Education and training programs should be geared to these plans so that the required experience, ability, and skills are forthcoming. Educational and training opportunities should be expanded and more scholarships and fellowships should be provided with emphasis on science, engineering, and management.

Research and Development. Because the world's natural resources are limited and problems of global expanse such as food, water, health, and energy are common to all countries, there should be more collaborative research among scientists and engineers from industrialized and developing countries on solving these problems in the mutual interests of all. Research and development, now heavily concentrated in industrialized countries, should be expanded in developing countries with greater reliance on their own scientists and engineers.

Information Systems. Developing countries should define obstacles to access and use of desired information as they see them. Industrialized countries should clarify the extent and sources of available information of both a proprietary and nonproprietary nature. Together both sides should devise practical and economic ways to improve the flow of mutually beneficial information in science and technology.

Cooperative International Mechanisms. Linking mechanisms between the public and private scientific and technological community of the industrialized and developing countries must be strengthened to promote the sharing of experience, knowledge, and skill as well as joint research and other problem-solving activities. These mechanisms do not require new international institutions; rather they call for closer integration of national and regional institutions which would facilitate cooperative efforts toward agreed goals.

Toward this end the President has proposed a new domestic foundation for international technological cooperation to serve as the focal point within the United States for the planning and implementation of international collaborative efforts in science and technology for development. The U.N. conference should encourage establishment of similar institutions in other countries. A network of such institutions could better use the creative talents of scientists and engineers throughout the world on problems of mutual concern.

A More Effective U.N. System for Science and Technology. The many useful science and technology activities within the U.N. system need a central focal point and policy direction so as to insure greater harmony and efficiency in working toward shared goals. This does not require creation of a new entity. The United States supports the idea of international collaboration on pilot programs in science and technol-

ogy for development which can be applied to critical global problems.

THE CHALLENGE WE FACE

"Humanity is, for the first time in history, within reach of managing its fate toward a better life for all."

With those words, an international group of scientists and engineers has assessed the present human condition. Meeting in Bellagio, Italy, in 1976 to discuss the role that science and technology can play in confronting the world's major problems, the participants bore witness to the potentialities for material progress for all mankind. But more importantly, they signaled the unlimited potential of man to forge the tools of his own survival with greater determination than he now contrives the weapons of his self-destruction.

While optimistic, these distinguished scientists were not euphoric in their outlook. Indeed, they had drawn attention to the principal challenge facing the globe—that 200 years of technological progress had not benefitted all nations equally. "A thirst for these benefits," they asserted, "is the focus of rising expectations for a better life in many parts of the world still in the grip of poverty and uncertainty about the future." (*Science, Technology and Society–A Prospective Look*, U.S. National Academy of Sciences, 1976.)

The question now is not whether technology can fulfill its promise but whether the human species has the will to harness scientific knowledge and technological skill for the benefit of all. This is a challenge that transcends expertise, cuts across the specialized fields of scientific branches, goes beyond the economic and industrial prowess of any single group of nations, and rests squarely on the active participation of the global community.

The U.S. Government views the upcoming United Nations Conference on Science and Technology for Development as a promising opportunity to transform scientific and technological progress into the elevation of the human condition.

This conference should be a sharing and learning experience, a reflection on how far we have progressed. It must also provide a vision of how far we must go so that the world's scientific and technological knowledge can truly become the world's own. No nation alone can guarantee that this will happen, and no nation can claim exemption from contributing its share, for science and technology are, indeed, the common patrimony. Each invention, each new breakthrough, must trace its genesis to the labor and ingenuity of successive previous generations.

Technology is much more than ever newer products or novel solutions. It bears the stamp of human rationality that enables all societies—large ones and small ones, advanced or poor—to survive, to assert their mastery over destructive forces, and to protect their identity and dignity.

And science is more than the systematic knowledge of the physical and material world. Science also bears the mark of an unending quest to answer the fundamental question of purpose.

If the 1979 U.N. conference is the right beginning, it is so because of its purposes: to insure that all countries derive greater benefits from science and technology and that all countries contribute their talent and fair share so that this may occur.

Conference Goals

The success of this conference is important to industrialized and developing countries alike. In an interdependent world, no single interest can prevail at the expense of others. The goals that the United States intends to pursue are, therefore, ones that it believes are in the mutual interests—economic, social, and political—of all countries concerned.

The goals we must seek are ones that will be responsive to the challenges confronting the advanced as well as the poor nations. Philosophies, priorities, and modalities of applying science and technology for development may differ among and even within nations. But there is hardly any disagreement about the fundamental premises that lend legitimacy to the conference itself: Science and technology *can* play a major role in confronting the problem of global poverty; science and technology *are* indispensable elements of eco-

nomic progress; and science and technology *can* be harnessed to confront global problems.

Consequently, the U.S. goals for the U.N. conference are offered not to exclude any specific priorities but to comprise overarching themes that can accommodate and do justice to them all.

- There is the challenge of meeting the basic human needs of over 1 billion people who live in conditions of abject poverty. The goals of this conference should, therefore, include overcoming the worst aspects of poverty by the year 2000. The conference should search for ways through which science and technology can best help to accomplish this.
- It must be recognized that without self-reliant economic progress within the developing countries and without a more equitable sharing of the fruits of economic progress among all nations, the issue of poverty cannot be addressed. Therefore, advancing the economic growth of the developing countries should be a major goal of the conference. Science and technology must be placed in the context of the continuing evolution of a new international economic order and a strengthened international economic system.
- In an interdependent world, poverty and economic underdevelopment in individual countries cannot be effectively overcome unless global measures are pursued to deal more effectively with global pressures on food and water, energy sources, raw materials, population growth, and the environment. The U.N. conference should lay the basis for strengthening networks of scientific and technological relationships that can support more effective efforts to meet these problems of concern to all countries.

U.S. Government Policies

The three general goals above are fully supported by basic U.S. foreign policy objectives.

American development assistance, both bilateral and multilateral, reflects a conviction that economic rights are an integral part of human rights and that economic aid to other countries must help to restore these rights. The masses of underemployed, unemployed, and idle are also the world's latent economic potential. Once incorporated into their countries' economic and social life, they will be the mainstay of self-sustaining growth.

Much of the official foreign assistance extended by the United States is intended to assist in meeting basic human needs—to help fulfill the economic rights of all and to help release the human potential now constrained by poverty and neglect. All countries must, of course, reach their own decisions on how best to address this task in a manner consistent with their own potentialities and needs. The United States will, however, continue to provide assistance in a manner consistent with its goals of eliminating obstacles to steady growth and overcoming the worst aspects of poverty.

The masses of underemployed, unemployed, and idle are also the world's latent economic potential.

The meeting of basic human needs can, of course, best be accomplished within economies that are themselves strong and vigorous. The industrialized nations have recognized that they alone cannot bring about world economic growth and recovery. Strong growth and economic expansion among the developing countries are, therefore, essential. The industrialized countries will also benefit from broader trading relationships; indeed, the expansion of trade among all countries is important to their own economic vitality.

U.S. policy accepts the premise that one element of encouraging the growth and expansion of the economies of developing countries and of achieving greater equity involves strengthening their scientific and technological capabilities. President Carter has expressed the policy objective of making scientific and technical cooperation with developing countries a key element in our relationships. Such cooperation should provide for working with upper- and middle-income developing

countries as well as low-income countries. The President is also seeking to improve U.S. participation in three international programs of fundamental importance: health, food, and energy.

The foreign policy objective of cooperating with other countries in these areas reflects a strong worldwide interest in dealing with problems which increasingly affect the quality of life of present and future generations. Although advances in science and technology have frequently been among the sources of problems confronting all countries (such as environmental deterioration), they have not been independent factors. Adverse impacts, where they have occurred, basically reflect the early failures to foresee the effects of uses to which science and technology have been put. If part of the problem now confronting the world is to remedy certain of these abuses, then the aid of science and technology will be essential.

Factors in Technology Transfer

In outlining general goals for the U.N. conference, four major variables must be kept in mind. First, that there are wide disparities among developing nations; second, that the generation and diffusion of technologies is a collaborative effort of governments and private sector institutions; third, that as much as science and technology may do to promote development, they are not panaceas; and fourth, that effective use of science and technology depends on the priorities and policies of the developing countries.

There are, of course, major differences among the developing countries in their present status and their potentialities. Their technological needs and aspirations, their capacities to absorb and utilize new scientific knowledge, and their development priorities dictate the pace and scope of technology transfer and determine the extent of their cooperation with other countries.

A number of developing countries have already achieved significant rates of economic growth and have established various elements of a scientific and technological infrastructure. Many such countries, while continuing to require greater self-reliance in some areas, are themselves able to play an active role in technical cooperation with other developing countries. Some are in position to provide financial assistance. But at the other end of the spectrum, there remain developing countries which are only at the beginning of the complex process of achieving economic growth and a greater degree of self-reliance. Because of this wide variety of circumstances, a range of approaches will need to be considered, and the time-scales for achieving results will necessarily differ.

It should also be remembered that science and technology are only means to an end and that even as a means they are not guaranteed.

Increased self-reliance is not the same as self-sufficiency. The United States and other industrialized countries have themselves benefited from scientific and technological advances originating beyond their borders. Developing countries in a number of instances may also find it less costly and more effective to utilize technologies which originated elsewhere, adapting them to local conditions. Strengthening the ability of developing countries to make such choices for themselves and to carry out any necessary adaptations is a fundamental factor in enhancing their self-reliance.

Policies that governments set, and the programs they advance for increased science and technology cooperation and transfer, can cover only some aspects of the global technology circulation. While in some countries the lines of demarcation between the private and the public sectors are altogether nonexistent, and in others blurred, in the United States and in the other industrial market economies the separation is quite pronounced. The scientific and technological efforts carried out in the United States today involve many different types of activities performed by a diverse set of public and private institutions.

It should also be remembered that science and technology are only means

to an end and that even as a means they are not guaranteed. They have provided the basis for achieving many dramatic advances. But beneficial effects do not flow automatically. Experience has shown that scientific and technological innovations can have harmful effects as well. Estimating in advance what the effects of change can be in specific circumstances and over time has proved to be a difficult art. It is, nonetheless, an art which developing as well as developed countries must seek to apply in weighing scientific and technological choices.

Developing and transferring new technologies is not an easy process. Major advances in scientific knowledge have, in some instances, opened the way for the development of wholly new technologies. But most technological advances represent improvements on *existing* technologies. And although it was once assumed that such transfer was relatively a straightforward process, it is becoming generally accepted that technologies—whether imported, adapted, or developed indigenously—must be suitable to local conditions.

Both innovation and transfer are influenced by such factors as the social and cultural fabric of the country, the resource base, the availability of capital, skilled labor, exchange rates, interest and wage rates, the quality of managerial and engineering expertise, access to supporting scientific and technological institutions, competition, and the incentives and disincentives created by governmental policies and market conditions.

Finally, while there is broad agreement on the need to enhance the scientific and technological infrastructures of the developing countries, the approach depends very much on the priority and effort that developing countries themselves are prepared to assign to this objective. The attainment of this objective involves building or strengthening a broad range of institutional and personnel resources—nationally and regionally—needed for education and training, management, marketing, and servicing.

In various analyses of the present distribution of scientific and technological capabilities, much has been made of the fact that so much of the world's capacity for conducting research and achieving technological innovation is concentrated in a relatively small number of industrialized countries. The answer to this problem is clearly not that the industrialized countries should do less but rather that the developing countries should be enabled to do more.

DEVELOPMENT IN THE UNITED STATES

The ways in which science and technology have evolved in the United States reflect the philosophical environment in which they have emerged—one that encourages freedom of thought and expression, a diversity of sources of competition and innovation, and the constructive development of individual talent and institutional resources.

Throughout U.S. history, there has been no long-term, overarching design or plan for scientific and technological development. Progress was incremental, a response to specific situations—from the early challenges of westward expansion, the mapping of the country's geography, and inventorying its natural resources to the more recent adventures of space exploration. Such challenges, plus those of military defense and the pursuit of economic development, have provided powerful motivation for the scientific community. And as economic growth has progressed, it has been possible to devote increased resources to science and technology.

A multiplicity of institutions—private and governmental—has emerged. This institutional pluralism has proved to be one of the major strengths of the United States in science and technology. On the one hand, these institutions have stimulated each other through competition; on the other hand, their respective strengths have had a mutually reinforcing effect.

The Early Years

In 1776, when the United States declared its independence, it was in all respects a "developing country"—importing from England and Europe virtually all of its technology.

Tools and know-how, ideas and skills were borrowed or brought along

by the steady stream of immigrants. There was poverty but no abject misery; necessity had a chance to become the mother of inventions. The technology that existed was one of improvisation and adaptation.

The Founding Fathers placed high value on the pursuit of knowledge and its application. Benjamin Franklin's scientific curiosity, George Washington's geographical surveys, Thomas Jefferson's fascination with labor-saving mechanical gadgets were testimonials to their faith in applying technology to the benefit of men. They supported exploration, new methods in agriculture, the establishment of institutions of higher learning, and measures to encourage invention. Among the Federalists, Alexander Hamilton led the efforts to overcome America's technological dependence on England by promoting the immigration of skilled manpower, capital inflow from abroad, and the protection of infant industries. This strategy to transfer technology and develop indigenous capabilities was not without adverse reactions. As a response to this early version of the "brain drain," Great Britain forbade the emigration of artisans, coal miners, and other skilled workers and placed embargoes on tools, machines, and everything else that might be used in manufacturing. To no avail. Progress in manufacturing was rapid considering the times.

As in the contemporary, post-Enlightment Europe, America too began to lay the foundations of an educated society. Schools offering courses in "practical" science and engineering were established in the first half of the 19th century. Colleges of medicine formed an essential element of the growing educational system. In 1862 the Congress provided each State with a grant of land to establish agricultural and mechanical colleges; these came to play a major role in U.S. agricultural development as well as in education. During the 1870's, graduate training in the sciences was firmly established in U.S. colleges and universities.

During the 19th century, a scientific community began to emerge. The American Association for the Advancement of Science (AAAS) was formed as a nongovernmental organization in 1848 "to give a more systematic direction to scientific research" and to encourage the availability of increased facilities for research. The National Academy of Sciences was formed in 1863; although chartered by the Congress, it was—and remains—independent of government control.

As one review of the history of science in the United States has pointed out:

> During the nineteenth century, American scientists were successful in convincing many private and public patrons that science was useful in a very practical sense. In the first decades of the twentieth century, there emerged a system—not exactly matched outside this country—in which new knowledge flowed from laboratory to application. In a nation growing more industrial, more urban, and more integrated, the rise of graduate universities, research-oriented government bureaus, industrial research laboratories, and non-profit research institutions stimulated and served American society. (*Science and the Bicentennial*, National Science Board, 1976)

Current Efforts

Although government-supported research began some hundred years ago, it has grown extensively in the present century.

The Department of Agriculture and the National Bureau of Standards were among the early governmental sponsors of research. In more recent years, emphasis on science and technology has been reflected in the establishment of

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such agencies as the National Science Foundation, the Atomic Energy Commission (now absorbed by the Department of Energy), the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Telecommunications and Information Agency, the National Institutes of Health, the Environmental Protection Agency, and, at the White House level, the Office of Science and Technology Policy. Other Departments having broad operational responsibilities also have research and development programs, e.g., Transportation and Housing and Urban Development.

Industrial research has also been a major factor in scientific and technological advance in the United States. In some cases, basic as well as applied research has been sponsored. A major stimulus has been the size of the domestic U.S. market. Since the process of technological innovation extends from the idea stage, through marketing, to placing items into actual use, the role of industry has been central to innovation in the United States. The managerial expertise of industry has been a major factor in insuring technological innovation by responding to market demands and attracting public interest to new products and services.

Frequently established through the generosity of leaders of private industry, private foundations have also contributed to the advancement of science and technology in the United States; independent research institutes and nonprofit research organizations add to overall U.S. scientific and technological institutional capabilities.

The Federal Government provides support of over half of the research and development carried on in the United States. During fiscal year 1979, the total research and development effort planned by the Federal Government involves estimated outlays of $27.2 billion. This total includes $13.9 billion for civilian research and development efforts and $13.3 for defense programs, many of which have eventual civilian applications. Certain nonmilitary programs may also have applications in defense. Therefore, the categories are not discrete.

The remaining support of research and development is provided by private industry, universities, state and local governments, and nonprofit organizations. Estimates for calendar year 1978 suggest a total non-Federally supported research and development expenditure of around $23 billion, of which $21 billion was invested by private industry.

Estimates for calendar year 1978 suggest a total non-Federally supported research and development expenditure of around $23 billion, of which $21 billion was invested by private industry.

The Federal Government does not have a comprehensive research and development budget or a comprehensive science and technology policy. Funding is provided in the budgets of some 29 separate governmental Departments and agencies; 12 have annual research and development budgets of over $100 million each. The White House Office of Science and Technology Policy maintains an overview of major programs and assists in setting priorities.

Federal funding is intended to meet several types of needs:

- Those where the sole or primary user of the research and development is the government itself;
- General economic and social needs where there are insufficient incentives for the private sector to invest adequately in research and development; and
- Specific national needs where the government seeks to accelerate and augment private efforts.

To suggest the general areas receiving the greatest emphasis in the Federal budget, the following list of civilian departments and agencies is presented in descending order of their proposed expenditures for research and development in 1979: the Department of Energy; the National Aeronautics and Space Administration; the Department of Health, Education and Welfare

(which includes the National Institutes of Health); the National Science Foundation; the Department of Agriculture; the Environmental Protection Agency; the Department of Transportation; the Department of Interior (which includes the U.S. Geological Survey); and the Department of Commerce (which includes the National Oceanic and Atmosphere Administration, the National Bureau of Standards, and the National Telecommunications and Information Agency); and the Agency for International Development.

Federally sponsored programs are carried out through a multiplicity of institutions—Federal laboratories, colleges and universities, nonprofit research organizations, and private industry. Government efforts are frequently carried out through demonstration projects to stimulate efforts by private industry to continue the work.

THE U.S. EXPERIENCE

Private Sector

Direct resource and technology transfers between and among governments are small by comparison with those made through trade, investment, and information exchanges among private sector institutions in the United States. For whatever motives—whether profit, scientific excellence, or the pursuit of social justice—the business community, foundations, voluntary organizations, and academia play a decisive role in the development and diffusion of technology. It is the basic process through which U.S. society pursues its aspirations and satisfies its need.

The relationship among industries and laboratories, foundations and professional associations, profitmaking and nonprofit organizations, is one of interdependence in which the regulating forces of the market interact with the tempering influence of social goals. Collaboration and competition are more than the social modes of existence, the traditional and accepted attitudes of the American way of life; they are also the principal stimulus of entrepreneurship, innovation, and incentives in the economic sphere.

Role of Private Enterprise. The growth and diffusion of technology are not ends in themselves. They are, rather, byproducts of the process of achieving and sustaining economic balance—the matching of technology with manpower, investment with resources, consumer demands with production.

While private enterprise is the critical arena for the development of technologies and a primary channel for their diffusion, business and industry are neither the missionaries of technological progress—as some would hope—nor the most salient problem in the process of transferring technology from the developed to the developing countries—as some would claim. U.S. private firms work to develop new technology principally in order to sustain their competitive positions.

It may be true that private companies are interested primarily in establishing total business relationships and not in the transfer of technology per se. But, in the final analysis, they become active as both suppliers and recipients of technology across national boundaries. Through private transfer channels, business and industry have made major contributions to the economies and welfare of the developing countries. Whether through investment, licensing, production contracts, joint ventures, or a host of other means, they have played a role in creating those economic conditions in which technology transfer

The issues involve the cost of transferred technology, respect for patent and licensing systems, the practices of multinational corporations, regulations by national governments, and the appropriateness of the technologies that are being sold or transferred to the developing countries.

has become both feasible and indispensable for the developing countries.

Among their contributions have been enhanced domestic employment, export potential, and local tax revenues; significant manpower and management training programs; establishment in some instances of research and development facilities; introduction and diffusion of organizational and production techniques; construction of generally useful physical infrastructure; greater diversification of local economies and development of a stronger capacity to meet economic and social needs through the provision of goods and services which might not otherwise have been available; and, ultimately, the impetus for constructive change by established firms which can be generated by the entry of new enterprises into the market.

Changes—whether wrought by simple technology transfers or by the very presence of foreign firms and businesses—are not, however, without strains, conflicts, or problems. This is perhaps even more true in a time of limited economic growth, worldwide inflation, balance-of-payments constraints, and energy scarcity. Such conflicts may also be magnified by a growing sense of nationalism and national pride in many parts of the world, particularly when international business transactions are insufficiently attentive to this point.

The diversity of viewpoints on the principal issues that have impact on the relationship between the less developed countries and international private enterprise is well known. The issues involve the cost of transferred technology, respect for patent and licensing systems, the practices of multinational corporations, regulations by national governments, and the appropriateness of the technologies that are being sold or transferred to the developing countries. The differing viewpoints on these issues cannot be resolved by fiat nor ignored in lieu of solutions. However, for a dialogue to take place and continue constructively, it is useful to be aware of common features that—from the perspective of U.S. private enterprise—have characterized successful technology transactions.

- Businesses prefer a stable and equitable economic, political, and legal climate in developing countries, one which allows decisions on investments and licensing to be made with reasonable predictability. They seek to engage in long-term relationships that are mutually profitable.
- They want to insure that the receiving country has the capacity to evaluate, absorb, and efficiently employ the technology supplied. They are prepared to broaden their dialogue with host governments to discuss additional ways to contribute to building this capacity.
- They want to insure recognition and protection of industrial and intellectual property rights, just as developing countries want recognition and protection of their natural resources. Both sides see these as vital to perceptions of risk and the expected costs of individual technology transfers.
- They seek agreements that provide firms with a reasonable return on the investment in the technology, as well as recovery of the costs associated with the transfer itself.
- They prefer nations with readily available mechanisms for the prompt and fair settlement of disputes that may arise between an industry and the host government or a local private-sector organization. (The United States generally supports the inclusion of arbitration clauses in contracts, but other devices may be employed.)

These preferences may or may not be reasonable from the point of view of many of the less developed countries. They may or may not be the most essential issues in technology transfer. Nevertheless, it is understandable that many of the disputants look to the U.S. Government to play a more direct role in the resolution of the outstanding issues.

Undoubtedly, there must be an interplay between government policies and market forces. Traditionally, however, the U.S. Government has exercised minimal interference in the affairs of business. Acting on the premise that the people, not the government, should be the major decisionmakers on the allocation of resources through their demand for goods and services in the market place, the U.S. Government intervenes in this interplay of private forces in only four fundamental ways:

- By assuring competition and preventing monopoly practices in the markets through antitrust regulations;
- By establishing standards of performance to insure that economic activities do not impair the health, safety, or environmental quality of U.S. communities;
- By establishing a structure of incentives and disincentives, grants, subsidies, or other fiscal measures to foster the production of public goods and services (e.g., in the fields of health, defense, and space) that market forces acting alone are ill-suited to produce in sufficient quantity or quality; and
- By insuring—through the protection of intellectual property by patent, copyright, trademark, and related regulations—that those willing to take the costly risks associated with the development of new and innovative technologies can realize the return on investment that is necessary not only to recoup costs but also to act as an incentive to the further pursuit of innovative activities.

Although the U.S. Government has generally been neutral toward commercial transactions of U.S. private firms, it has taken steps to facilitate foreign investment and technology transfer to developing countries. The Overseas Private Investment Corporation provides insurance for private U.S. investments in some 80 developing countries. It also helps to identify suitable investment opportunities and, in some instances, provides direct lending and guarantees of private U.S. lending. The Export-Import Bank provides financing for many export transactions, including a number involving technology transfers to developing countries. Substantial loans to many developing countries have also been provided by many U.S . commercial and investment banks and other financial institutions. In September 1978 President Carter announced a new program to provide increased direct assistance to U.S. exporters, reduce domestic barriers to exports, and reduce foreign barriers to our exports and secure a fairer international trading system for all exporters.

Impact on Developing Countries. Each of the mechanisms through which U.S. private industry transfers technology to developing countries may be expected to bring different benefits to the receiving nation.

Licensing, for example, brings technology but it may not involve extensive training or access to other related technologies. On the other hand, direct foreign investment can bring capital and technology as well as attract important managerial, technical, and marketing skills that may be scarce in developing countries. Since U.S. firms now rely primarily on host country personnel at all levels to insure the successful operation of their foreign subsidiaries, they recognize the need for training and manpower development.

There are also other benefits from technology transfer. Host country investment opportunities are increasingly available, since many U.S. firms no longer insist on maintaining 100% ownership of their overseas branches. Host country firms may be encouraged and relied upon for the supply of needed parts and materials. And research applicable to a country's particular problems may be conducted locally or in a private company's laboratories in the United States.

Educational opportunities offered to residents of the host countries by U.S. companies often begin with primary schools.

Educational opportunities offered to residents of the host countries by U.S. companies often begin with primary schools. Some firms have built village schools in rural areas, established cooperative relationships with local vocational training schools, made teachers available from their own staffs, donated technical equipment, and provided training courses within the company. Some U.S. firms are training technicians from local hospitals in company laboratories or permitting local engineering schools to conduct experiments in U.S. factories in the country. U.S. companies have also offered scholarships to send students to domestic and U.S. educational institutions, including persons not associated with the sponsoring

companies. Educational programs for all local personnel of a particular company have also been offered.

The need for sophisticated negotiating and bargaining skills is also important, not only for dealing with supplier companies and other governments but also for labor relations and arrangement of financing.

Similarly, the injection of new technological activity into a developing nation may stimulate the growth of local mechanisms for settlement of disputes and for protection of industrial and intellectual property rights.

Another result may be the institution by a developing country of its own standards for operation of business and industry. Nations may wish to insure that new industrial and technological activity operates in a manner most compatible with the health and safety of employees and other residents of the host country, with protection of local environmental factors and with optimum nonwasteful use of natural resources. A country's choices of technology and of particular industries should fully take into account these and other standards.

In short, the greater the extent of technological development in a country, the more there is a need for auxiliary services, standards, and legal mechanisms that can benefit both the recipient nation and the private businesses that are supplying the technology.

Impact on the United States. There is no doubt that the transfer of technology to developing nations provides important opportunities and benefits to private business and industry in the United States. It enables them to expand their markets and to enhance their skills and experience through opportunities to address new problems and challenges in their respective fields, as well as to help developing nations meet serious needs for technological progress.

At the same time, concern has been raised within the United States about technology transfer that can have adverse effects on domestic employment in the United States. There is a widely held view that the U.S. economy is undergoing a transition, becoming more service-oriented and knowledge-intensive and less geared to the production of goods. The growth of production capacities in other nations is certainly not the only reason for this apparent shift. Nevertheless, there is a certain fear that the transfer of U.S. technology to developing nations may result in the eventual closure of production facilities in the United States or in the creation of new or additional foreign producers of goods that will be in competition with U.S.-produced goods, entailing a loss of jobs and income within the United States.

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Whatever the causes of the transition in the American economy, there is a need to develop effective adjustment mechanisms to avoid undue hardships for the corporate owners, employees, workers, and communities most directly affected by reduced production, and efforts to do so are underway.

Another solution is continuing technological innovation which can insure opportunities for new employment. In order to maintain the traditional technological creativity of the United States, President Carter has appointed an Industrial Innovation Coordinating Committee to conduct a full review of U.S. policies in this regard. The committee will seek to identify ways to influence the rate and direction of industrial innovation in order to create the most positive benefits to the U.S. economy and society.

As a basic policy, the U.S. Government continues to believe that all countries—including the United States—can benefit from the strengthened international system that will result from economic growth in the developing nations and from worldwide

expansion of trade. Certainly the United States has benefitted substantially from technology imported from abroad, even as it has been a major provider of technology to others. And industries of other nations are tending to increase investment and production facilities in the United States.

In terms of expanded trade, it has been recognized that, of the $120.2 billion of total U.S. exports in 1977, more than $40 billion (about 35%) went to developing countries. These nations constitute a market that is growing at a rate of more than 20% per year. More U.S. manufactured goods were sold to developing nations in 1977 than to Western Europe, Japan, and the Communist countries combined. Approximately 1,200,000 jobs in the United States are directly dependent on these exports, and many more are indirectly affected. U.S. encouragement of the success of the developmental process is, therefore, very much in U.S. interest.

Scientific and Engineering Organizations. Most prominent of the professional organizations in the United States concerned with science is the National Academy of Sciences, established over 100 years ago as a principal source of objective, nonpolitical, scientific advice to the government. It also serves as the U.S. link to the International Council of Scientific Unions. Comparable roles are played by the National Academy of Engineering and the Institute of Medicine. The National Research Council is the operational arm of these organizations.

The more effective application of science and technology to the problems of development has been pursued by the National Academy of Sciences, with modest government support, since 1958. The National Research Council, which prepared an extensive study of world food and nutrition following the U.N.'s World Food Conference, also developed a major report in support of U.S. preparations for the U.N. Conference of Science and Technology for Development.

The center of the academy's efforts has been the Board on Science and Technology for International Development (BOSTID). Since 1964, in more than a dozen countries in Asia, Latin America, and Africa, BOSTID has been helping developing countries acquire a "problem-solving capability"—including the policies, institutions, manpower, and environment that can help a country identify its own problems and apply its own scientific and technical resources. This objective has been advanced through workshops and study groups operated jointly with counterpart institutions.

The Advisory Committee on Technological Innovation, sponsored by BOSTID, draws on the services of U.S. scientists and engineers, as well as representatives of developing countries, to identify new and underutilized technologies applicable to developing country problems. The reports of this committee include such subjects as new sources of plant protein, alternative energy technologies especially suitable for villages and rural areas, mechanisms for water management and conservation in arid lands, and remote sensing.

The National Academy of Engineering, which is a partner in many of these activities, also offers assistance to educational systems and institutions in various areas of engineering.

The AAAS, founded in 1848, is the world's largest federation of scientific and engineering societies, with some 280 affiliated organizations. The AAAS is publisher of the magazine *Science*, a major international source of information on scientific and technological developments. Its Western Hemisphere cooperation project includes publication of a scientific journal in three languages. It also sponsors or arranges for U.S. participation in many international conferences related to development and is supporting U.S. preparations for the U.N. conference. The Consortium of Affiliates for International Programs, formed by 78 of the participating societies, compiles a summary of the international activities of AAAS affiliates which facilitates access to expertise that can assist development.

Other professional societies that serve as transmitters of science and technology information and as sources of advice to developing country professional groups include the American Chemical Society, the Engineers Joint Council, the American Physical Society, and the Institute of Electrical Engineers.

Foundations. A number of U.S. philanthropic institutions traditionally have directed part of their activities toward the problems of developing nations. The two largest foundations—Rockefeller and Ford—have pioneered new and experimental approaches to problems in food and nutrition, public health, family planning, and education. Both assisted in the establishment of the agricultural research programs and centers, discussed elsewhere in this paper, that developed new high-yield grain varieties.

In all there are some 50,000 foundations and charitable trusts in the United States. Although there is no available measure of the total assistance in science and technology being provided to developing countries by these organizations, their efforts constitute an extensive and effective supplement to governmental and private industry activities.

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The Ford Foundation devotes about 40% of its income to overseas activities. Over a period of 25 years, the foundation has provided grants totaling close to $1 billion to about 100 countries. The foundation's developing country programs are concerned with population planning, food production, strengthening educational systems, and improvement of the capacity of local agencies to plan and execute developmental activities.

The Rockefeller Foundation—involved in international activities for more than 60 years—devotes about half of its total income to overseas programs in food, population, and health. The foundation's "Conquest of Hunger" program, which marked the beginning of the system of international agricultural research centers, seeks to improve food production, nutrition, and distribution. In population the foundation has supported research in reproductive biology and contraceptive development. Health funding has been concentrated on major diseases in the developing world.

Service Organizations. Many private service organizations in the United States arrange for advice and assistance to be made available to developing countries.

The International Executive Service Corps recruits experienced executives, usually retired from U.S. business and industry firms, to serve in developing countries as volunteer advisers to locally-owned enterprises that request managerial or technical assistance. Since this effort began in 1965, volunteer executives have completed more than 5,000 project assignments in Latin America, Asia, Africa, and the Middle East.

Volunteers for International Technical Assistance (VITA) supports programs designed to help low-income people in developing countries to meet their needs. VITA offers problem-solving and technology design, project planning and support, assessments of needs, and feasibility studies. Emphasis is placed on renewable energy sources, agriculture, food processing, water supply, sanitation, housing, construction, and small business development and management. Over 4,000 VITA volunteers, representing virtually every technical field, donate their time and expertise to assist with efforts related to this goal.

Technoserve promotes self-help enterprise in developing nations through its professional full-time field staffs, most of whom are citizens of the recipient country. Working directly with local private enterprises in the industrial and agricultural sectors, and with local enterprise development institutions, Technoserve helps to identify and implement managerial and production technologies that are consistent with the resources and capabilities of low-income groups.

The Overseas Development Council and the Council on Science and Technology for Development serve as privately organized sources of analysis of problems in the developmental process. Both contribute to the general understanding of issues in this field and to the formation of government policies.

Colleges and Universities. U.S. colleges and universities—supported both with governmental resources and private funds—have played a crucial role in the United States in scientific

and technological advances, as well as in traditional educational functions. They have also played a significant role in assisting the efforts of developing countries to build and strengthen their own universities, research organizations, and other scientific and technological institutions. In addition, they have provided technical assistance in many fields and offered education and training to students from developing nations.

Many colleges and universities participate in collaborative international research projects and technical assistance programs. In 1976 and 1977, with funding provided by the Federal Government, more than 1,300 staff members of U.S. land-grant colleges and universities were involved in providing overseas technical assistance in Africa, Asia, the Middle East, and Latin America.

Probably the greatest single impact that U.S. colleges and universities have had in enhancing the scientific and technological capabilities of developing countries is in education and training. Since 1949 more than 2 million students from developing countries have studied in U.S. universities, land-grant colleges, and community colleges. This total includes large numbers of engineers, agriculturists, scientists, medical and health experts, and educators who have returned to positions on university faculties and in research institutes, government ministries, and public and private enterprises. Over 200,000 undergraduates and graduate students from developing countries are currently studying in U.S. colleges and universities.

Many of these individuals are studying in institutions that have been created since the late 1940's for the training of engineering and industrial technicans with different levels of skills and knowledge. Associate degrees in engineering and industrial technology are offered by 89 two-year accredited technical colleges in the U.S. Community colleges, junior colleges, technical institutes, and secondary-level schools also offer technical programs. Since many developing countries have great need for middle-level engineering and industrial technicians who can operate technical systems now coming into use, some of these institutions are considering ways to pool their resources and make their capabilities better known to developing nations.

Specialized and academic training has been arranged over the last 30 years for some 200,000 individuals from developing nations through AID. This "participant training" program is designed to enable individuals to participate in specific development activities in their own countries. Large numbers of these individuals have received training in such fields as agriculture, health, population, nutrition, mathematics, computer technology, engineering, physics, chemistry, metallurgy, meteorology, geology, and oceanography.

For example, the U.S. assistance program in one north African country includes a training component that covers petroleum technology, remote sensing, pollution research, and computer technology. With specific development objectives in view, engineers and scientists of this country are being trained in U.S. educational institutions to expand oil production, gather and interpret data on erosion and natural resources, improve research capabilities in environmental control, establish a communications system, and conduct studies that can make programs more responsive to the needs of rural and village populations. Although this is an exceptionally broad effort, it illustrates the ways in which training can directly support development objectives.

Since 1949 more than 2 million students from developing countries have studied in U.S. universities, land-grant colleges, and community colleges.

Similar training is accompanied through AID programs, with costs reimbursed by the developing country sending the students. For example, one west African country is underwriting the cost of training 2,000 students in the United States. At the request of the government involved, 90% will take 2-year technical training programs and 10% will be in 4-year programs, ap-

proximately half of whom will receive engineering degrees.

Exchange programs administered by the U.S. International Communication Agency provide the basis for a number of exchanges in the fields of science and technology. Domestic and foreign scholars and experts—including those from developing nations—receive grants for study, research, teaching, and observation for both short and long periods. Also, each year a number of multiregional projects bring groups of foreign scholars and experts to the United States to concentrate for a short period on core subjects such as environment, energy, and management. Participants in these programs are particularly urged to establish ties with U.S. counterparts that will permit them to continue their exchange of information and experience after the visit ends.

Several issues relating to the education of students from developing nations in U.S. institutions have been raised for discussion.

One concerns the need to make the education that foreign students receive in the United States more directly relevant to the conditions and needs of their countries. Most courses of study in U.S. institutions are naturally geared to the needs and interests of U.S. society. However, the increasing numbers of students coming to the United States has brought about some adjustments, and more U.S. colleges and universities have been urged to develop special courses that relate more specifically to the concerns of students from other nations. This approach appears to have special feasibility where several educational institutions in the same area have a large enough concentration of students from developing areas to warrant offering special courses. Some institutions have taken steps in this direction, but it is generally agreed that more needs to be done.

There are, of course, many "side benefits" to the education of students from other nations in the United States. These include opportunities for the students—many of them future leaders in their own countries—to become familiar with the U.S. way of life, its culture, and its governmental decisionmaking process as well as opportunities for U.S. citizens to learn more from the students about their nations. The result can be continued contacts between influential people in the U.S. and other nations and, potentially, stronger relationships between the countries and better international understanding.

On the other hand, it is argued by some that, rather than come to the United States or another industrialized country, students from developing nations can obtain more practical benefit from their education by attending institutions at home or in other developing countries where circumstances and courses of instruction more closely parallel situations in their own nations. There is undoubtedly merit in both arguments, and they deserve continued attention from those who plan and implement educational programs for students from developing nations, whether as senders or receivers.

A related problem in the educational field is presented by the so-called brain drain, the causes of which need to be studied, discussed, and better understood. While most students educated in the United States return to their own countries, significant numbers remain in the United States or return later. Most do so under private auspices rather than on government-sponsored programs. Because remaining in the United States often constitutes the loss of needed skill to many developing countries, the problem is serious. Constructive ways of responding to the situation must be found within a framework which respects the traditional value of freedom of choice for the individual.

Development of an efficient and easily accessible system to help students from other nations identify the U.S. institution that is best suited to their needs is another objective of many in this field. There are thousands of institutions in the United States offering education, and it is very difficult for students to determine the ones that can both match their academic interests and provide the environment in which they can function best. Counseling services aimed at assisting students from other nations to make appropriate choices are supported by the U.S. International Communication Agency and by various private institutions. In addition, the American Council on Education is studying the merits of a central information and referral system.

Finally, because of the growing

interest in the application of science and technology to developmental problems, it has been suggested that greater research is needed on the effectiveness of existing systems for education and training in this field, in both industrialized and developing nations. The need for scientists, engineers, doctors, managers, mid-level technicians, and other qualified personnel is growing and must be met if developing nations are to achieve the self-reliance they seek. Proposed for discussion is a major collaborative research program, on a broad international scale, that can examine the existing systems and recommend improvements that can help meet the growing needs.

President Kennedy gave U.S. efforts a new thrust and rationale by creating the Agency for International Development (AID) and launching the Peace Corps and the Alliance for Progress.

Public Sector

Thirty Years of Development Assistance. Since the end of World War II, the U.S. Government has made extensive and concentrated efforts to share with other nations the benefits of its experience in applying science and technology to development.

The Marshall plan, begun in 1947, was aimed at reconstruction of the industrialized nations of Western Europe—countries which already had highly developed science and technology infrastructures, access to raw materials, and enormous consumer needs. In contrast, the point 4 program, announced by President Truman in 1949, was the beginning of a program to make "the benefits of our scientific advances and industrial programs available for the improvement and growth of underdeveloped areas."

President Kennedy gave U.S. efforts a new thrust and rationale by creating the Agency for International Development (AID) and launching the Peace Corps and the Alliance for Progress. In 1978 President Carter took steps to further improve the effectiveness of U.S. assistance programs and to strengthen the coordination of the work carried out by a number of U.S. Government agencies.

Since the initiation of foreign aid programs, total outlays for economic assistance by the U.S. Government have been in excess of $100 billion. In 1976, the United States contributed 32% of the official development assistance provided by the Organization for Economic Cooperation and Development; for 1979 the Congress has appropriated $6.8 billion. And throughout this period, continuing efforts have been made to draw upon U.S. scientific and technological resources as major components of the program.

While AID has many qualified scientists, engineers, and experts in many areas on its staff, its role is essentially that of a broker between the needs of the developing countries and the American scientific and technological community. It does not have a monopoly on the evolving science and technology, it is not an owner of patents and does not conduct industrial or agricultural research. It must be recognized, however, that the vast majority of technology that is relevant to development needs is nonproprietary. New techniques of cultivation, the application of mass communication to education, health care management, and a host of other activities are in the public domain. The government—and specifically AID—can, therefore, play a significant role as a facilitator and enabler of technology transfer for development.

Although various policy emphases have evolved on the basis of program experience, one continuously stable element of the U.S. Government's involvement in this field has been the steady effort to build collaborative relationships with other organizations, agencies, and countries concerned with development.

- None of the achievements of this period could have been accomplished without the substantial concern and

participation of private-sector organizations—industries; labor unions; universities; scientific, engineering, and other research institutions; and nonprofit and voluntary organizations.

- Many U.S. Government executive branch departments and agencies have joined with AID in efforts to share scientific and technological activities with other nations.
- The concerns of the executive branch could not have been implemented without the continuing interest and support of the U.S. Congress. Despite periodic debate over the size and content of the aid programs, concerned members of both branches of the government have supported this extensive activity.
- As international organizations extended their interests to economic development and as new organizations were created—to work particularly in fields that demanded sizable scientific and technical components—the U.S. Government has entered into many collaborative and supportive arrangements with these organizations. (From 1967 to 1977, U.S. contributions to U.N. programs, international lending institutions, and other multilateral assistance programs increased tenfold—from $114 million to over $1.2 billion. Today 30% of U.S. development assistance is channeled through multilateral programs.)
- In the case of countries which do not require concessional assistance, reimbursable technical assistance is providing a link between U.S. scientific and technological capabilities and the needs of middle and upper income developing countries.

Lessons of the Past. The achievements of U.S. development assistance need to be put in perspective. The strong position of the United States in science and technology during most of this century—its robust economy, stable political system, and military strength—could not be viewed as the mere coincidence of separate attributes or as the consequence of serendipitous events. Not surprisingly, science and technology came to be regarded as the unifying factors, the lifeblood of progress. This had a basis both in fact and in faith.

There was a basis in fact because the technological breakthroughs in mass production, in nuclear energy, in space hardware, in electronics—from the Model-T automobile to the first manned landing on the Moon to miniaturized transistors—were not limited to spectacular achievements in isolated fields. They tended to spill over, affecting and revolutionizing many areas of economic activity.

As accomplishments, they gave birth to a new faith—or optimism—that with sufficient capital, political will, and managerial ingenuity, no problem would long remain unresolved when science and technology were put to work. This optimistic attitude—discounting the different conditions in the developing countries—became an organizing principle for development assistance in the United States and, following the Marshall plan's success, in Western Europe as well.

While this attitude probably influenced the generation of strong public support for a U.S. commitment to foreign aid, it also gave cause for major disappointments and miscalculations. Rising expectations soon gave way to frustrations on the part of aid providers and to recriminations on the part of the recipients. Development turned out to be a far more complex, arduous, and lengthy process than many enthusiasts of development assistance had ever dreamed. The management theory which lay behind the major technological advances—that heavy concentration of manpower and resources in a crash effort could produce specific results in a relatively short period—simply did not apply to the development process.

Much has been written and more is yet to be learned about the significant incremental advances and the dramatic success stories that have occurred in development assistance, but shortcomings of past efforts cannot be overlooked. While experience and hindsight may brand as inappropriate some of the policies and methods of the past, they do not necessarily make them incorrect for periods in which they were pursued. The substantial progress made by a number of developing countries—partially because of development assistance—attests to its enduring qualities.

While most of the lessons learned in 30 years may be applied to all spe-

cialties of development assistance—no matter which country tried to pursue them—some lessons are particularly relevant to the manner in which the United States attempted to transfer its own scientific and technological experience to the developing areas. The lessons noted below are by no means of only recent vintage, and much that has been found in error has been corrected. But the learning process continaes. Still, these lessons are part of the story of aid, worth sharing if the hazards of repeating past errors are to be avoided.

Setting Priorities. In retrospect, it is now a commonplace observation that there was a critical misjudgment—though unintended—that the United States and other industrial countries could be the role model for the evolvement of science and technology in the developing countries. In the early years of foreign aid, it was assumed by the United States and probably by other industrialized countries as well that, as the more advanced partners in scientific and technological fields, they would have especially relevant insights into the policy framework for development and the establishment of priorities.

By this time, the need for developing countries to establish their own policy framework and to set their own priorities has long been recognized. Such autonomy does not imply that reliance on outside suppliers of technology would cease; it means rather that each developing country would control the direction, the pace, and the social effects of technological evolution. They may need additional information or capabilities to perform these tasks effectively, but these are clearly tasks that developing countries must perform for themselves. Recognizing that the American experience with science and technology is not always applicable directly to the current problems in the developing countries, the U.S. Government is beginning to show increasing support for technological cooperation among the developing nations themselves.

Developing Local Expertise. In earlier times, technical assistance was often viewed as the direct application of expatriate knowledge to local tasks, with the expertise to be recalled when the tasks were accomplished. Consequently, the advanced countries, in their research and development, emphasized the problems of the developing areas. Programs were mainly concerned with the recruitment, training, and dispatch of American experts and on the creation of efficient delivery systems that could have direct impact on local problems. The preferred, though not exclusive, forms of technical assistance thus avoided layers and filters of the institutions and inexperienced technicians in the [developing countries]. The transfer of knowledge and expertise per se to local counterparts was secondary; it occured only incidentally.

The management theory which lay behind the major technological advances—that heavy concentration of manpower and resources in a crash effort could produce specific results in a relatively short period—simply did not apply to the development process.

Over time, however, this preoccupation with the direct application of American know-how to local tasks was replaced by more collaborative relationships. The training of local counterparts began to occur simultaneously with the transfer of problem-solving techniques. The sharing of the results of major research programs was replaced by the cooperation in the research itself.

Building a Scientific and Technological Infrastructure. Programs to assist the creation of indigenous scientific and technological capacities in the developing countries have been a feature of foreign aid since its earliest days. The establishment of institutions dedicated to agricultural research and to the eradication of tropical diseases and assistance to universities in many developing countries attest to the significant progress made in this area. An important distinction existed, however. Aid-supported indigenous institutions

of science and technology were not meant to respond to the imperatives of scientific knowledge for its own sake but were supported as accessories to development programs and projects; they were task-oriented. Investigation and studies were undertaken to resolve particular problems. As such they contributed to the building of indigenous capabilities for development but did not alter their continuing dependence on the initiatives of scientific centers of the Northern Hemisphere.

An authentic science and technology capacity is not autarkic. It remains intertwined with scientific advances elsewhere. It must include understanding, inventing, selecting, adapting, using, managing, maintaining, and marketing its and other's intellectual products. The objectives are to permit people to learn (even if what they learn is already known), to invent (even if what they discover already exists), and to create (even if what they produce is already available).

The creation of science and technology infrastructure is, by definition, a long process and one that is not susceptible to "quick fixes." AID and its predecessor agencies were primarily charged with administering programs from which immediate benefits and results were expected. The development of local, self-generating, and self-reliant scientific and technological scholarship, or "pure research," was not a priority. Projects and programs could not afford to risk scarce aid resources on more speculative efforts which might—or might not—have had direct application to the development needs of the Third World countries.

This dilemma remains a problem, dependent on factors other than official development assistance. The Foundation for International Technological Cooperation proposed by President Carter in March 1978 is, however, a direct recognition of the need that this issue must and can be addressed in the future.

Science and Technology and the "Trickle Down" Strategy. As was the case with most aspects of development assistance, the transfer of technology was part of what later came to be called the "trickle down" strategy. This strategy assumed—in its simplest interpretation—that economic growth by itself would create the necessary conditions which would incorporate incrementally greater and greater numbers of people into the mainstream of a nation's society and economy. While it proceeded on the assumption that the ultimate objective is people, it focused on those sectors of society that were economically more animated and entrepreneurial and on those sectors of the economy that were susceptible to rapid growth rates and immediate returns.

The same process applied to science and technology. Thus, to the extent that the indigenous science and technology infrastructure was assisted, the principal conveyances were institutions of higher learning, university students trained at home and abroad, and, in general, the elites who were better prepared to absorb foreign scientific and technological imports.

Unfortunately, this "trickle down" strategy led, in many developing countries, to even more dualistic societies, where the benefits that accrued to one sector did not automatically improve the conditions of the majority of people or other sectors of the economy. It could even be said that science and technology contributed to social and economic divisions within society, exacerbated the problem of the "brain drain," and often led to the uncritical acceptance of foreign norms that accompanied technology transfer.

The recognition of these problems has not led to the rejection of the objective of economic growth, which re-

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mains at the heart of the development process. But the "trickle down" strategy is now dead. Instead, there has been increasing insistence in foreign aid programs on broader participation of people in the development process.

Avoiding the Negative Impact of Technology. It has been long recognized that the introduction of new technologies—imported or domestic—can create sharp discontinuities with harmful side effects on a country's culture, social dynamics, and political institutions and can have a dislocating impact on the existing economic endowment factors.

It is highly speculative to trace these unwanted and unintended effects to a particular technology or to the role of development assistance. Other factors could be equally blamed. Nevertheless, in some cases there is a need to be less uncritical and more objective. The "green revolution," for example, much as it has helped to increase global food production, was not without a stiff price tag for many rural communities where the necessary infrastructure was nonexistent. New high-yield grains could be used effectively by some farmers, but others could not afford them.

Nowhere is this phenomenon of double effect more pronounced than on the status of women in the less developed countries. In fact, the role of women in development has too often been ignored. Women in less developed countries have done the bulk of the farming and also handled the spinning and weaving, drawing of water, market gardening, and food processing. The ways in which new methods and technologies are introduced has tended to undermine these traditional roles and to restrict the economic independence of women. As development in the Third World has proceeded, women almost universally have lost ground—they are denied advanced training, lack access to credit and money, and are cut off from required technical skills. What is needed are science and technology policies that actively and equally involve and benefit women and open opportunities for [them] to become part of the modern economic system.

In these, as in a number of other cases, analysis which contrasts the negative impact of technology transfer with its beneficial effects may or may not balance out in favor of the latter. It is certainly true that some technologies require less labor than others. There are trade-offs between values and necessities. What one day appears to be a technological solution may give rise to new generations of problems. Nevertheless, while there is now a conscious effort to avoid these negative effects, it must be acknowledged that, given the need and demand for the transfer of more advanced technologies, such harmful consequences are not always avoidable.

Technology, after all, does not exist in a vacuum. Changing technologies imply changing institutions, policies, and societal values—in the advanced as well as in the developing countries. But the alternative to implied risks—and making corrections along the way—is the unacceptable option of no action at all.

Principal Approaches to the Transfer of Science and Technology. There is no field of endeavor in development and development assistance that does not, in some form and to some extent, involve technical skills, scientific knowledge, or technological hardware. Thirty years of development assistance has proven that even the most direct transfer of technologies is essentially an adaptation process that requires the existence of expertise—not only on the part of the donor but on the part of the recipient as well. Local adaptation of foreign expertise, the operation of imported equipment, or the effective use of technical assistance all require a high degree of collaboration [among] people of different cultures, experiences, and needs. Educational and training activities in many fields are, therefore, fundamental to the process of transferring and adapting technologies.

What one day appears to be a technological solution may give rise to a new generation of problems.

Science and technology have never been a separate domain in development assistance, with clear lines of demarcation from all the other activities.

Rather, they have always been an implicit, integral part of various specific programs or projects, whether they dealt with satellite communications or with the teaching of home economics.

Three basic approaches can be identified as characteristic of the programs that the U.S. Government—particularly AID and its predecessor agencies—have pursued in applying science and technology to development. Although these approaches have been pursued simultaneously, there have been varying degrees of emphasis on each, and each of them is interdependent with the others. These three approaches are:

- The building of indigenous infrastructures, national as well as international—institutions, organizations, and trained personnel—with the capacity to carry out effective development work and continue it after the termination of outside assistance;
- The direct transfer of capital goods, products and operational systems through concessional sales and grants for the purchase of equipment and services for the purpose of stimulating indigenous productive capabilities; and
- The provision of technical personnel and scientific knowledge to address development needs of specific nations, including direct use of expertise as well as support for research.

Building the Institutional Infrastructure. Most development programs can only be effective in the long run if they are supported by a wide range of indigenous research institutions and a cadre of trained manpower. Institution-building, with significant exceptions, has been a relatively lower priority effort of foreign aid. Nonetheless, U.S. activities have contributed in a major way to the establishment or strengthening of colleges and universities in several countries, industrial research and planning institutes, and major research facilities in other fields.

As discussed in a previous part of this paper, activities initially funded by U.S. private foundations led to the so-called green revolution, in particular to research breakthroughs at the International Maize and Wheat Improvement Center in El Batan, Mexico, and the International Rice Research Institute in Los Banos, Philippines.

Nine additional institutions are making similar contributions on food research: the International Center for Tropical Agriculture (Palmira, Colombia); the International Institute of Tropical Agriculture (Ibadan, Nigeria); the International Potato Center (Lima, Peru); the International Crops Research Institute for Semi-Arid Tropics (Hyderabad, India); the International Laboratory for Research on Animal Diseases (Nairobi, Kenya); the International Livestock Center for Africa (Addis Ababa, Ethiopia); the International Center for Agricultural Research in Dry Areas (Cairo, Egypt); the West Africa Rice Development Association (Monrovia, Liberia); and the International Board for Plant Genetic Resources (Rome, Italy).

The work of these centers is currently supported by a group of donors formed in 1971—the Consultative Group on International Agricultural Research (CGIAR). CGIAR involves some 30 donors and is under the auspices of the World Bank and the Food and Agriculture Organization. About one-fourth of the support is provided by the United States.

While receiving the advice of a technical advisory committee, the centers have a high degree of scientific independence and of dedication to achieving development results. They are linked to each other, to developed country laboratories, and to institutions in the developing countries that participate in the research and adapt the results to their local requirements.

Training programs for staff who will implement developmental projects are also an essential part of building local infrastructure. Each year AID supports 8,500 nationals of developing countries in training programs in a variety of fields in the United States and elsewhere. And local training opportunities are being made available through AID and other sources for young scientists, engineers, and managers in a number of technological fields in many countries.

Capital Goods Transfers. The direct transfer of capital goods, including technologies embodied in finished products, has been a function of the large economic transfusions that characterized the early years of U.S. development assistance. Concessional loans or grants for dams, airports, railroads, highways, machinery, and

equipment have contributed to the creation of needed infrastructure for economic growth.

A distinguishing characteristic of technology transfer via capital goods is that it represents a use of imported products rather than indigenously created or produced technologies. Their transfer should not be considered, however, as separate from the overall transfer of technology since their use, operation, and maintenance require the indigenous acquisition of skills—engineering as well as managerial.

Capital goods transfers are not meant as a substitute for private foreign investment or to compete with multilateral development banks. In the long run, such technology resource transfers are more directly affected by the trade, investment tariff, and tax policies of the industrialized countries as well as of developing countries. Currently, capital resource transfers, given the relatively scarce resources that official development assistance commands, are concentrated more on types that directly and immediately enhance the capacity of the developing countries to address basic human needs concerns.

Technical assistance includes support of activities to help small-scale farmers adapt technology to local conditions. . . .

Technical Assistance and Cooperation. There is no area of science and technology transfer where technical cooperation does not play a critical role.

Traditionally, as described earlier, technical assistance was the local application of expatriate knowledge to indigenous problems. Experience, however, has transformed technical assistance into technical cooperation—from a simple task-orientation to problem-solving, from the application of expatriate expertise to a shared learning process involving the beneficiaries themselves. Now it seeks to identify existing, unused, or underutilized technologies, both of indigenous and foreign origin, with a potential for application to developing nations and transform them where appropriate. It fosters research into development of new technologies. It offers developing countries specialized knowledge of concepts, methodology, and adaptation.

While it continues to provide technical expertise in many priority fields, the character of technical assistance has undergone major modifications. First, the foreign expert's role is no longer dominant. Second, there is a decreased dependency on the industrialized countries, as technological cooperation among developing countries is a growing phenomenon. Third, technical cooperation is becoming increasingly complementary to the building of an indigenous science and technology infrastructure. And fourth, technical cooperation augments the capacity of the developing countries to meet not only the problems they confront but global problems that confront all nations.

The methods of technical assistance and cooperation fall into a variety of categories.

The use of American experts—both in **advisory and operational roles**—continues as a significant device. Personnel hired by AID to provide these services are supplemented by the activities of a number of private organizations under AID contracts.

- The development of low-cost delivery systems to provide health, nutrition, and family planning services involves assistance at local levels. In 1978, the United States supported projects in 31 countries aimed at providing integrated health services to 186 million poor people.
- Technical assistance includes support of activities to help small-scale farmers adapt technology to local conditions, construct small irrigation systems and storage facilities, and utilize the recently developed high-yield grains.
- Drawing on its own experience in aiding the growth of small industries in rural areas, the United States is providing assistance in the promotion of small-scale industries in rural farm areas in 11 developing countries.
- In response to congressional directives, AID is sponsoring a private, nonprofit organization—Appropriate Technology International—to identify and assist in introducing technologies

most suitable to meeting various needs of developing countries.

Direct application of technologies already in existence is the most immediate form of transferring the benefits of scientific and technological development.

- The use of radio, television, and other educational technologies for instructional purposes has been employed by AID in assisting developing countries for over a decade. Classroom radio is a growing method of increasing access and improving quality at low cost. Experimental use of communications satellites for educational purposes was illustrated in a program conducted by the U.S. National Aeronautics and Space Administration and India.
- New AID legislation authorizes assistance to developing countries to strengthen their capacity to manage their environment and natural resources. More than 50 programs are being assessed for possible implementation. Technical assistance is already provided in interpreting and analyzing data acquired by Landsat satellites concerning the Earth's environment and resources.
- Tools of remote sensing are being applied in many developing countries to establish census boundaries, to monitor grain production, to locate potential mineral deposits, and to predict water runoff in mountain ranges.

The training of experts in the recipient country is a significant aspect in insuring understanding of scientific and technological developments.

- The U.S. National Bureau of Standards, through a variety of techniques including workshops and seminars, in cooperation with AID, has assisted officials from over 40 developing countries in improving standards and measurement services.
- Eventually a total of 6.5 million people are expected to be reached through a project operated by the American Home Economics Association with AID support. The project, which involves local and regional workshops for heads of families in 28 nations, provides family planning information, education, and services.
- Direct training of local farmers provides the benefits of scientific advances in food production. An AID project begun in an African country in 1976 will provide skills and training to some 14,000 farmers. The project will operate through the Central Cooperative Union, which will be able to reenforce and extend the training.

Support of research in a variety of fields—whether conducted in the United States, in intended recipient countries, or in international research centers—serves to apply scientific and technical skills directly to developing nation problems.

- AID has programmed over $16 million to support the new International Fertilizer Development Center in Muscle Shoals, Alabama, which has begun a major effort to discover new fertilizers and fertilizing methods for use in tropical developing nations.
- Similarly, AID supports University of Nebraska research into the genetic upgrading of wheat, Purdue University experiments in genetic improvement of sorghum, Cornell University research into soy-based supplements, and University of Georgia experiments in increasing the nutritive value of tropical root crops such as cassave, yams, and taro.
- The Caribbean Agriculture Research and Development Institute is being assisted in an investigation of the problems of small-scale farmers in the eastern Caribbean.
- A program of the Denver Research Institute has helped industrial research organizations in 30 developing countries improve their research on organization, management, marketing, and various technologies.
- The United States has made a 5-year commitment to provide support to the World Health Organization's special program for research and training in tropical disease. Support is also being provided for research on a heat-stable vaccine for measles, a malaria vaccine, and a drug for use against schistosomiasis.

Such activities as the foregoing illustrate only a small part of overall U.S. technical assistance and cooperative activities. To insure that such assistance is available to the largest number of countries possible, AID arranges reimbursable technical assistance to nations which can afford to cover the costs. The greatest demand

has been in the areas of public works and transportation, communications, housing, public administration, agriculture, health, manpower training, and mineral and water resources development. In 1977, 16 U.S. Government Departments and agencies were participating in providing such assistance to some 40 developing countries.

New Directions and Future Trends. During the past 30 years, varying shifts have been made in the areas of emphasis and in the policies governing official development assistance. The notion of what constitutes development has also moved with the times. Development, as measured by economic growth alone, has given way to fundamental questions about the quality of life. Any changes in foreign aid—in its strategies and concepts—require a constant search to make it more effective and its impact more directly beneficial. There has never been a change in the fundamental commitment of the American people to aid those in need.

The challenge of development assistance remains essentially the same—that of insuring that its resources reach the people who are most in need of help. This goes far beyond the mere provision of commodities or food or health services. It goes to programs of lasting impact, of making even the neediest people self-reliant and full-fledged participants in the economy and society, people who can in time become more productive and meet their basic human needs without continuing dependence on beneficial assistance.

The new directions in development assistance that now urge greater support for meeting basic human needs are novel not because they rededicate aid policies to serving people in need but because they establish explicit links between this objective and development strategies for achieving it.

- As an objective, the satisfaction of basic human needs encompasses such tangible and intangible minimum living standard targets as adequate sustenance, sanitation, health, clothing, shelter, and education for all human beings. Therefore, it stresses *equity*
- As a strategy, the satisfaction of basic human needs stimulates and directs overall production to meet these needs and serves to increase the productive capacity and income of the poor. Therefore, it emphasizes *growth*.

During the past several years, the United States has made major strides in focusing its assistance more sharply on the neediest sectors of the population, emphasizing increased food production; greater productivity of small farmers; expanding industries that create jobs; and basic programs in nutrition, education, health care, and family planning.

The greatest demand has been in the areas of public works and transportation, communications, housing, public administration, agriculture, health, manpower training, and mineral and water resources development.

Today almost 80% of U.S. development assistance goes to countries where annual per capita income is less than $300. Most of the science and technology programs that AID sponsors cater, therefore, to their needs. The critical challenge—facing both the leaders of developing countries and the aid programs of the industrialized countries—is the search for a strategy to give the masses of people greater access to technologies and to make them more familiar with, and receptive to, technologies that can best assist them in meeting their basic needs.

The first task is to make technological advances more affordable to those who most need them. For example, some research advances of recent years—as with the new grain strains and pesticides—have tended to be more accessible to relatively more affluent farmers than poor farmers. If scientists prove able to produce nitrogen-fixing grain strains and pest-resistant strains, the poor as well as more affluent farmers would benefit.

The second task has been to find more and better ways to bring scien-

tific, technical, and educational resources to bear on building institutional capacity in developing countries and sharing with them the task of solving critical development problems. This is obviously more difficult than simply sharing what is known; it calls for a change in style from the didactic to the experimental to self-reliant learning. This goes beyond applying science and technology to meet the basic needs of the developing countries. This calls for a strategy that enhances the ability of the poor to create and use science and technology to meet their basic human needs.

The mounting pressures of population, environmental deterioration, and resource depletion cannot be seriously addressed without major advances in science and technology.

The third task, therefore, is the building of institutions capable of broad problem-solving efforts, original research, and investigation in the developing countries. The current emphasis on the rural poor does not preclude application of what is discovered, invented, or adapted to other areas of development. Without indigenous capacity to analyze problems, [illegible] for solutions, create and use technolo[illegible] and organize and manage productive [illegible]cities, basic human needs will never be adequately addressed. Nor can rural development be achieved without attention to industrialization and to the mounting urban problems.

A fourth task is to apply science and technology to global issues. The mounting pressures of population, environmental deterioration, and resource depletion cannot be seriously addressed without major advances in science and technology.

The fifth and final task is the selection of the "right" technology. The expression "appropriate technology" is often used to mean "intermediate" technology, one between the primitive and sophisticated technologies. Appropriate technology is, indeed, often an intermediate technology—but not always. The science and technology requirements of basic human needs are similar but not synonymous with intermediate technology. Whether a specific technology is the "right" type of technology depends on site-specific considerations, including the availability of technical and managerial skills, labor, and capital resources. Depending on the problem and available resources, the choice of technology may be labor-intensive or capital-intensive. In many developing country environments, the resource endowment will dictate small-scale, centralized enterprise. At the same time, the production of petrochemicals, steel, and other goods where the economies of scale are extremely important may require highly capital-intensive, centralized production facilities.

In sum, appropriate technology enables developing countries to provide goods and services for their people in a manner which is compatible with their economic and social conditions. They relate to national employment, output, and equity objectives as well as global goals in these and such other areas as environment and population. Basic to the concept of appropriate technology is choice. Too often feasible technologies that could better achieve objectives have been ignored or dismissed. An open and flexible attitude is the key to selection of technologies that will best achieve the objectives we all seek.

"Appropriateness" refers primarily to the criteria of instrumentalities—to tools, equipments, procedures, skills, and capacities. But it does not address the principal development condition. After all, every technology is appropriate for reaching some objectives. Basic human needs also deal with the purposes to which technology is applied. These purposes in turn qualify what is "right" or "appropriate" and, in the final analysis, determine the choice among technologies.

INTERNATIONAL INSTITUTIONAL ARRANGEMENTS

U.S. experience indicates that policies and programs to enhance the contributions of science and technology to development should include a wide range of decisions and actions carried out through diverse governmental, in-

tergovernmental, and private institutions. The same conclusion is suggested by the diversity of the present and potential needs and capabilities of the developing countries themselves.

Efforts to strengthen institutional arrangements should, therefore, take into account such possibilities as those discussed below. These include basic approaches, regional arrangements, and the role of the United Nations and its family of agencies.

Basic Approaches

Several basic approaches of potentially widespread utility would strengthen existing international institutional arrangements.

The central need internationally is for "horizontal" networks and links among many institutions, whether governmental or private, working in the same or related problem areas. Such networks would involve a diversity of institutions in industrialized and developing countries as well as international institutions. There is no evident need for new "hierarchical" international structures.

"Institutional arrangements" should be viewed broadly as embracing not only "organizations" in the traditional sense and formally established relationships but also informal working relationships among governmental and private organizations. Such relationships could be advanced through a variety of means—study groups, seminars, conferences, improved information exchange including exchange of the findings of specific research projects conducted separately but directed toward the same or related problems, collaborative research efforts, and other problem-solving approaches frequently arranged on an ad hoc basis.

Increased effectiveness of efforts to apply science and technology to development will also depend on increasing cooperation among the developing countries themselves, to share their own experience, knowledge, and skills. The United States, therefore, supports the general recommendations and the programs for action of the recently concluded U.N. Conference on Technical Cooperation Among Developing Countries.

Perhaps the most basic institutional implication of efforts to enhance the contributions of science and technology to development is that their success will depend on the systematic strengthening of the scientific and technological capabilities of the developing countries. The U.S. Government assumes that there will be broad agreement that a major objective of UNCSTD will be to achieve an international commitment to cooperation in further strengthening the indigenous scientific and technological capabilities, including institutional capabilities, of the developing countries. The U.S. Government believes there is no need for a separate new institution at the global level to deal with this matter. However, as discussed below, improvement can be made in the framework of present U.N. organizational arrangements.

The needs of developing countries are so significant and so diverse that governments and private institutions should be prepared to cooperate in innovative arrangements and procedures on a consciously experimental, trial-and-error basis—recognizing that mutual respect and confidence frequently make more important contributions to successful cooperation than the establishment of formalized arrangements.

The central need internationally is for "horizontal" networks and links among many institutions, whether governmental or private, working in the same or related problem areas.

Regional Arrangements

The employment of science and technology in support of development has strong implications for regional as well as more broadly international arrangements. The role of regional institutions in science and technology, including the U.N. regional economic commissions, warrants a systematic

and detailed study of options and constraints.

Because of the significant differences between the needs and resources of the several developing regions and of various countries within each of these regions, and because of the different scientific and technological problems that need to be addressed, there are few, if any, institutional "models" valid for all regional needs and purposes.

Evolving organizations will need to be highly pluralistic in their approaches in order to meet the varying and changing needs that will confront them.

It may be possible to establish a number of international and consultative arrangements, involving both private and governmental expertise from a number of countries and designed to address specific critical problems; also to secure the needed level of financial support through arrangements similar to those which have worked well in the case of the Consultative Group in International Agricultural Research. Such arrangements would not necessarily involve new research centers but could include a variety of approaches. The basic principle involved is to encourage and provide financial support for cooperative problem-solving efforts while maintaining the freedom of scientific and technological inquiry needed to elicit the best efforts of researchers.

There are many who support President Carter's proposals on the "Reform and Restructuring of the U.N. System," particularly U.S. suggestions for achieving greater efficiency within the United Nations.

The United Nations System

At the present time there is within the U.N. system no widely accepted definition of what constitutes a "scientific and technological activity" for development (in this respect the situations in the United Nations and the U.S. Government are quite similar).

Practically all science and technology activities are carried out in the specialized agencies and other U.N. organizations in accordance with their specific mandates. In general, many of various activities within the U.N. system (training scientists, engineers, and managers; introducing advanced techniques; and providing other assistance) contribute to the development process through enhancing the scientific and technological awareness and understanding of developing countries as well as their indigenous capabilities.

In several U.N. organizations, science and technology constitute major, identifiable elements of their programs. In others, science and technology are significant elements of their programs but are not separately identifiable.

The United Nations and various specialized agencies also sponsor training for holders of fellowships. The United States cooperates in arranging training for some 300 U.N. fellows each year and in placing fellows sponsored by various specialized agencies.

Despite the difficulties of making a detailed quantitative assessment of "science and technology" activities throughout the U.N. system, efforts have been made to assess the extent of these activities. For example, a report of the U.N. Administrative Committee on Coordination estimated that in 1977 nearly $65 million was devoted to scientific and technological activities related to the mandates of specific U.N. agencies. (On balance, this estimate appears very low and seems to reflect an exceedingly narrow definition of the scientific and technological activities of a number of U.N. agencies.)

There are many who support President Carter's proposals on the "Reform and Restructuring of the U.N. System," particularly U.S. suggestions for achieving greater efficiency within the United Nations. These suggestions look toward more effective managerial control and accountability so that the United Nations can become more responsive to the needs of individual countries and the requirements of addressing compelling global problems.

Strengthening the effectiveness of science and technology activities throughout the U.N. system calls for at least four points of emphasis.

- Regarding overall management, the U.S. Government believes it would be desirable to assign responsibility to some institution within the present U.N. system to serve as a focal point for science and technology having a measure of authority for proposing actions, monitoring programs, and serving as liaison with the international scientific community. In this connection, the United States has already called attention to the need for expanded coordination of the technical assistance activities of the U.N. Development Program and other U.N. agencies.
- More comprehensive data must be collected on the many components of the U.N. system that depend most heavily on science and technology for their work. Preparations for UNCSTD have revealed such serious deficiencies in this respect, for example, that even the most elementary kind of program budgeting simply cannot be done for research and development in the U.N. system.
- The most senior officials at U.N. headquarters and at the major agencies must have available sound and independent advice about the technical quality of and new technical opportunities for major U.N. programs. Strengthening both staff functions and advisory support in science and technology should be considered.
- Programs at the most decentralized levels—at the country level and the village level—must receive adequate technical attention. Thus, even as the scientific and technological functions of management at higher levels are being strengthened along the lines mentioned above, it will be important to focus on how adequate scientific and technological advice can support ongoing programs in the field.

In summary, the U.N. system as a whole must be made to work more effectively with a stronger "strategic" sense of science and technology at the top of the system, along with greater technical talent applied in the field. Intermediate levels of organizational coordination should, in principle, be much more efficient within such a framework.

In addition to the foregoing, in the U.S. view, the participants in UNCSTD might well agree on a limited and carefully selected set of specific high priority development problems for pilot activities in international technological collaboration.

Assignment of responsibility for sponsoring such activities might include existing international financial institutions, the regional development lending banks, and the specialized agencies and possibly some advanced technical organizations. But these, in turn, should be urged to search for innovative ways to bring scientific and technological knowledge and know-how to bear more directly on the solution of specific problems of human and resources development in their areas of specialization. And any such pilot activities should be reviewed and assessed as a program of experimentation and learning.

FUTURE COURSES OF ACTION

It is not enough to define desirable futures and expect that science and technology will work their way in the desired directions. That technology is not intrinsically beneficial is attested to by the dangers of nuclear war, the proliferation of conventional arms, the depletion of criticial resources, and environmental pollution.

Man's Promethean powers are a mixed blessing. Future progress in technology will not necessarily or automatically resolve all the problems that past advances of technology have bestowed upon the present. The continuing evolution of technology does not accommodate a moratorium that gives us time to create preconditions in which technology can only act in beneficial ways. The major challenge, therefore, is whether we allow technology to set its own pace and direction or control it ourselves.

That science and technology should serve human ends, assist in the elimination of the worst aspects of poverty, stimulate self-sustaining economic growth, and be harnessed to confront global challenges are goals in which all nations—irrespective of ideology and economic status—have a stake.

It is imperative that we view this conference from the outset as a major

collaborative effort for common ends. As previous U.N. conferences have proven—on the environment, population, women, and a host of other issues—all nations have everything to gain, and none has anything to lose.

While this conference will concentrate on the application of science and technology for development, with the primary focus on enhancing the less developed countries' capacity to create and adapt technologies, the industrialized countries—including the United States—also have a major stake in its eventual outcome. They recognize that the ways in which the developing countries improve their technological conditions are vital to the economy, to their quality of life, and to the very survival of the industrialized world. Global issues that are directly related to the diffusion and beneficial utilization of science and technology—such as pollution, environmental protection, natural resources, food production, narcotics, disease control, fertility rates, the management of the ocean and deep seabeds, nuclear power sources, satellite communication—all directly affect the United States as well as the other advanced countries.

Therefore, it is in the interest of both the developed and the developing countries to initiate policies and implement practices that emphasize fairness among global partners, acknowledge need, and reward positive action that alleviates that need. The world cannot be divided into producers and creators, on the one hand, and purchasers and consumers of technology, on the other hand, without continuing the prospect of confrontation.

The transfer of technology for development is, therefore, more than the transfer of commodities or of technologies embodied in products. It is, first of all, a transfer of the processes of science and technology to enhance the developing countries' capacity to understand, adapt, create, use, manage, maintain, and market their own technologies. Approaches to increase self-reliance in science and technology constitute an important long-range step to reduce the technological gap between the developing and industrialized countries and to permit the developing countries to contribute their talents to global prosperity.

Fairness, need, and action in the global transfer of science and technology suggest certain norms worth considering.

First, the transfer must be a cooperative and joint effort of governments and the private sector in which development priorities of the recipient countries are respected and in which private industries and organizations enjoy due protection and due returns on their investment and inventiveness.

Second, in order to have an effective transfer, the information base in the developing countries must be broadened to permit them to select what they need from the international supermarket of technology, to reject what they do not need, to choose among competitive offerings, and to acquire what is most appropriate and economical to their development needs.

Third, the transfer must include an increasing shift in research and development to the developing countries. Research and development that are locally based and oriented toward indigenous resources, needs, and demands contribute not only to the growth of self-reliant capacities but to a widening of markets and technological innovations as well.

Fourth, the transfer of technology must occur not only between the North and the South but among the developing countries themselves. The 1978 U.N. Conference on Technical Cooperation Among Developing Countries was a promising indicator that de-

Research and development that are locally based and oriented toward indigenous resources, needs, and demands contribute not only to the growth of self-reliant capacities but to a widening of markets and technological innovations as well.

veloping countries can also serve as significant exporters of technological know-how and that the industrialized countries need not be the sole and indispensable clearinghouse for the global flow and circulation of technology.

With these general norms in perspective, three major future courses of action need to be explored. In developing its own recommendations, the U.S. Government is reviewing the need to:

- Assist in strengthening indigenous capabilities of developing countries;
- Improve arrangements within the United States in order to draw more effectively on science and technology in meeting needs of developing countries; and
- Enhance collaborative efforts among nations.

Strengthening Developing Country Capabilities

One of the principal issues this conference may consider is that of strengthening the indigenous scientific and technological capabilities of developing countries. This should entail:

- Strengthening the capabilities of developing countries for assessing, selecting, inventing, adapting, and disseminating technologies tailored to their specific goals and situations;
- Improving their ability to make the best use of presently available scientific knowledge and technological know-how; and
- Establishing a stronger base from which developing countries can increasingly make their own contributions to the world's scientific knowledge and technological capabilities.

There are several areas in which intensified efforts can be expected. Support for educational institutions and programs suggest themselves as logical measures. This might include expanded programs for undergraduate and graduate study in fields of physical and social sciences, as well as engineering, medicine, health, and management. It would also involve training in vocational skills for workers and paraprofessional training in medicine, engineering, and a host of other fields.

In order to respond to local needs—primarily but not exclusively in the fields of agriculture, health, and energy—research and extension service organizations could be expanded in order to make the best use of local materials, adapt effectively the imported technologies, and develop indigenous patterns of innovation.

Much can be accomplished by enhancing the technological and managerial qualifications of developing country personnel engaged in the various transactions of technology transfer. This implies improved negotiating skills on the part of the developing countries and reliable information on sources, availability, and cost of technologies so that they may reach equitable bargains with multinational corporations. It also includes the strengthening of indigenous capabilities in the area of licensing to facilitate the reception of technologies and to encourage inventiveness and innovation. Along these lines, the development of standards is also essential to assure competitiveness in local and international markets.

Improving U.S. Institutional Arrangements

The pluralistic nature of American society makes the support of Congress and the private sector essential in improving U.S. policies and programs to promote the application of science and technology for development. As described in earlier sections, the U.S. Government has no monopoly over scientific and technological affairs, though it supports and, in some areas, regulates them. The Agency for International Development, in cooperation with a number of Federal agencies, continues to be a major resource transferer to the less developed countries and a broker between the American scientific community and the technological needs in the developing areas. Most of the science and technology transfer and the development of indigenous capacities will, however, be decisively influenced by the active cooperation of the private sector, industries, banks, research firms, foundations, universities, and voluntary organizations.

Within this context, there are, however, several major policy and action initiatives that should improve the U.S.

institutional arrangement to speed up and expand the use of science and technology for development. Bilateral official development assistance will continue to stress resource transfer strategies that emphasize the meeting of basic human needs in the context of self-reliant economic growth. Multilateral assistance, through the U.N. family of agencies and international financial institutions, will emphasize these objectives along with the global approaches to global problems.

On March 29, 1978, President Carter announced, in a speech to the Venezuelan [Congress,] that the United States intends to establish a new organization to improve technological cooperation with the developing countries. Although still in the planning stage, this new organization—the Foundation for International Technological Cooperation (FITC)—should provide a substantial contribution to the effectiveness of U.S. cooperation with developing countries.

The primary purpose of the foundation is to improve the availability and application of technology, and to expand knowledge and skills needed to meet these problems. The foundation would work with all developing countries, including middle-tier countries, in collaborative programs for this purpose. It would address problems of mutual concern to the United States and the Third World including the still unmet pressing needs of nutrition, health, and education and the major global problems of energy, natural resources development, and environmental protection. The foundation would be specifically structured to have developing country experts participate at all levels of the foundation's planning, programming, and evaluation to insure a truly collaborative method of operation.

Capacity Building. The foundation would work with developing countries as they build their own capacities to generate, adapt, utilize, and diffuse technologies needed for their development. As examples, FITC may engage developing country experts on programs of joint research and testing of new systems which will build experience and ability. It may assist by improving the quality of training programs. It may help institutions abroad through provision of American experts, materials, and relevant teaching methods.

Research and Development. The foundation would plan with developing countries—and support through grants and contracts—research on critical development problems. The ineffectiveness of some vaccines, the resistance of pests to chemicals, the need for new energy supplies, the demand for lower-energy agricultural systems are examples of problems where research is clearly needed.

Building Cooperative Linkages. The foundation would foster linkages between the scientific and technological communities of the Third World and those of the United States through exchange and support for joint research and problem-solving activity. It would encourage cooperative linkages between institutions and professional associations and facilitate formation of networks of scientists to address persistent problems.

Marshalling U.S. Agency Resources. The foundation would serve to bring more harmonious planning and improved coordination among various U.S. public and private agencies whose science and technology activities bear on development problems.

Building U.S. Competence. The foundation would strengthen the capabilities of U.S. scientific and technical institutions so that they may work more productively with developing countries in research, training, and other cooperative efforts.

Involving the Private Sector. The foundation would work with the private business community to promote cooperative arrangements for management training and other programs which will improve the environment and process of technology transfer.

The complexity and magnitude of U.S. scientific and technological activities means that a great many private institutions will continue to engage in activities that presently or potentially serve international development needs. The mobilization of the large scientific and technical community spread

throughout universities, research institutes, industrial organizations, and other places is a large task. Some special organizations to aid developing countries have already proven to be highly effective—including the Population Council, the Midwest Universities Consortium for International Activities, and the Institute of International Education. The need to strengthen the capacities of such organizations and to develop new ones where required has been recognized and encouraged by the U.S. Government.

Continuing efforts will also be made to insure an effective, equitable role by private industry. To this end, the United States has already initiated, for example, a project to familiarize small- and medium-sized firms in the United States with opportunities so that they may play a more active role, possibly through building relationships with firms of similar size in developing countries. Other direct collaborative arrangements between U.S. business and industry and developing nations will continue to be encouraged, since these relationships provide the most likely stimulus to technology that is newly created or adapted to the specific needs of these countries.

Improving International Cooperation

All measures involving scientific and technological cooperation between the industrialized countries and the developing areas will be influenced to a decisive degree by the global infrastructures of cooperation. No effort between individual countries or even a group of countries can, in the longrun, respond adequately to the task of an increasingly interdependent world.

Beyond the existing or proposed arrangements to apply technology and science to development, this conference should also consider the wide diversity of relationships that characterize the interactions among states and between governments and transnational institutions and corporations.

Collaborative problem-solving efforts to confront all global problems that have impact on individual countries should suggest that this conference enlist the support of the participating governments for the following purposes:

- To insure the availability of sound and independent scientific and technological advice throughout the U.N. system and to enhance the capacity of the United Nations to manage scientific and technological programs;
- To cooperate in a sustained effort to help developing countries expand their indigenous scientific and technological capabilities and assign responsibility within the U.N. system for monitoring and catalyzing this effort;
- To support systematic study of possible improvement for regional and interregional level organizations in specific subject areas of critical importance and for specific functions;
- To make appropriate institutional arrangements at national levels to sustain these efforts;
- To consider assigning higher priority in their national research and development programs for problems of pressing interest to developing countries; and
- To endorse a carefully selected set of experimental and pilot activities involving joint efforts to bring scientific and technological resources to bear upon specific high priority developmental problems.

In contrast to previous U.N. conferences which addressed specific—though major—global problems, science, technology, and development cut across all fields of endeavor and influence decisively the manner in which we approach the world's critical issues.

To the extent that the U.S. experience with science and technology in its own development is applicable, and to the degree that the U.S. contribution to the developing countries is important, the conference can confidently look toward an active U.S. participation. Between now and August 1979, when the conference convenes for its final and decisive session in Vienna, Austria, events will alter many of the currently significant issues. They will not, however, in any way lessen the U.S. resolve to be a constructive partner in this unique effort to make science and technology work better for man.