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SOME UNITED STATES ACTIVITIES USING

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SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

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USING SCIENCE AND TECHNOLOGY FOR DEVELOPMENT: SOME U.S. ACTIVITIES

This pamphlet was prepared by the United States for use at the U.N. Conference on Science and Technology for Development (UNCSTD) which convened August 20, 1979, in Vienna, Austria. The U.S. activities described do not purport to be a full range of developmental programs, nor are they necessarily typical. Rather, they simply illustrate the variety of scientific and technological assistance projects which the United States has conducted for more than three decades.

Since the end of World War II, the United States has spent in excess of $100 billion for economic assistance. In addition, U.S. programs, particularly those of the Agency for International Development (AID), have enabled thousands of Americans to put their scientific and technical talents at the service of developing-country needs. Indeed, 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.

In its earliest years, U.S. development assistance focused on direct application of U.S. know-how and goods to economic and social problems in developing countries. As it became apparent that effective technological transfer depended for success on local capacities to absorb it, more stress came to be put on helping to build indigenous infrastructures, national as well as international—institutions, organizations, and trained personnel—with the capacity to absorb and adapt ideas and technology from outside long after foreign assistance had been phased out.

These approaches still characterize much of the U.S. program today. They have been joined by an increasing tendency to work collaboratively with others to try to solve some of the most persistent development problems, especially those relating to the basic requirements of the poorest sections of the population. Thus, over the past several years, AID has made major strides in focusing its technical assistance more sharply on increased food production; greater productivity of small farmers; small and medium-sized industries that create jobs; and basic programs in nutrition, education, health care, and family planning. Along with these shifting concepts of what constitutes effective development assistance has come a heightened understanding of how many aspects of development are still poorly understood and the consequent need to enlist the insights of research to fill gaps in our knowledge.

While AID has many qualified scientists, engineers, and technical experts on its staff, its role is essentially that of a broker between the needs of developing countries and the scientific and technical community, both in and outside of government. Thus, "AID projects" are often carried out by others—U.S. and foreign government agencies, international organizations, universities, research institutions, industries, trade unions, nonprofit and voluntary organizations—acting under AID contracts and grants.

In addition, both AID and other U.S. agencies are increasingly involved with international networks of researchers working on problems of specific interest to developing countries. They support participation of U.S. specialists in international meetings and conferences. They encourage research collaboration between scientists and engineers in U.S. institutions and counterparts abroad. They coordinate their own research and development programs, and those they support in the private sector, with important scientific and technological programs sponsored by the United Nations and other international agencies. In some cases, AID funds have enabled some of the essentially domestic agencies to build an international capability. In others, the international implications of problems being faced in the United States and the need of U.S. science and technology to keep abreast of new developments around the world simply require that these agencies look increasingly outward. Thus, the Departments of Health, Education and Welfare, Energy, and others, as well as AID, are working closely with the international scientific and technical community for research and development addressed to development needs that cut across national boundaries and affect U.S. interests no less than those of the Third World.

The programs and projects described in this pamphlet illustrate some of the mechanisms that have proved useful in marshaling the many talents that exist in the United States and around the world. They range over subject matter as diverse as health delivery and space technology, forestry and family planning, small industry and soil science research. A limited selection of the sort presented here cannot, of course, do full justice either to the United States or to the many governments and institutions with which the United States cooperates. One study identified more than $1 billion in U.S.-supported projects involving significant scientific and technological components. Nonetheless, it is hoped that these illustrations convey some idea of the range and content of U.S. interests in international development.

AGRICULTURE AND RELATED FIELDS

Programs in agriculture and related fields have always been a fundamental component of U.S. development assistance. These programs have taken on ever-greater urgency in view of the overwhelming need to feed the world's growing population, much of which still goes to sleep hungry.

In recognition of the continuing gaps in knowledge of how to meet this problem, U.S. programming increasingly emphasizes support for research, both basic and applied, in all parts of the developing world. It provides important support for the burgeoning network of international agricultural research centers as well as for basic studies like the benchmark soils project, both of which are described below. Many other U.S. programs emphasize the application and adaptation of agricultural research to specific circumstances in specific countries. One such program in Kenya is described in these pages.

Of course, the United States also continues to support many agricultural extension projects, demonstrations of new techniques and systems, training programs, credit schemes, and the like in individual developing countries. Re-

sponsibility for these projects normally lies with the appropriate governmental authorities in the country concerned. AID's contribution often is to pay the foreign exchange costs of U.S. equipment, training, and personnel when they are requested by those authorities. The U.S. Department of Agriculture and U.S. land grant universities frequently provide the substantive expertise, though more and more often AID is contracting with Third World institutions, like the Institute for Oil Palm Research in Nigeria, or with international institutions, like the International Maize and Wheat Improvement Center in Mexico, to undertake research or training. In some instances, as with the foreign currency agricultural research grants of the Department of Agriculture, grants have been made directly to Third World investigators. The programs described here are but a few of the many U.S. activities that relate broadly to the rural sector.

International Agricultural Research

U.S. development assistance seeks increasingly to encourage the international scientific and technical community to collaborate in research on specific development problems. The work of the **Consultative Group on International Agricultural Research** (CGIAR) has proved how valuable it can be to harness these energies for development purposes.

The CGIAR finances and coordinates the growing network of international agricultural research and training centers which are using biological and socioeconomic research techniques to explore new ways to advance agricultural progress in the Third World. These centers link with national research programs of developing countries and with appropriate research activities in selected institutions of developed countries to form a continuum of scientific activity that extends from the farm level to the research laboratory. Private U.S. foundations were among the first to support this kind of activity. It is now sponsored jointly by the United States; the Food and Agriculture Organization; the World Bank; the U.N. Development Program; and 32 other governments, international regional organizations, and foundations, with the United States providing about 25% of total funding.

Programs supported by CGIAR now embrace the major food crops and livestock in most ecological zones of the developing world. Their hallmark is research carried out by multidisciplinary teams of scientists, including plant breeders, geneticists, soil scientists, plant physiologists, entomologists, economists, and others as a particular problem may demand. By 1976, there were 11 centers and programs employing more than 300 principal scientists and more than 4,000 persons in all. In addition to its basic research program, each of the centers engages in substantial training and outreach activity to help individual developing countries convert research results into production results on farmers' fields.

This sustained international effort is paying off. For example, by 1976–77, high-yielding varieties of rice developed by the **International Rice Research Institute** (IRRI) in the Philippines were planted on about 25 million hectares, representing 28% of the total area planted to rice in developing countries. High-yielding varieties of wheat, developed by the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, were planted on about 30 million hectares in developing countries, or over 44% of their total area under wheat.

The successes of IRRI and CIMMYT are well known. The work of the remaining centers shows equal promise.

- The **International Institute of Tropical Agriculture** (Nigeria), begun in 1967, has developed farming systems that reduce erosion and increase production. Insect-and disease-resistant cowpea varieties have been identified. Higher yielding strains of cassava and maize have been bred and distributed, and a promising zero-tillage system for maize production has been developed. The Institute is also working on improved varieties of yams, sweet potatoes, and rice.
- The **International Center for Tropical Agriculture** (Colombia), opened in 1968, is working on cassava and beans in rotation with corn. Improved disease-resistant cassava varieties have been identified. The center also conducts research on rice and maize and on pastures and forage to increase beef production.
- The **International Potato Center** (Peru), begun in 1972, has made progress in developing white potato varieties with greater disease resistance and tolerance of a range of climates. Low-cost solar dryers are under development.
- The **International Crops Research Institute for the Semi-Arid Tropics** (India) since 1972 has been identifying sorghum varieties with greater resistance to pests and diseases and has begun to breed superior pulse varieties. A major accomplishment has been the design of an improved water-management system.
- The **International Laboratory for Research on Animal Diseases** (Kenya) was established in 1974 to develop control methods for certain devastating livestock diseases. The Laboratory has now developed a method of growing trypanosomes outside a host animal, a significant step toward developing a cure for sleeping sickness. The Laboratory is also doing research on theileriosis (east coast fever).
- The **International Livestock Center for Africa** (Ethiopia) was begun in 1974 to support efforts of countries to improve systems for producing livestock and for marketing livestock products.
- **The International Center for Agricultural Research in Dry Areas** (Syria), opened in 1976, serves as a world center for improving barley, lentils, chickpeas, broadbeans, and forage legumes. The Center's overall purpose is to study farming systems in countries with Mediterranean-type climates and cool winters.
- The **West African Rice Development Association** (Liberia), a cooperative intergovernmental regional organization dating from 1971, emphasizes the importing, testing, and identifying of improved rice varieties for the 14 countries of the region.
- The **International Board for Plant Genetic Resources** (Italy) was begun in 1974 to encourage and assist the collection, preservation, and exchange of plant genetic material. More than 50 genetic resource centers are now working with the Board, and a computer-based classification system has been completed.

Benchmark Soils Project

AID supports a number of potentially important collaborative research programs in addition to CGIAR. One such is the benchmark soils project, a combined effort of the Universities of Hawaii and Puerto Rico and researchers in Indonesia, the Philippines, Brazil, and Cameroon. By providing a common base of knowledge about key tropical soils, these scientists are aiming to shorten the expensive and time-consuming process of making site-specific experiments all over the world to determine optimum farming practices.

The benchmark project builds on the soil taxonomy developed over the past 30 years by the Soil Conservation Service of the U.S. Department of Agriculture. The taxonomy is a system for classifying soils into a limited number of orders and suborders, which are in turn divided into narrower groups, subgroups, and families on the basis of their physical, mineralogical, and chemical characteristics; their climatic environments; and other variables.

Wherever they occur, soils of the same family have certain limiting factors that affect crop yields—their water-supplying capacity, their nutrient supply, the availability of energy (sunlight and temperature), erodability, and so on. Thus, simply knowing the family characteristics of a soil (and therefore the limiting factors that must be overcome) could save agricultural scientists much of the time and energy they would otherwise spend on site-specific investigation.

The soil taxonomy was originally prepared for U.S. soils, however. Its classification of tropical soils is incomplete. The benchmark soils project thus seeks to study and correlate the characteristics of key—or "benchmark"—tropical soil families and to store the resulting information in a computerized soil data bank maintained at the University of Hawaii. Project scientists have begun investigations of three such families of soils at widely separated sites in Latin America, Africa, Asia, and the Pacific. They are also testing the proposition that soils with similar characteristics will, in similar climates, have similar production potential and require similar farm management techniques.

The research is already yielding practical results. The investigators have found, for example, that one family of volcanic soils does not necessarily need the lime treatments usually recommended for acid soils because it contains relatively little extractable aluminum and relatively high amounts of calcium. This finding applies to soils as far apart as Java (Indonesia), Luzon (Philippines), and the island of Hawaii; it could result in considerable savings for farmers wherever this particular kind of soil occurs.

This approach to deriving farm management recommendations from a knowledge of standard soil classifications is beginning to spread. The Indonesian Soil Research Institute, for example, is now analyzing other families of soils in south Sumatra using benchmark concepts and methodology. Its hope is to provide newly resettled Javanese farmers with advice on how to obtain good results from Sumatran soils that are quite different from the ones they knew at home. The success of Indonesian plans to relieve population pressures on crowded Java may well hinge on advice of this sort.

As more and more information on different tropical soils is added to the soil data bank and cross-referenced and analyzed, agricultural experimental stations throughout the tropics will be able to use the basic taxonomy in their own studies. At least 20 other institutions and organizations have submitted tropical soil profiles and related data to the bank. This information, as well as derived or calculated data, can all be retrieved quickly and easily from the bank's system, thus enhancing the possibility of agricultural information exchange within and among tropical developing countries.

To encourage linkages among interested parties, the soils project is conducting seminars and workshops, disseminating progress reports, and providing training to soil scientists from developing countries. The project is also working cooperatively with a number of the CGIAR research centers as well as with national research organizations in Europe and the Third World. It is an example of the kind of international scientific and technical collaboration that the United States believes holds great promise for the future.

Kitale Maize

International agricultural research must be complemented by adaptive research in myriad country- and site-specific situations before results can be seen in farmers' fields. For this reason, much of U.S. agricultural assistance has always gone to support development, testing, and distribution of improved varieties of crops at the national, even subnational, level.

The improved maize varieties now being grown over large parts of Kenya are a result of one such investment. Maize is an important human as well as livestock food in Kenya. In the highlands, it is grown mainly as a commercial crop, for sale in the cities. In the lowlands, it is usually grown as a subsistence crop to be consumed on the farm. Thus, urban consumers as well as farmers could benefit from improved maize quality.

At Kitale, Kenya: Inspecting experimental hybrid maize that grows two ears instead of one. (Photo by AID)

Work on breeding methodology began as far back as 1964 at the Kitale research station in Kenya under the direction of a maize geneticist from the U.S. Department of Agriculture. This research program, with support from AID, was originally designed to serve the several countries of the East African region, but it became a national project after the breakup of the East African Community in 1977. Its major focus was to promote improved breeding techniques for maize and to supply desirable germplasm to breeders in Kenya and other parts of East Africa. The emphasis was on enhancing protein quality, disease resistance, and yields. The Opaque-2 gene, which is associated with improved protein, was to be utilized in the conversion of improved seed lines adapted to both high and low altitudes. A protein quality laboratory, also supported by AID, was established to evaluate new lines.

As the Kitale program progressed through the years, variety trials of various seeds were undertaken by up to 100 cooperators a year in different ecological zones; technical papers were published; reports were issued; and breeders in national programs were informed of progress through biennial regional workshops. Annual planning conferences were conducted for Kenyan breeders, and classes in breeding methods were conducted at both Kitale and the University of Nairobi. In recent years, this work has been carried on largely by Kenyan technicians, some of whom were trained at the International Maize and Wheat Improvement Center in Mexico and other institutions abroad.

As improved varieties and genetic material were developed, they were made available for commercial use as well as for continued input into a program to improve maize populations. The Kenya Seed Company, which has a monopoly on sales of improved maize varieties in that country, was advised on seed production techniques and began to incorporate genetic material from Kitale in virtually all its hybrid varieties. Seed companies in Tanzania, Ethiopia, Uganda, Zambia, and elsewhere also began to use Kitale methods and materials.

Acceptance by Kenyan farmers, especially the commercial farmers in

the highlands, has been little short of amazing. In 1976–77, they bought 122,240,000 kilos of improved maize seed, 6.4 times the amount in 1967–68. Seventy percent of this seed went to farmers cultivating less than 2 hectares, 90% to those with less than 20. Based on yield data, the increased production over old varieties is estimated to have had a value of $45.8 million (U.S.) in 1976–77.

The Government of Kenya has now established a semiautonomous Kenyan Agricultural Research Institute to continue and expand the maize breeding effort. Future AID support will focus on identifying and testing varieties of maize and other crops particularly suitable for the lower altitude, rain-short areas of Kenya where subsistence farming is concentrated. Ironically, the need for training Kenyan scientists and technicians for this work is as great as ever, because Africans who have been associated with the high-quality work of the past have found their skills highly marketable; many have been promoted to administrative positions or hired by private seed companies, universities, and international research institutions.

Pondculture and Other Fisheries

A basic objective of U.S. technical assistance to developing countries is to promote technology that is useful to the rural poor. While the most appropriate technology for this purpose may be quite simple, it is often based on the results of sophisticated scientific research.

In Panama, for example, farmers in very poor communities in the mountain province of Veraguas are raising tilapia and other food fish in small community ponds that they have built themselves under a project supported by the Panamanian Government and AID. The fish, which provide badly needed protein for local diets, feed mainly on plankton, which grows profusely in the ponds because they are fertilized with wastes from the pigs and ducks introduced under the project as "cash crops." The pondculture research station of Panama's National Directorate of Aquaculture has, among other things, developed an ingenious system for aligning the ponds and animal pens so that water flows from a spring or stream through the pens to carry wastes into the pond. Thus, the pond water serves as an aerobic waste-disposal lagoon, produces a large crop of fish for local consumption while cash crops of animals are being reared, and provides a focal point for community development generally; enriched water from the ponds is now being used to irrigate and fertilize vegetable crops and fruit trees in the surrounding area.

The first of the community ponds were built as demonstration projects. Now individuals and groups of families are beginning to build them on their own, and Panama plans to create a revolving loan fund to help others do so through rural cooperatives, which are also supported by AID. In fact, the ponds have become so popular that the demand for help in designing, building, and stocking them now far exceeds the directorate's available resources. AID expects to help Panama expand the program to other areas and with such new types of fish as the Chinese carp, which will further increase production.

The Panamanian pondculture program is deceptively simple. It builds on a sophisticated knowledge of complex relationships—for example, of the dietary requirements of cultured fish and the water chemistry-aquatic plant relationships that are best for managing the pond environment.

Auburn University, in Auburn, Alabama, is perhaps the leading center in the United States for research on low-technology fish production. Its unique approach to experimentation, supported by excellent field facilities, has resulted in the development of techniques and procedures of warm-water fisheries management and aquaculture that are today in general use throughout much of the United States and in many foreign countries.

Thanks to sustained support from AID, the university has been able to build its International Center for Aquaculture into a major source of advice, training and research for developing countries. The chief of Panama's National Directorate of Aquaculture received graduate training at Auburn. Indeed, graduates of Auburn's degree and special nondegree programs are now at work in almost 30 developing countries from Taiwan to Swaziland, from Colombia to Nepal. Research undertaken by these graduates while at Auburn has enriched the total knowledge base available to development workers everywhere. In addition, more than 80% of the Center's staff participate directly in overseas projects. Fishculture surveys and short-term studies relating to specific fisheries problems have been carried out in 50 countries, most at the request of AID missions and their host counties. Center experts helped to plan and build the pondculture research station in Panama, for example. Ten staff members are currently serving as resident fisheries advisers in other developing countries. Another is supervising a large-scale private fish farming operation in Nigeria. Thus, Auburn University is at the center of a network of ongoing, mutually reinforcing aquaculture research and development that is making a visible difference in the lives of the ordinary people who are the ultimate targets of development programs.

Within the U.S. Government, the major source of expertise and training in fisheries management and development is the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA). This Service manages an extensive program of individually structured schedules of academic course work, observation, and practical experience in NOAA laboratories, U.S. universities, and private industry. More than 100 foreign students, most of them from developing countries, are involved in the programs each year.

A course on the identification of larval fish and the use of such data in fishery assessment has been given six times, most recently attended by 24 people from Latin America, 5 from Asia, and 6 from Africa. For the past 5 years, NOAA and Mexican institutions have cooperated to offer specialized instruction in fisheries techniques in both countries. NOAA fisheries centers have also trained scientists from developing nations in establishing and maintaining a computerized data base for fisheries management problems. Center personnel have worked cooperatively with numerous countries to transfer science and technology involving tuna, billfish, anchoveta, porpoise, salmon, marine turtles, shrimp, aquaculture, stock assessment, fishery management, environmental assessment, and protection. They have been instrumental in preparing working papers and manuals to help developing countries exploit their fisheries resources in accordance with modern management and conservation principles. All fisheries efforts are intended to build developing countries' capacities for technical independence and for contributing to the sum total of knowledge in this field.

Rural Development From Below

Since the Peace Corps was established in 1961, some 82,000 volunteers have served in approximately 75 countries around the world in people-to-people development. In one variation or another, the Peace Corps pattern has been a model for the numerous volunteer service programs sponsored by both rich and poor countries to undertake village-level development work.

Peace Corps volunteers are trained to speak the local language, to seek to understand local cultures, and to share the day-to-day lives of the people with

Peace Corps volunteer helps to dig a well in Upper Volta. (Photo by Peace Corps)

whom they work. The approaches they suggest for solving development problems are those that are firmly rooted in community participation. As the Peace Corps training manual advises: "New practices must be integrated with the social and religious aspects of (a villager's) life and modified to fit in better with what the farmer considers important to that life. The real test is whether the practice is passed from father to son."

Peace Corps volunteers attempt to suggest simple, inexpensive changes in technology that, without greatly disturbing tradition and culture or asking farmers to incur unacceptable risks, will help villagers to cope with the increasing pressures on their land and means of livelihood. For example, one Peace Corp volunteer wrote that he was concentrating on promoting better use of bullock power rather than tractors. He commented: "The bullock training center offers a valuable service to this area, where 99% of the farming is done by hand and only 1% is being tilled by tractors. The use of bullocks means a gain in productivity for the farmer and a saving in physical energy over the *tedious traditional method of hoe and* cutless." Another noted: "You may be wondering why these Philippine barangays are not building their own pumpwells if the cost for one well with a pump, pipe, rods, wire, and cement is only about $75.00. The fact is that some farmers earn only about $200 a year, on which they must support families with six to eight persons or more."

The Peace Corps believes that its critical impact on technology is not limited to the Third World communities in which its volunteers work. "Appropriate technology" is also being applied by VISTA (Volunteers in Service to America), which is Peace Corps' analog agency in combatting poverty in the United States. Indeed, a growing number of development workers in both Third World and industrialized countries have come to feel that this approach to technological development can make measurable and lasting differences in the lives of many people who are not touched by more capital-intensive scientific and technical programs.

Foreign Currency Agricultural Research Grants

In some cases, U.S. development assistance generates local currencies that can be recycled to support development activity. This is especially true of monies generated by concessional sales of agricultural products under the U.S. Food for Peace program, where sales agreements provide that local currencies may be used in recipient countries for certain purposes in lieu of U.S. dollar repayments.

These monies provide the financing for the Department of Agriculture's foreign currency agricultural research grants, which are worked out by USDA scientists in concert with counterparts in developing countries where local currencies accumulate. The grants subsidize research by Third World scientists that is considered of mutual interest to their governments and the United States; scientific equipment, supplies, and some training may also be provided.

Thus, in 1973 a foreign currency grant financed a 5-year study by investigators from Cairo University and the Egyptian Ministry of Agriculture of nematode problems in newly reclaimed irrigated lands. Their final report found the nematode to be a source of damage to wheat, corn, barley, milo, and Sudangrass over wide areas. One particular cyst nematode poses a threat to vast cereal-producing regions of Egypt and surrounding countries. On the basis of this information, the Egyptian Government now hopes to reduce nematode damage to food grains through an integrated pest management program.

In India, to take another example, a study on biological control of stem borers in rice, conducted under a foreign currency grant by the Central Rice Research Institute, produced significant new information on control measures. Of numerous parasites evaluated, one that attacks stem borer eggs was the most effective and offers the best hope for integration into pest management systems for rice in India. The Indian prime investigator is now working with his government to help put these recommendations into practice.

Landsat could track these Ethiopian herdsmen's shifting patterns of land use. (Photo by AID)

ENERGY AND NATURAL RESOURCES

It appears that some of the advanced technology that was developed initially for space exploration has terrestrial applications of considerable interest to developing nations for enhancing energy supplies and exploiting natural resources. U.S. projects are helping a number of countries to explore these potentialities. For example, a demonstration in Upper Volta of a water pump and grain grinder powered by photovoltaic cells is the first of a number of projects that will test the applicability of advanced solar technology to development problems. The United States is also sponsoring a good number of experimental projects to investigate other technologies based on renewable energy, such as solar heating, crop-drying, and biomass. Projects in several countries are making use of Landsat, a technology developed by the National Aeronautics and Space Administration (NASA) that is already proving its worth for locating and assessing natural resources, studying weather and crop patterns, and mapping the topography of inaccessible areas. A limited selection of these high-technology projects is described below.

Making full use of natural resources in developing countries does not depend on advanced technologies such as these, however. The afforestation project supported by AID in Chad seeks to transfer forestry techniques based on well-tried scientific knowledge. Other projects involve transfer of water and range management techniques and various methods of environmental protection. The work of the National Academy of Science's Advisory Committee on Technology Innovation is among the most interesting supported by AID; it is calling attention to the potential value of existing, perhaps half-forgotten, resources.

Various combinations of old and new technology go into the resource surveys and energy assessments that are important aids to development planning. The U.S. Departments of Energy and Interior, particularly the

latter's Geological Survey, have been especially active in helping developing countries to acquire these tools. Some of their activities in Egypt and Saudi Arabia are described in these pages.

Energy Assessment

Since 1977, President Carter's international energy development program has made it possible for the Department of Energy (DOE) to collaborate with other countries in refining their techniques for comprehensive energy assessment. These assessments provide a way of looking at the totality of a country's potential energy supply and evaluating various options for meeting projected demand. They are useful tools for planners in an age of uncertain world energy supplies.

Two assessments have already been completed in cooperation with developing countries, and others are anticipated. The first was conducted with Egypt in 1978. To make the assessment, a team of U.S. and Egyptian specialists analyzed Egypt's economic development and energy resource base, identified supply and demand options up to the year 2000, and outlined alternative energy supply and utilization strategies. The team used analytical methods developed at DOE Brookhaven National Laboratory in the United States to represent energy production and consumption in 1975 and to project demand-supply balances for 1985 and 2000. Specialists from the U.S. Geological Survey (USGS) assessed the prospective availability of energy resources and energy-related minerals. Other specialists examined technologies that might be used and the potential impacts of their use. An energy supply facilities model developed by the Bechtel Corporation and used previously for DOE policy studies was used to estimate the cost, manpower, and materials implicit in various alternative strategies.

The binational team was made up of Egyptian planning and energy officials and U.S. specialists from Brookhaven and Argonne National Laboratories, the Geological Survey, and Bechtel and other private-sector firms. Their work was coordinated by a supreme committee of representatives from a number of Egyptian ministries. The team concluded, *inter alia*, that Egypt can continue to be a net energy fuels exporter through the year 2000—*if* the targeted level of oil production can be attained and maintained; measures to use natural and associated gas can be effectively implemented; the indications that Egypt has deposits of economically recoverable uranium ore can be confirmed and the ore developed; and available and emerging solar energy technologies can be applied to exploit Egypt's highly favorable solar, wind, and biomass resources. However, the group noted that improvements were needed in management and technical capabilities, as well as in planning, if these conditions were to be realized.

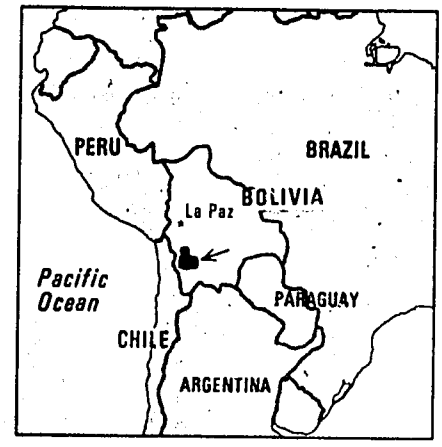
The assessment product is a technical analysis, not a policy study. No optimization of the planning options is attempted nor are value judgments rendered. Rather, the assessment brings together the analytic tools, evaluation factors, and underlying data that provide Egyptian planners with a more accurate and complete information base and a solid understanding of the potential effects of various energy options on the country's future.

This energy assessment—along with a similar one performed in Peru which emphasized increased use of renewable energy resources and more efficient use of energy in the transport and industrial sectors—is believed to be the most comprehensive ever made for any developing country. Both Egypt and Peru have indicated that the assessments, data, methodologies, and recommendations will be used in their future energy planning.

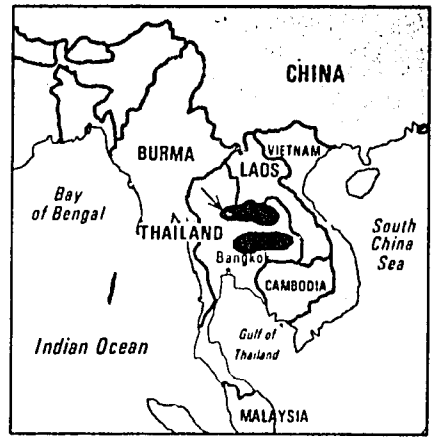
Energy assessment is only one part of the large reservoir of scientific and technological expertise lodged in DOE, through its headquarters and field office staffs, laboratories, and research institutes and contractors. The global nature of the energy problem has led DOE increasingly into international cooperative arrangements for research and development on energy technology. While the majority of these efforts

Some mineral deposits investigated by the U.S. Geological Survey.

Phosphate in Colombia.



Lithium brines in Bolivia.



Potash in Thailand.

Copper in Pakistan.

are with other industrial countries, a growing number involve developing countries and span a wide range of technologies. Examples of current projects, in addition to the energy assessments, are a geothermal resource evaluation study with Mexico and a joint solar energy technology development and application activity with Saudi Arabia.

Solar Power From Photovoltaic Cells

Within the relatively near future, technology for producing electricity directly from the Sun may be able to meet rural energy needs in the Third World more efficiently than conventional means. That is the proposition being tested by the Government of Upper Volta, with help from AID and a laboratory of NASA.

The site for this experiment is the village of Tangaye, 200 kilometers east of Ouagadougou. There, on March 29, 1979, Prime Minister Conombo, for Upper Volta, and Ambassador Boyatt for the United States, cut the ribbon on a photovoltaic (solar cell) installation that is now powering a village water pump and grain grinder. The opening was the culmination of 2 years of planning and design work by NASA's Lewis Research Center and several months of installation by the villagers of Tangaye, with technical help from NASA and AID. Since 1976, the Lewis Center has installed 17 such systems, mainly in the United States, to provide energy for refrigeration, weather instruments, water pumps, and the like in rural or remote areas.

Photovoltaic technology was originally developed to power space satellites. Increasingly, it is being looked to for terrestrial applications. Many energy experts believe that, of all the solar technologies, photovoltaics have the most flexibility for meeting small-scale, decentralized energy needs in developing countries. The systems have many desirable features: they are modular and so can be built small and enlarged only as needed; installation and maintenance are relatively simple and easily learned; they are potentially long-lasting; and many of the system components can be readily manufactured and assembled in developing countries.

Wider use of photovoltaics has been limited by their cost and by lack of experience with the technology. The Tangaye project, and others that are presently in the planning stage at AID and DOE, are directed to the second of these constraints. Technically, a photovoltaic system for small-scale rural energy use is relatively simple, consisting of an array of small silicon solar cells, energy storage, and regulation and control devices. In Tangaye, for example, the heart of the project is a bank of solar panels containing the photovoltaic cells which convert the sunshine into electric current. A shed built by the villagers houses the grain mill and electric storage batteries. Directly in front of the building, a small electric pump draws water from a well and stores it in a new 5,000-liter water tank.

One of Tangaye's biggest problems has been its lack of water. The new pump is designed to supply 5,000 liters of water a day; it is actually supplying 14,000 liters a day for use in making mud bricks, stock watering, and laundry, in addition to providing water for cooking and drinking. The grinder is expected to cut from 2 hours to 10 minutes the time required to produce 350 kilos of millet and sorghum flour for each of the 60 to 70 families involved, leaving time for the women who normally do these jobs to raise vegetables, expand their production of millet cakes for sale in local markets, spend more time with their children, etc.

Researchers from Upper Volta and the Lewis Center will test the reliability of this system over the next year and measure the sociological impact its presence has on the lives of the villagers. The results of the technical research may lead to new solar-energy equipment designs and modifications. Equally important, the project will help to provide a base of knowledge and familiarity for decisionmakers who may not yet be convinced that photovoltaic technology is ready and adaptable to their needs.

The Tangaye project is particularly timely, because the situation with respect to cost, the second constraint, is changing rapidly. The price of solar cell modules has fallen 40% in a few years and will continue to decrease as technology is improved and demand increases. Furthermore, photovoltaic systems are already cost-effective in rural areas that use only small amounts of electricity. If experiment-related costs are subtracted, for example, electricity is being produced at Tangaye about as cheaply as it would be from a diesel generator. Since fossil fuel prices are continually rising and photovoltaic manufacturers are benefiting from economies of scale, the advantage of such solar systems is likely to grow. The United States is planning far wider use of photovoltaics in such areas as health delivery systems, communications, and education delivery programs.

Both the United States and developing countries have an obvious interest in gaining operational experience with energy systems that use the power of the Sun. DOE recently launched an extensive national photovoltaic program designed to make solar-cell systems economically competitive with other electrical systems for dispersed on-site applications (for the near term) and, ultimately, for central power stations. The wider the use of solar cells around the world, the faster that goal will be approached and, in turn, the sooner developing countries will be in a position to capitalize on cost-effective solar technology as it becomes available.

Remote Sensing

Between 1972 and 1978, NASA supported a remote sensing investigations program to explore the many practical uses to which its new satellite, Landsat, could be put. Under this program, NASA offered to supply free Landsat-generated images and computer tapes and to provide technical review for researchers around the world who needed the data for projects of their own. Before the program ended, 145 investigators from 46 countries and 4 international organizations had participated.

Experience has confirmed Landsat's initial promise. Multispectral scanning from space is now a proven mapping technology which enables countries quickly and relatively cheaply to determine the extent and condition of their arable land, forests, rangeland, and water resources; to identify promising areas for mineral exploration; and to monitor the changing condition of their natural domain for such purposes as forecasting crop yields, detecting erosion of land and pollution of water, recognizing alterations in land use, and giving early warning and assessing damage of natural disasters. The following are the results of just a few of the applications of Landsat technology by investigators in developing countries.

- The Bangladesh remote sensing program, with support from the U.N. Development Program, uncovered more than 10,000 square kilometers of new land in the Bay of Bengal, the result of accretion of sediment washed down from the Himalayas. The Government of Bangladesh has issued a directive setting aside the new land for afforestation and has begun to stablilize the soil through controlled planting so that it can be used for agriculture in the future.
- Through digital analysis, the Earth resources technology satellite program of the Geological Survey of Bolivia

identified a promising iron-rich formation and an outcropping of sandstone in eastern Bolivia, later verified with aerial photography and ground information. Elsewhere, lithium deposits of unusually high concentration (1,600 parts per million, compared with 300 parts per million considered exploitable in the United States) were discovered after Landsat data showed that there was something unusual about the site. The Bolivian Government is now studying the possibilities for extracting lithium from this remote site.

- The same agency, with support from AID and the U.S. Census Bureau, used Landsat data to draw up basic maps pinpointing residential areas prior to the 1976 Bolivian census. These maps were supplemented by field information before the census takers were actually dispatched.
- Technicians from the National Remote Sensing Center of Egypt used Landsat imagery to identify areas for iron-ore prospecting and geologically safe sites for nuclear power plant construction. With AID support and training, they also prepared ground water and drainage maps for the entire country—a task that would have taken at least 10 years by traditional methods.
- In Pakistan, investigators from the Space and Upper Atmosphere Research Committee were able to evaluate the damage from a flood of the Indus River by comparing preflood Landsat imagery with imagery taken at the height of the flooding. These comparisons contributed to prompt settlement of disputed claims by local farmers.
- With AID support, scientists from the Environmental Research Institute of the University of Michigan used Landsat data to map the planned site of the new Pakistani industrial port, Port Qasim. This data provided a basis for mapping changing channel patterns, the extent of saltwater intrusion, coastal currents, and sedimentation. Information on sedimentation is particularly important in relation to dredging requirements for the channel.

As more and more technicians from developing countries are trained in data analysis techniques and as decision-makers understand Landsat's practical value, increasing use of the Landsat system can be expected. Future versions of the satellite will produce more detailed images and will have heat-sensing capabilities, making this technology still more useful.

On the ground, the Landsat satellites are complemented by a growing network of national or regional ground receiving stations. Such stations are currently operating in the United States, Brazil, Canada, Italy, Japan, and Sweden, and three more are under construction in Argentina, Australia, and India. Because these stations are expensive to build and maintain, the outlook is for greater emphasis on regional installations in the future. The U.N. Economic Commission for Africa and the Asian Institute of Technology, among others, are currently supporting plans for new stations and related training facilities. In return for an annual fee of $200,000, such agencies receive direct access to Landsat data as well as informal technical advice. They must agree to make all the data they acquire publicly available without discrimination and at a reasonable price. An informal working group of ground station managers meets every 6 months to exchange information and keep up with the latest technological developments.

Mapping and Resource Surveys

U.S. agencies whose primary responsibility is domestic make their technical expertise available to developing countries through two principal routes: the first is via contracts and agreements with AID or other aid agencies; the second is via reimbursable services, which can be arranged by U.S. Embassies abroad for countries that can cover the costs, either with their own funds or with funds borrowed from other sources. Under the reimbursable program, participating U.S. agencies serve, in effect, as primary contractors to host governments. They usually supplement their in-house technical capabilities by subcontracting with U.S. private firms or institutions.

Since 1963, for example, the U.S. Geological Survey (USGS) has been providing Saudi Arabia with needed scientific and technical services in its area of expertise. In its domestic programs, USGS is oriented mainly toward the appraisal of mineral, energy, water, and land resources; research on new concepts and techniques for appraising resources; and publication of the results of its work to guide resource exploration, production, and utilization. The program in Saudi Arabia is helping to establish an indigenous institution with similar expertise.

The Earth-sciences aspect of the Saudi Arabian program has concentrated on geologic studies preliminary to an exploration of the economic potential of the Arabian Shield, in the western part of the Kingdom. This is a region of older rock formations of the type that normally contain mineral deposits, as distinct from the younger rocks to the east which contain Saudi Arabia's well-researched petroleum resources. The program is an outgrowth of an earlier effort to map the geology and geography of the entire Arabian Peninsula, which was accomplished through the cooperation of seven countries of the region, the USGS, and several oil companies. In its present phase, the objective of the program is to transfer to Saudi Arabia permanent capabilities for carrying out geologic studies and related activities.

Twenty-six USGS specialists are presently posted to Jiddah for 2 years or longer, while others are carrying out special shorter term studies. All of them work closely with Saudi Arabian counterparts in the Ministry of Petroleum and Mineral Resources. Since 1973, 82 Saudi Earth scientists have been sent to the United States for specialized academic training or on-the-job experience at USGS offices and laboratories.

The multifaceted program includes a series of mapping exercises at varying levels of detail to identify geologic areas of possible interest. Some of these maps use Landsat imagery; others are based on aerial or ground surveys. A laboratory has been established for interpreting data by means of photogrammetry, making Saudi Arabia one of the few countries to have such a sophisticated mapping tool. Sixty-eight maps of the eastern region, on a scale of 1:100,000, have already been compiled and about 40 published. In addition, a Landsat mosaic of the entire country, at 1:2,000,000, is being compiled.

Besides mapping, the USGS scientists are studying properties of the terrain itself—heat flow, gammaray emission, paleomagnetism, ability to carry sound waves, strata sequences, mineral anomalies, and the like—by various techniques, both new and old, both in the field and in the laboratory. Much of the isotope geochronology data for Saudi Arabia has been produced and interpreted. These studies help to clarify the geologic history and structure of the region and throw light on the origins of mineral deposits.

Known and newly identified areas with economic potential are being studied in greater detail. Several areas have been delineated as having potential for tungsten and tin deposits, for example. A significant source of gold was located at the ancient Mahd adh Dhahab mine. Large sulfide deposits are being studied for their zinc and copper potential, and evaporite deposits for their potential as sources of lithium, potassium, bromine, and boron. Field investigations are being carried out to locate sources of nonmetallic resources (building stone, abrasives, ceramic clay, marble, and

limestone) for use in diversifying and expanding the economy.

In all, Saudi Arabia has contracted for more than $800 million in technical goods and services from U.S. public agencies and private firms through the reimbursable program. More than 40 other countries have also taken advantage of the program to obtain training, technology transfers, and project identification or feasibility studies. The greatest demand has been in the areas of public works, transportation, communications, housing, public administration, agriculture, health, manpower training, and mineral and water development.

Reforestation

Alarmed by the loss of millions of hectares of natural forests in the face of encroaching agriculture, cattle raising, urbanization, and rising world demand for timber, many countries have given higher priority to reforestation and the possibilities for sustained, multiple use of forest resources. Nowhere is such activity more urgent than in the Sahel, where the disastrous drought of 1974 exacerbated an already critical shortage of trees for firewood and where denuded soils were deteriorating rapidly in the Sun and wind.

Much research remains to be done before sustainable forests can be assured around the world. Improved varieties need to be identified and tested, growth rates determined, resistance to insects and disease improved, and so on. The United States National Academy of Sciences (see p. 8) is looking into neglected fast-growing trees and shrubs. But some reasonably fast-growing varieties of tropical trees are already known and can be planted with relatively simple, low-cost technology to begin to meet the immediate problem.

AID is supporting a number of projects that look to reforestation in the relatively short term. One of the more successful is presently under way in the Sahel, being carried out by CARE (a private U.S. voluntary organization) and the Government of Chad. This project makes use of two well-known trees—*Acacia albida* and *Azadirachta indica*, commonly called neem—which can ultimately provide firewood for fuel, shade for men and cattle, and enrichment for the soil of this area.

After initial training by CARE personnel, technicians from the Chad Department of Water and Forests are growing seedlings of acacia and neem at small field nurseries located in the Sahelian parts of the country. These seedlings are then given to farms or villages if local people agree to plant and care for them.

Peace Corps volunteer inspects seedlings in Sahelian reforestation project. (Photo by AID)

About 2,400 Chadians have participated in this project so far, planting trees in return for a daily ration of food for themselves and their families. CARE supplies the necessary hoes and shovels, as well as the seedlings. Chadian forestry agents, working with U.S. Peace Corps volunteers, then follow up with advice and help in transplanting and maintaining the trees. The amount of technical assistance needed is minimal. As an evaluation of the Chad project notes: "Basic activities such as building a fence, filling plastic pots with dirt, and planting a tree in a farm field are, by their nature, not so complicated that a great deal of academic, conceptual 'learning' is necessary, especially as the 'students' know the country, the farmers, and the existing land-use practices far better than someone fresh off the plane."

By the time of the 1978 planting season, 178,000 acacias had taken root. They will take 5–15 years to mature. Local farmers like the acacia because it does not interrupt farming. It loses its leaves during the 4-month rainy season, thus permitting cultivation beneath the tree. In addition, the pods and leaves are high in vegetable protein and can be used for animal feed. The tree is also a good conserver of soil. Since the acacia is a legume, it serves the function of a fertilizer, fixing nitrogen in the soil. Furthermore, its shade attracts birds and cows, and their droppings, combined with the leaves that fall during the rainy season, further enrich the soil.

The 58,250 neem trees planted by 1978 already exceeded the 1979 target by 11%. The neems are being planted for shade in public spaces, for windbreaks in the fields, and in small village woodlots where they can be cultivated as a domestic crop for firewood, the only energy source in rural Chad.

If external forces do not interfere, the prospect for self-sustaining growth of this reforestation effort is good. The trees are showing a 56% survival rate, and it has been observed that, even when firewood is short, the farmers try to avoid cutting them down. As the trees grow larger, they will have a cumulatively beneficial effect on the quality of the environment, the soil, and even of village life. The nurseries should continue to produce more seedlings for transplanting, thereby compounding the benefits.

CARE technicians have prepared a field manual with detailed information gleaned from the experience in Chad; it could become a valuable field guide in other Sahelian countries.

Neglected Plants, Animals, and Technologies

For the past 9 years, AID has financed the work of the Advisory Committee on Technology Innovation, an unusual venture in applying knowledge to development. The advisory committee is a unit of the U.S. National Academy of Sciences. It is charged with taking a fresh look at existing technologies, plants, and animals which might be useful to developing countries but which, for one reason or another, have been overlooked by researchers, governments, and development agencies.

Much of the committee's work has focused on gaining scientific attention for "poor man's crops." It is a universal phenomenon that certain plants are stigmatized by their humble associations; indeed, the soybean was one such plant until well into the 20th century. Scores of highly promising crop plants around the world receive no research funding, have no varieties collected or compared, no germination or spacing trials, and no yield determinations or nutritional analyses. Yet merely to have survived in peasant gardens as useful crops suggests that the plants are inherently superior and might even be crucial to the survival of millions of people.

In questionnaires sent out by the National Academy of Sciences, respondents have named over 2,000 fast-growing tropical plants, legumes, woody shrubs, and trees that deserve greater recognition. The most promising of these are being scrutinized by ad hoc panels of international experts called together by the advisory committee. Their reports and conferences are beginning to bear fruit in increased interest and, more importantly, funds for the research needed to exploit their full potential.

For example, when the committee's report, *The Winged Bean, a High-Protein Crop for the Tropics*, first appeared in 1975, the little-known legume was grown almost exclusively in Papua New Guinea and Southeast Asia. Virtually every part of this remarkable plant is edible. Its green pods can be collected every 2 days over several months to provide a continuous supply of fresh green vegetables. Its tubers contain more than 10 times the protein of cassava and can be eaten the same way. Its seeds are comparable to soybeans in oil and protein. But, unlike the soybean, the winged bean is a tropical plant with potential for many developing countries.

Since 1975, the bean has been introduced in more than 70 countries and has started to reach the marketplace in some of them. So many researchers and farmers are involved that a special newsletter, *The Winged Bean Flyer*, is now published just to keep up with their findings. The Governments of Indonesia, the Philippines, and Zambia have formally designated the bean as a priority research crop.

Other plants were highlighted in the committee's study, *Underexploited Tropical Plants With Promising Economic Value*. Tarwi, for example, is commonly grown by the Indians of Peru, Bolivia, and Ecuador. It is richer in protein than peas, beans, soybeans, or peanuts and makes an important contribution to the nutritional well-being of the Andean regions, where meat is a luxury. Its oil is light-colored and acceptable for kitchen use. Like other poor men's crops, tarwi is robust and adaptable, but it remains grossly neglected by science. Scattered research already completed in Peru, Chile, Australia, and elsewhere suggests that nontoxic varieties could be bred for specific locations in the Andes as well as for cool tropical highlands and temperate regions all over the world.

The committee also drew attention to guayule, a desert shrub native to Texas and northern Mexico which is potentially an alternative source of natural rubber. World demand for natural rubber will outstrip expected production from rubber trees by the end of the 1980's or 1990's. At the same time, petroleum prices are pushing up the cost of synthetic rubber. What has prevented the development of guayule until now is difficulty in separating the latex, but there is early promise of overcoming this problem. Major tire companies are already undertaking guayule research, as are various elements of Federal and State Governments in the United States and Mexico. In 1978, the U.S. Congress proposed a $30 million program of guayule research and development in response to the growing interest in this exotic plant.

Reports on these and other plants, as well as on technologies such as ferrocement for boatmaking, and animals such as the manatee and the water buffalo, are available from the National Academy of Sciences. Requests from developing countries have made this AID-financed series something of a "best seller," with some 160,000 individual pamphlets already distributed. Demand has been so great that several of the publications have gone through multiple printings.

HEALTH, POPULATION, AND NUTRITION

A sizable proportion of U.S. assistance relates to health, population, and nutrition. Research and development is especially important in these fields, in view of the failure of almost all countries, including the United States, to bring effective health and related services to the poor in rural areas. The projects described here are likely to benefit U.S. domestic efforts in this regard no less than those of developing countries. They are just a few among a wide variety of U.S. activities that include medical and nursing training, institution building, contraceptive technology, biomedical research, and much more.

Each of these projects approaches the problem of improving rural health from a different angle. Thus, MEDEX is one of many AID projects that seek insights into improving *systems* for delivering health services. The World Fertility Survey, among others, promotes *international collaboration* in strengthening mechanisms for collecting basic data for planning purposes. Extrusion cooking is an innovative *technology* with the potential for improving nutrition in developing countries by expanding production of low-cost food products. *Research* on diseases of special interest to developing countries is receiving new emphasis.

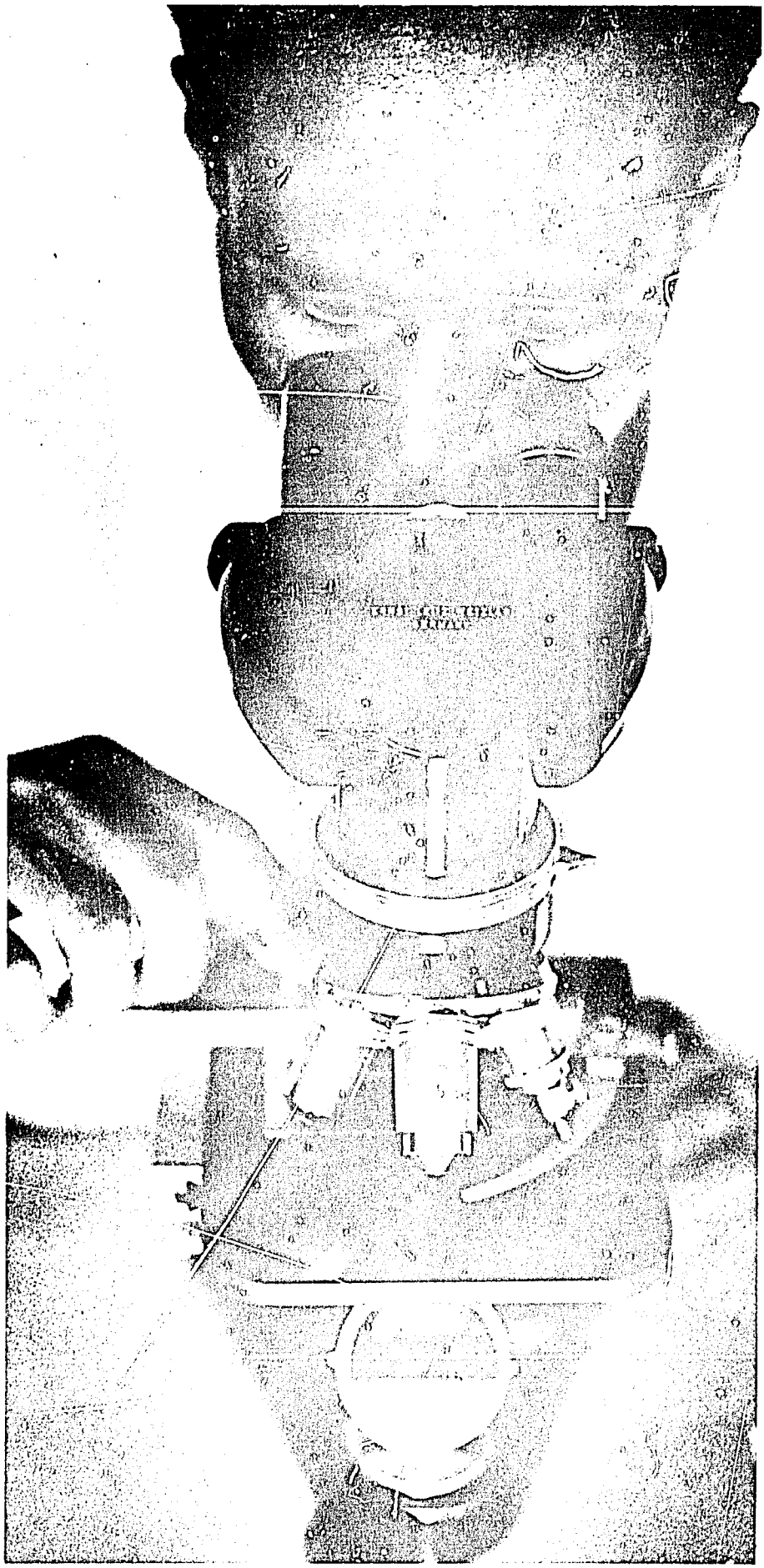
Health Care Delivery

The most effective technology that can be put to developmental use is often a system rather than a process or piece of machinery, and the United States has made many investments in systems research and development over the years. One of the most promising of these investments—in the key area of delivering primary health care—is now ready for field testing.

This system is called MEDEX. The key to MEDEX is its use of innovative teaching modules to train paramedical workers in basic curative and preventive medicine. The acronym MEDEX means that these workers *extend* the work of fully trained physicians. Indeed, it is estimated that one fully and expensively trained doctor can serve 50,000-100,000 people if he or she is properly supported by less costly personnel.

This approach was originally developed by Dr. Richard Smith, of the U.S. Public Health Service, to improve services in rural and impoverished areas of the United States where a lack of doctors often makes a mockery of the citizens' "right" to health care. MEDEX-type programs have been highly successful. Thirty-five States have begun to include paramedics in their health systems, and MEDEX training centers have been established in about a dozen university medical schools throughout the country.

AID began to invest in MEDEX in 1974, after demonstrations in Micronesia—supported by the U.S. Department of Health, Education and Welfare—had shown that the system could be adapted to the conditions and cost constraints of developing countries. Dr. Smith, now based at the University of Hawaii and working with AID funds, has developed a flexible MEDEX framework that can be adapted to many developing countries. The system features a three-tier approach whereby physicians work with



teams of paramedics who, in turn, serve as links with community health workers. The accompanying illustration gives a schematic illustration of the MEDEX system. It is described more fully in the book *Manpower and Primary Health Care*, published in 1978 by the University Press of Hawaii under contract with AID.

Dr. Smith's health manpower development staff has also developed training programs and a basic format for MEDEX training material. More than 30 teaching modules had been drafted by 1977. The information in each one—text, diagrams, exercises, tapes, slides, films—includes all that a worker needs to know in order to perform a certain medical task, along with learning activities to provide practical experience. These draft prototypes are not for general distribution but will be adapted for use in specific countries in cooperation with people who know local health problems, facilities, and community attitudes.

As others became interested in Dr. Smith's work, some parts of the evolving system were tested in pilot projects in developing countries. For example, the Lampang health development project in Thailand, using AID funds supplied through the American Public Health Association, successfully adapted MEDEX teaching materials to train midlevel health workers. The Government of Guyana, supported by the International Development Research Centre of Canada, is now training its second class of paramedics along MEDEX principles. In a countrywide program, Pakistan is now training paramedics at 12 sites covering all four provinces; the paramedics, in turn, will be training community health workers.

Now the time has come to test the delivery system more broadly. During the next 5 years, AID hopes to fund projects in eight countries. Working with national and local government officials, physicians, educators, and public health workers, the project staff will seek ways to adapt the MEDEX concept to the specific needs, priorities, facilities, and customs of each participating country.

Guyana is expected to be one of the countries to cooperate with AID. Health officials there have already had experience adapting MEDEX materials. The Guyana Government now hopes to use the full MEDEX system to deliver health care throughout the country. AID funds will support consultation by Dr. Smith's staff, enlarged

Ethiopian laboratory technician researches the problem of malaria eradication. (Photo by AID)

training programs for paramedics and community health workers, and logistical support, as well as some upgrading of rural clincs. If the MEDEX program is as successful in Guyana as it has been elsewhere, it will truly mark a breakthrough in health care delivery that is of worldwide importance.

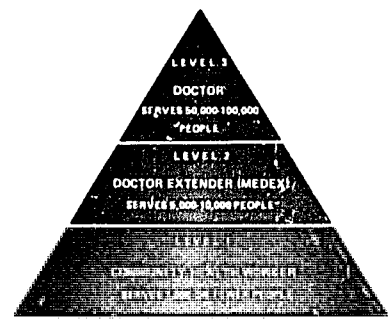
Tropical Disease Research

Among the most difficult diseases to deal with, and the most devastating in their effects, are the so-called "tropical diseases" which are found mainly in the developing world. Indeed, these diseases are of such importance that the World Health Organization (WHO) has targeted six of them—malaria, Hansen's disease (leprosy), filariasis, trypanosomiasis, schistosomiasis, and leishmaniasis—for attack under its special program for research and training in tropical diseases. The magnitude of the problem can be demonstrated in numbers alone, although the suffering of each individual afflicted is enormous. As many as 200 million people worldwide suffer from malaria; 300 million from filariasis; and another 300 million from schistosomiasis. WHO selected these diseases not only because of their high incidence but also because it appears that their effective control could be achieved through an intensive research and development program.

Agencies of the U.S. Department of Health, Education and Welfare are contributing to this worldwide effort through their research programs. Two recent advances in malaria research demonstrate the approach being taken by one such agency, the National Institute of Allergy and Infectious Diseases (NIAID). The first has to do with the process by which the malaria parasite invades the body's susceptible red blood cells. Scientists in NIAID's Laboratory of Parasitic Diseases made an unexpected observation that invasion only takes place when a specific substance—Duffy antigen—is present on the surface of the cell. In scientific jargon, what the NIAID investigators found was that resistance to one type of malaria—*P. vivax*—can be directly correlated with the absence of a certain Duffy antigen. The identification of this "portal of entry" is obviously important to future strategy for developing a vaccine and new or more effective drugs.

In the second instance, Drs. William Trager and James Jensen, NIAID-supported scientists at Rockefeller University, were able to grow the malaria parasite in a laboratory culture for the first time. This basic laboratory finding will open up new opportunities for medical research into vaccines and drugs.

The MEDEX Pyramid *



Each doctor . . .

- Manages a regional health system
- Supervises training and work of medex
- Treats patients when necessary
- Evaluates quality of curative care
- Plans and evaluates preventive services

Each medex . . .

- Manages a district health center
- Gives primary curative care
- Gives emergency paramedical treatment
- Supervises training and work of community health workers
- Refers patients to doctor when necessary
- Reports to doctor on health trends and problems

Each community health worker . . .

- Promotes general health education
- Carries out a nutrition education program
- Advises on child spacing and prenatal care
- Gives immunizations
- Administers first aid
- Gives simple curative care

*Adapted from the book *Manpower and Primary Health Care*

Leprosy research is carried on in the Public Health Service hospital in Carville, Louisiana, which is the primary government facility for treating Hansen's disease. This hospital maintains a visiting scientists' program, participates in international conferences, and produces multilingual training materials in order to share its knowledge with international colleagues. Until a research team at the Carville Hospital developed the technology for cultivating leprosy bacilli in the armadillo, scientists were forced to depend on patients' tissues for this basic research material. Now the hospital provides scientists throughout the world with live Hansen's disease bacilli and extracts needed for laboratory and immunotherapeutic studies.

The Carville Hospital has also had a lengthy collaboration with the Jawaharlal Nehru Institute of Postgraduate Medical Education and Research in India to study the role of arthropods in transmitting leprosy. This research has shown conclusively that a number of insects—including the culex mosquito—is capable of transmitting the disease from human to human. This finding has importance for the eventual control of leprosy.

These are but a few examples of U.S.-sponsored research that may speed the day when mankind is free of ancient diseases. Beginning in the fall of 1979, scientists from developing countries will join in these and other tropical-disease research efforts under a fellowship program established through the cooperation of the National Institutes of Health and WHO. In addition, WHO and the National Library of Medicine are cooperating to produce a quarterly bibliography on the six major tropical diseases; it is produced from the library's computerized information storage and retrieval system, which includes references to relevant U.S. research as well as that in countries with which the library exchanges material. U.S. activities relating to all tropical diseases are being expanded as part of President Carter's international health initiative (see below).

International Epidemiological Service

Another approach to controlling tropical and other diseases is being taken by the Center for Disease Control, a component of the U.S. Department of Health, Education and Welfare, which is enthusiastically supporting WHO plans to establish an international epidemiological service.

Epidemiologists are medical detectives. They keep track of the spread of diseases that threaten lives and economic productivity. They investigate outbreaks of diseases, both common and exotic. They know how to look for weak points in the chain of transmission and can evaluate the effectiveness of programs to reduce the burden of disease and injury. Indeed, epidemiology, the study of the distribution and determinants of diseases and injuries in human populations, is fundamental for the planning and provision of health services, including prevention and control measures.

It is now widely recognized that epidemiologic methods were essential in breaking the chain of smallpox transmission, thereby making possible eradication of that dread disease. This success has stimulated WHO to propose the creation of an international epidemiological service of skilled and resourceful epidemiologists to stand watch against all the other diseases and injuries that plague mankind.

In the United States, investigative

field epidemiology is carried on by the Epidemic Intelligence Service. Nearly 1,000 officers of this Service have been trained since 1951 by the Center for Disease Control. Officers study applied epidemiology and biostatistics. But the key to their effectiveness is a rigorous 2-year, on-the-job training with a senior epidemiologist in a master-apprentice relationship.

This training will be the model used for WHO's new international epidemiological service. The Center for Disease Control is helping to establish the first WHO training course which will be in Southeast Asia, and will provide senior epidemiologists to assist with the training until there are enough international service graduates to carry on the essential master-apprenticeship training chain. Eventually, WHO hopes that officers committed to the exacting standards of the international service will be found not only in Southeast Asia but in all developing countries.

World Fertility Survey

High quality data is the *sine qua non* of modern scientific research, economic planning, and evaluation. Recognizing this, AID supports a number of data-gathering efforts in various fields related to development.

Perhaps the most ambitious of these is the world fertility survey (WFS), a large-scale, concerted scientific program whose goal is accurate measurement of human fertility throughout the world. The survey's scope and magnitude are truly unique. It may well be the largest single social science research project ever attempted.

Since 1972, more than 40 developing countries and 17 developed countries have agreed to undertake nationally representative fertility surveys as part of the WFS program. These surveys, each of which covers up to 10,000 people, are designed according to the most rigorous scientific standards. They strive to identify meaningful differentials in patterns of fertility and fertility regulation and to clarify factors affecting fertility. Data are internationally standardized, thus permitting comparisons from one country to another and greatly enhancing the interpretation of national statistics. Sixteen countries have already completed their surveys and produced final analytical reports; another 6–10 final reports are expected by the end of 1979.

Further analysis of the field data will depend on the needs and interests of the countries concerned. A country might, for example, use its data for in-depth studies of levels and differentials in infant and child mortality, breastfeeding and its impact on fertility, socioeconomic determinants of contraceptive use, or indirect methods of estimating fertility levels. The central WFS staff, based in London, has identified these and many other topics with potential significance for planning and decisionmaking.

On the one hand, the WFS research operation is an international collaborative venture which has established a worldwide network of scientific contacts in its field. Its rich yield of data will permit fruitful research by demographers and statisticians all over the world for years to come.

On the other hand, the survey is proving to be of particular value to developing countries, especially as a vehicle for strengthening indigenous scientific capacity. Large sections of the technical manual developed for the program are directly adaptable to surveys in other fields. For example, the survey organization manual is devoted to planning and organization. The roles of the national executing agency and survey director are clarified. Basic planning decisions are set forth. Stress is laid on specifying survey objectives and preparing a timetable. The manual traces the life of a national survey in an operational sense from the first decisions to preparation of documents, sampling, pretesting, and training; it moves on to field work, then to coding and editing, and finally to tabulation, analysis, and reporting. Some of these same aspects are treated in more detail in other WFS manuals. Technical assistance from WFS headquarters has reinforced the written materials where necessary. Many survey directors have indicated that experience gained in the WFS program has led to an altogether new standard of survey administration in their countries.

The features of WFS operations which are expected to have a lasting impact on future survey work in participating countries include:

- The use of local languages in questionnaires to elicit fuller and more accurate information (in Kenya, for example, the survey questionnaire was prepared in seven languages in addition to the usual English and Swahili);
- The use of female interviewers, which is particularly important in studies of fertility;
- Intensive training of field workers, lasting as long as 3 weeks, to insure consistent data collection (more than 1,700 field workers have received training for WFS surveys in developing countries);
- Careful techniques for monitoring field work;
- Data processing packages that can be used in any country with a small computer, whatever the subject matter of the survey; and
- Technical assistance in report writing and data analysis.

As a result of the extraordinary interest in this program, the WFS has been extended several times so that more countries could participate and greater use could be made of the data that were collected. Consideration is now being given to undertaking second-round surveys in some developing countries. For its contribution to scientific knowledge, as well as for its permanent transfer to developing countries of the best and latest survey methodology, the WFS must be counted a considerable success.

Financing for the survey, which is managed by the International Statistical Institute, has come chiefly from AID and the U.N. Fund for Population Activities. AID has so far contributed over $13 million to the project, or about one-third of the total spent by all donors and participating countries.

Nutritionally Fortified Foods

In January 1979, 45 representatives of 18 countries gathered in Dar es Salaam, Tanzania, to exchange the latest information on their respective activities for producing nutritionally improved foods by means of low-cost extrusion cookers (LEC), a U.S. technology designed for processing soybeans in American farms that has now been adapted for use in developing countries. Participants at the workshop, which was cohosted by the Tanzanian National Milling Corporation and Colorado State University, heard numerous presentations which confirmed the potential importance of this AID-funded program in combatting malnutrition, especially in young children. Whereas the majority of LEC projects were just on the drawing board at the time of the first international workshop in June 1976 and tentative expressions of interest were the order of the day, reports at Dar es Salaam focused on actual testing and production experience. This time, the mood was one of enthusiastic optimism based on results.

LEC technology as a means to produce nutritious foods at low cost is spreading. The Tanzania plant is producing a baby food called "lisha," composed of locally grown maize and soy, milk, and imported vitamin and mineral additives, for distribution to maternal-child health centers. Other applications include the manufacture of "thriposha" for food donation programs in Sri Lanka, where construction of a new dual "Brady cooker" proc-

essing complex is slated for completion this fall. In Costa Rica, the recently installed CARE plant, jointly financed by CARE and AID, began production of a fortified corn-soy-milk blend and full-fat soy flour in June. In Bolivia, where initial production of "maisoy" was for use in government feeding programs, the Nutrinal Company is now marketing its expanding line of extrusion-processed products commercially. The Guyana Pharmaceutical Corporation in Georgetown is currently engaged in test marketing and plans to begin production of its LEC baby food, "cerex," by January 1980. In Chihuahua, Mexico, extrusion-processed full-fat soy flour is being used by Productos Alimenticios Delicias as a fortifying ingredient in a variety of food products sold in the marketplace. Other countries, such as Thailand, Honduras, and the Philippines, are involved in product formulation and testing or other activities preliminary to establishing production facilities. And additional formulations are being tested on extrusion cookers provided by AID/USDA for that purpose in Pakistan and Guatemala.

One of the best-received LEC applications to date has been the use in Costa Rica of an extrusion cooker to process a dry soup powder. The soup mix, made from whole dried peas provided by the Food for Peace program through CARE, was served to nearly 400,000 school children throughout the country. Other ingredients in the mix, in addition to the peas (70%), are nonfat dry milk (8%), soy-fortified wheat flour (7%), and whole soybeans, flavoring, and spices. Part of the venture's uniqueness was the number of entities cooperating in it. Besides CARE and AID, the Ministry of Health provided transport, storage, and distribution of the raw materials and the end product. The University of Costa Rica's Research Center in Food Technology monitored quality control and provided technical assistance to the local processor. The Office of Social Development and Family Assistance financed the production costs for less than a penny (U.S.) per serving. Costa Rican farmers grew the soybeans. And finally, Pronutre, a private Costa Rican company whose owner had purchased a Brady cooker soon after observing the machine elsewhere and learning of its capabilities, custom-designed a processing line at its factory for manufacture of the soup.

These various production facilities are demonstrating that LEC technology is appropriate and transferable to specific products and programs in developing countries and that it can make a contribution to the nutritional well-being of their people. That private entrepreneurs—so far, in Bolivia, Costa Rica, and Mexico—have entered the market on their own initiative underscores the point.

The research and development necessary to adapt LEC technology to other crops and other food products was sponsored by the nutrition and agribusiness group, a core staff within USDA which is able to draw on U.S. experts in government, private companies, universities, and consulting firms for work on nutrition problems affecting developing countries. The group's activities, which are financed by AID, relate largely to developing and transferring technologies that can lead to new or improved weaning foods, fortified foods, or inexpensive food extenders and substitutes.

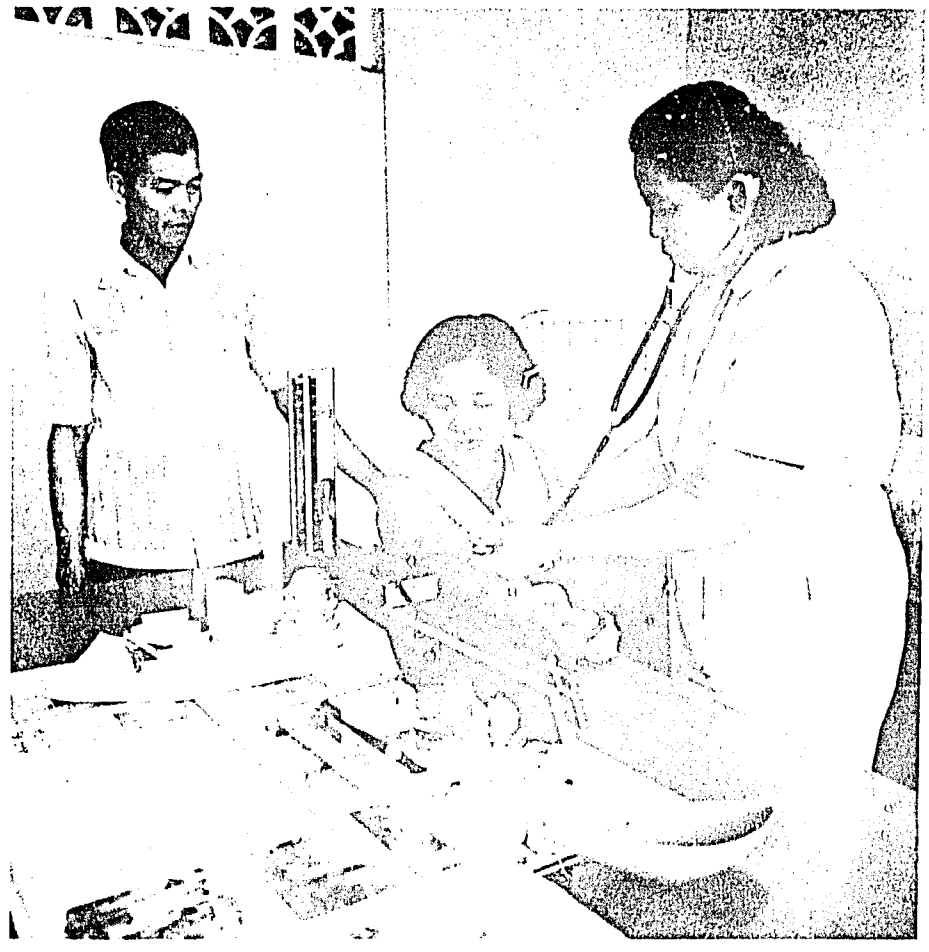
Research on Breastfeeding

To help infant populations, the National Institutes of Health are sponsoring basic research on breastfeeding that is of concern to health planners everywhere.

As important as breastfeeding is for human survival, we have yet to understand fully the degree to which maternal nutrition in pregnancy and cultural and educational considerations affect the quality and quantity of breast milk. The National Institute for Child Health and Human Development, one component of the National Institutes, has in its research portfolio studies of the physiological and immunological properties of human milk and colostrum and of the behavioral components of breastfeeding. Benefits of this research will be development of knowledge to indicate the appropriate duration of breastfeeding and proper nutritional supplements to breast milk prior to and at the time of weaning. Effective application of this knowledge would produce healthier infants and result in reduced morbidity and mortality from infections and developmental diseases.

Other important areas of study include differences in nutritional requirements among individuals and racial and ethnic groups, the nutritional relationship between the mother and her fetus, and the relationship of prenatal and childhood nutrition and the onset of disease in adults. Research is also under way on abnormal infant metabolism, with a view to preventing mental retardation.

An AID-supported local clinic in the Philippines. (Photo by AID)



INDUSTRY AND EMPLOYMENT

Within the limits of the U.S. system, which places primary responsibility for decisions regarding industrial technology in the hands of the private sector, U.S. Government programs have encouraged transfers in the industrial field of a wide range of technological know-how and the scientific knowledge that underpins it. Thus, for example, AID's 5-year science and technology program carried out in cooperation with the government of Sao Paulo, Brazil, helped to strengthen industrial research and development institutions in that State, especially in metallurgy and agribusiness. The fortified foods project described elsewhere (see p. 16) has opened up new opportunities for manufacturing firms in several developing countries. The National Bureau of Standards is providing support for the measurement and standards services that are essential to industrial production. And the National Technical Information Service, described in another section (see p. 23), is providing access to both high and low industrial technology developed with U.S. Government support.

AID's recent activities in the industrial field have focused particularly on low-capital technologies for small enterprises with employment-generating potential. One of the more unusual of such projects is AID's support for the YWCA of Korea, which is training women to handle construction technologies that were once the exclusive preserve of men. Other projects, involving both men and women, researchers and workers, focus on the promotion of small, capital-saving industries of various sorts. The Georgia Institute of Technology, among other private-sector institutions, has greatly assisted in this regard.

The specific programs mentioned are described below, but there are many others of varying content.

An AID loan program helped this blanket factory in Jordan to expand its exports. (Photo by AID)

Institution-Building for Research and Development

U.S. activities have contributed in a major way to the establishment or strengthening of colleges and universities, industrial research and planning institutes, and research facilities in a number of developing countries. Such programs have been a feature of foreign aid since its earliest days.

In Brazil, for example, AID concluded a $15 million loan in 1973 to support a program to upgrade research and development in the heavily industrialized state of Sao Paulo. A study of local conditions had convinced technicians from the Sao Paulo government that continued expansion of Brazil's industrial base would require intensifying the ties of science and technology with the country's economic development. Sao Paulo's 5-year science and technology program was developed to meet this need.

The objectives of Sao Paulo's ambitious program were: to promote the range of technological services available to industry, especially in metallurgy and agribusiness, in order to help producers reduce costs, improve quality, diversify their production lines, and promote exports; to improve the capabilities of local research institutes to supply those services; to encourage companies to contract with research institutes for help in solving technical problems; and, by these and other means, to develop strong ties between the research institutes and the production sector.

U.S. funds were made available to strengthen the program at a few points where the Sao Paulo government believed U.S. expertise could make especially significant, even crucial, contributions. Specifically, the loan financed the services of technical consultants from such entities as the Stanford Research Institute, Massachusetts Insti-

tute of Technology, and the U.S. National Bureau of Standards to four major, state-supported institutions in Sao Paulo—the Council of Technology, the Institutes of Technological Research and Food Technology, and, indirectly, the University of Sao Paulo. Training for research managers, information exchange, and more than $1 million worth of scientific and technical materials were also included.

After 5 years, the program's goals relating to the research institutions had been largely accomplished. AID funds, along with those from the Brazilian State and Federal governments and the institutes themselves, were instrumental in promoting substantial administrative modernization, the updating of libraries, improvements in laboratories, and the like. Capabilities were strengthened in the areas of metallurgy, packaging, quality control and certification, food, biogas, and planning and management of science and technology, among many others. Contract agreements between the Brazilian and foreign institutions served as a bridge to overseas technology, and ties created during the program have continued beyond the contract period. A Brazilian evaluation notes that this ability to collaborate with foreign institutions "becomes valuable to a country like Brazil, which seeks shortcuts for its economic and social development."

The objectives relating to the interplay between the research institutions and the production sector had been less fully realized by the end of the 5-year program. The research centers and institutes had provided training in the management of science and technology to about 120 managers from more than 30 private laboratories and state companies. More than 150 research and development projects had been undertaken, some 82 of them subsidized by a newly created revolving fund for scientific and technological development. The State Development Bank of Sao Paulo became sufficiently interested in the area of technological modernization to create new lines of credit with its own funds.

But applications for new projects declined in the face of delays in approving contracts and other administrative problems, as well as changes in the economic climate of Brazil. Furthermore, according to Brazilian researchers, "the program seems to have placed an exaggeratedly great emphasis on research and development when in fact the needs of industry and agriculture were considerably more rudimentary . . . . The most serious problems of the industrial sector related to quality control, cutting down losses, work rationalization, [and] improved information on already available technical solutions."

Further benefits may lie in the future, however. The same researchers concluded that the program has "greatly helped to disseminate a maturer understanding of the importance of investing in science and technology" and had "created the conditions for . . . a significant expansion of the technological capacity of the state [of Sao Paulo] and of Brazil itself."

In 1977, AID concluded a science and technology agreement with the Government of Indonesia similar to that with Brazil. However, building on the lessons of the latter experience, as well as on more recent awareness of the need for social justice and enhancement of basic human needs, the research and development activities to be supported by AID loan funds will relate more closely to improving incomes and employment opportunities of the average poor and rural Indonesian.

Measurement and Standards Services

Several years ago, a Latin American country exported several tons of frozen shrimp to the United States only to have the shipment rejected because it contained more water than the U.S. standard allowed. The loss was several hundred thousand dollars. In an Asian country that produces tapioca for cattle feed which can easily be made 99% pure, the produce was often deliberately adulterated with several percent of sand and dirt because the standard for cattle feed allows this amount of impurity. In a Middle Eastern country, a bread seller balances his scale with an automobile spark plug because he doesn't have a standard weight for the purpose. Such misinterpretations and misunderstandings of the use of standards are common in many countries.

In the United States, standards, measurements, and quality control services are provided by a large number of government and private institutions. A key role in this network of services is played by the National Bureau of Standards (NBS), which serves as the official reference laboratory for measurements in the physical sciences, engineering, and the marketplace. While NBS specializes in the measurement standards and methodology needed to insure that product and engineering standards are actually achievable and enforceable, its research covers a broad range of science and technology basic to U.S. technological development — microelectronics, automation technology, and chemical analysis, to name just a few.

For many years, NBS has helped other countries to develop their own infrastructure services to help insure that their technological development is built on a solid foundation of practical and realizable standards for performance, production, quality control, and research and development. While much of this activity has been supported by AID, other programs have been funded by the developing country itself or by other international organizations.

The NBS program involves various related activities that help strengthen a developing country's measurement and standards system. These include:

- Workshops on metrological and standardization services of the United States;
- Surveys of other countries needs for services;
- Regional seminars on subjects of interest to developing countries;
- Distribution of standards prepared by U.S. organizations;
- Distribution of materials to facilitate instrument calibration and accurate measurements in industries and laboratories;
- Assistance to national research institutions;
- Opportunities for scientists and engineers from other countries to train in the Bureau's laboratories;
- Consultation on research and measurement problems;
- Help in instrumentation procurement and maintenance; and
- Aid in interacting with other governmental and private-sector organizations concerned with standards and measurement technology.

Country surveys, for example, are conducted by teams of NBS specialists together with officials from participating countries. They undertake detailed assessments of a country's need for measurement and standards services and its capabilities for getting them. To date, such surveys have been made in Ecuador, Korea, Turkey, Thailand, Bolivia, Philippines, Guyana, Indonesia, Sudan, and Pakistan.

In some of these countries, the NBS survey has had an important effect on the course of development. In Korea, for example, where industrial development had reached a level at which the need for accurate standards at the forefront of world technology was already being felt, the NBS survey of 1972 provided the final stimulus for a government decision to establish the Korea Standards Research Institute. Since that time, NBS has cooperated with its Korean counterpart to help it reach a position among the world's top rank of metrology and standards laboratories.

One important effect of these NBS surveys is to show by example how standards specialists can help small-scale industry to solve often unsuspected problems. In Indonesia, for example, the survey team visited a small furniture manufacturer specializing in custom-made orders. For every item sold, the highly skilled wood carvers produced a duplicate, which was kept in storage in anticipation of a repeat order. A system for determining and recording standardized dimensions and types of carved ornaments would have made this procedure unnecessary. Or the duplicates could safely have been sold to other customers. Or identical parts, such as legs for chairs and small tables, could have been developed for dissimilar pieces of furniture.

Since written standards for products and processes are vital in helping a country know what performance it can expect from products it is buying or producing, an important element of the NBS assistance program has been to supply standards literature. There are about 400 groups in the United States writing various standards today; NBS strives to make this assembled standards knowledge available for use by other nations.

Parallel to its activities in the United States, NBS makes available to laboratories in other countries more than 1,000 different standard reference materials to facilitate the accurate calibration of instruments and other devices. These materials are used by laboratories to evaluate the accuracy of their equipment and test methods; they are vital measurement tools in chemistry, metallurgy, medicine, and dozens of other areas. Under the NBS/AID program, about 3,000 such samples have been distributed to laboratories in 11 developing countries.

Research institutions in Korea and Brazil have made long-term arrangements with NBS to cooperate in their technical development. Staff members in these institutions can work in NBS laboratories in order to transfer know-how in measurements and standards back to their countries. Qualified personnel from many other countries have also been welcomed at the Bureau's unique laboratory facilities. Some of these scientists and engineers are sponsored by their own home institutions, some by international organizations, and still others by AID.

Procurement of instrumentation is an important and often difficult task for most technical institutions in developing countries. Once the instruments are obtained, keeping them in proper working order, so that they can be relied on for accuracy and precision, is equally difficult. The AID program has permitted NBS to help several institutions abroad by reviewing the specifications for major pieces of equipment to be purchased. NBS has also operated an experimental course in procurement for officials of institutions just getting established.

These are just some of the activities through which the Bureau endeavors to help developing countries to enhance their rate of industrial development, insure equity in the marketplace, and enter their products into world trade.

Better Jobs for Women

Private voluntary agencies often look to AID for "seed money" for innovative programs that can be taken up and expanded locally once their value has been proven. Support for such private-sector activity is a relatively small part of AID's program in financial terms but not in terms of results.

One of the more unusual of AID grants to private voluntary organizations is that to the National YWCA of Korea to train women in nontraditional technical skills. Although they constitute 40% of the labor force in Korea, women, like youth, have not benefited proportionally from the economic growth that has carried Korea into the ranks of middle income nations. They have been limited primarily to jobs as unskilled or clerical workers or to such traditional occupations as beauty culture, dressmaking, and knitting, with little opportunity for advancement. They have generally been excluded from technical training programs offered to men in similar occupational circumstances.

The YWCA's concern for the health and welfare of working women is long-standing and consistent. Since 1970, all 18 branches of the Korean YWCA have placed special emphasis on finding jobs for unskilled workers, counseling, and establishing night schools for women. The association has been active in training women in traditional occupations, as well as in social programs such as consumer protection and literacy.

Having conducted a survey of Korean women as part of its International Women's Year activities, the YWCA is now determined to respond to the women's call for better jobs. Its survey revealed a wide range of blue-collar jobs in which women thought they could perform as well as men; indeed, in some construction trades, women were already acting as "assistants" to men, performing the same work for less than half the pay. The project currently being supported by AID focuses on three of these trades—wallpapering, tile laying, and painting.

Since the project began in 1978, almost 200 women, out of a projected total of 600 by 1980, have received training at YWCA facilities in Seoul and Kwangju. Initially, there was some fear that the program would meet with resistance from traditionally minded employers and skilled workmen. In the event, however, the women who have gone through training have been well received. Construction companies, hard pressed by labor shortages in Korea's booming economy, have welcomed this new source of trained workers. As for the women, they have all been placed in jobs and are now averaging $200 a month income, as compared to an average monthly wage of about $85 before training.

Funding for this 3-year project is presently shared by AID, the Government of Korea, and the YWCA itself. The Korean Government has promised to increase its support in future if the project is successful. It has already accredited the YWCA as a vocational training center authorized to present officially recognized diplomas to trainees who successfully complete the training courses.

The YWCA is establishing a permanent job placement office to review job openings, place trainees, and follow up the progress of each woman placed in a job. With government support and with increasing experience, the association hopes to expand training to other occupational fields in the next few years. It will also urge the government to train more women at provincial training centers and encourage private industry to develop its own training program. A publicity campaign is under way at each of the association's branches to inform and educate both Korean men and those women who are either unaware of or afraid to take advantage of opportunities for personal advancement. The YWCA is confident that this campaign, coupled with the proven ability of the trained women, will accelerate the reversal of traditional, conservative attitudes toward women and, ultimately, upgrade their general status in the society.

The AID representative in Seoul reports that the program's success "has far surpassed our most optimistic expectations." It is an example not only of the U.S. commitment to try unconventional approaches to development but also of its increasing willingness to grant funds directly to developing-country institutions ready and able to carry out development projects without outside technical assistance.

Promotion of Small Industries

U.S. colleges and universities have often been urged to develop special courses and other capacities that relate specifically to the concerns of students from other nations. In order to speed this process, AID has made a number of grants to selected universities to enable them to build staff and programmatic experience relevant to developing-country problems. AID's 5-year grant to the Georgia Institute of Technology, in the field of small-industry management, provides a good example of how this program works.

The Georgia Institute of Technology has a long history of applied management and technical assistance to domestic and overseas industry. In the past 21 years, subunits of its engineering experiment station have helped some 9,500 small industrial enterprises, especially in the State of Georgia and in Latin America. This record of performance has attracted many students from developing countries.

AID support between 1973 and 1978 enabled Georgia Tech: (1) to develop a special Master of Science program geared to students from the Third World; (2) to deepen faculty expertise in problems specifically related to enterprises in those countries; (3) to expand its library resources; and (4) to build a network of contacts with counterpart institutions in the Third World. Each of these elements reinforces the others, so that the institute now possesses both a continuing commitment to respond to developing-country needs in education and research and the capacity to carry out that commitment more effectively.

The Master of Science program with emphasis on industrialization is now an established part of the School of Industrial and Systems Engineering. It was developed with the aid of graduate students from developing countries, combining existing courses and new material in feasibility analysis and case studies. In 1978, 15 students from 10 developing countries were enrolled. Masters theses and case studies by present and past students have investigated, *inter alia,* the feasibility of a vegetable canning plant in Brazil, abaca pulp processing and fishmeal production in Ecuador, reprocessing motor oil in Panama, and a cultured quartz plant in Korea. Over 1,000 students from this and special training programs for Third World participants have now returned to their home countries. Many of them work in development agencies, private industry, and government. One is the Under Secretary of Industry in Paraguay, another is Minister of Transportation in Venezuela, and a third is Secretary of Planning (Labor Department) in Brazil.

Forty-three Georgia Tech faculty and staff professionals have participated in field trips to many developing countries. In addition, a continuing series of conferences, seminars, and workshops has exposed faculty members to a variety of problems and problem-solving techniques in those countries. Thus, the institute now possesses a substantial cadre of individuals with recent, substantive overseas experience. They have generated at least 60 reports, bibliographies, videotapes, and monographs for use in institute training and for distribution to inquirers.

Georgia Tech also maintains an International Development Data Center whose holdings include about 8,000 books, pamphlets, and other materials on small industry development, capital-saving technology, solar energy, and related areas. These holdings increasingly enable the staff to respond to technical and other inquiries, many of which come from institutions in developing countries.

Of perhaps the greatest potential value, the institute now has formal cooperative agreements with 11 counterpart organizations (educational institutions, government organizations, and research institutes) in the Third World. This network of 12 organizations maintains communications; exchanges program staff, information, and technology; and provides in-country bases for research related to small-industry development. The institute reports that these linkages are "the most rewarding element" in their program.

In 1979, Georgia Tech had over 500 students from developing countries studying on its campus in Atlanta. The purpose of the AID grant will have been achieved if these and future students from the Third World find that the education they receive in the United States is more responsive to their needs and those of their respective home countries.

EDUCATION

Education and training at all levels have been prominent features of U.S. development assistance from the start. Most of the programs described earlier —indeed, almost all U.S. development projects—include a training component to insure that permanent skills are in place after the project ends. This is equally true of programs directed to the education sector itself. One such program, that seeks to put space-age technology at the service of education in developing countries, is described below, as is another, which uses simple transistor radios to enhance elementary education in rural areas. The U.S. Peace Corps has been particularly active in providing needed personnel for secondary school systems in the Third World, especially for teaching the technical subjects, math and science, and English that are often the keys to further growth in a country's scientific and technical capabilities. In addition, the Peace Corps and AID are increasingly developing nonformal, community-based programs in order to reach the large numbers of Third World people who are unable to pursue formal education or who find it irrelevant to their particular needs.

In addition, various agencies have provided advanced education and training in the United States and third countries for thousands of Third World scientists and technicians. They, along with the much larger number of students from developing countries who come to the United States under private auspices, have been welcomed to many public and private campuses and laboratories over the years, returning with knowledge and skill that can be put at the service of development in their home countries. Some of the exchange programs sponsored by AID are described below. Other programs designed to encourage U.S. institutions to develop curricula that are specially geared to developing-country needs have been touched on earlier.

Education via Satellite

Broadcasting satellites have the potential for enabling developing countries to bring education and other services to rural areas that would otherwise wait years, even decades, for telephone lines and the like to reach out from urban centers. This is the basic premise of a major initiative recently announced by the United States. AID has now set out—in cooperation with a number of developing countries and with the providers of satellite services such as INTELSAT—to test whether this premise can be fulfilled at reasonable cost.

Earlier experiments have shown that satellites using small, low-cost ground stations can be used effectively in reaching rural populations. For example, the 1-year satellite instructional television experiment brought Indian television programs to 2,400 remote villages—to an average of 200,000 people every day—by direct telecasting through a satellite to village TV sets. The programs transmitted through SITE related to agricultural techniques, health and hygiene, family planning, teacher training, and in-school education. NASA provided technological as-

sistance and loaned the satellite used for this demonstration. It was considered so successful that the Government of India now expects to launch its own satellite in 1981 to expand telecommunications in the countryside.

The pan-Pacific education and communication experiments by satellite also use a NASA satellite. It links 12 island nations of the Pacific region via satellite and small, low-cost ground terminals for voice and data transmission. A large number of programs and conferences in health, nutrition, education, and training are produced and broadcast annually by dozens of institutions in the region. The satellite system is also used by the University of the South Pacific, with AID assistance, for economic transmission of courses serving much of its student population, which is spread over 11 islands.

In 1977, a similar experiment was conducted by the University of the West Indies (with funds and technical assistance from AID) to link three of its island campuses. Conferences of rural social service workers, classroom lectures, and administrative meetings of university officials were carried out successfully via satellite-transmitted television, two-way radio, and facsimile facilities.

Now AID proposes to fund an organized program, including seven or eight different pilot projects lasting 1 or 2 years, as well as additional short-term demonstrations. Each will involve from three to six satellite ground stations, a master control station linked to existing telephone lines, and telephones, rebroadcast loudspeakers, and other equipment to extend outreach beyond the immediate vicinity of the ground receiver.

Core activities will involve: (1) educational broadcasting produced locally to support rural services in health, agriculture, and education and (2) basic two-way systems to enable local administrators and extension workers to seek advice, make suggestions, and otherwise communicate with their respective headquarters in the cities. These pilot projects will use existing satellite systems, such as INTELSAT or Indonesia's PALAPA satellite, in order to facilitate a later transition from experimentation to continuing operations. To keep costs to a minimum, only voice and other "narrow-band" transmittal, such as facsimile data and slow-scan television, will be used.

The Government of Peru is likely to be the first to join with AID in this experiment to support integrated rural development in the Amazon region of Peru. Technical training, evaluation, and information exchange are all included as integral parts of the proposed projects. Training in program production techniques will have special emphasis. Thus, an important byproduct of these experiments will be the building of permanent communications technology skills and systems in the developing countries concerned.

Another important byproduct, it is hoped, will be lowered costs. AID plans to provide some funds for research and development to lower the cost of ground receivers. More importantly, it hopes that the rural satellite project will demonstrate the existence of a viable market for the small ground stations and high-powered satellites that are needed to reach rural areas most effectively, thus encouraging local and international firms to seek economies of scale in the production of ground stations and encouraging satellite designers to provide an appropriate capacity.

Radio Mathematics

Radio, television, and other educational technologies have been used for instructional purposes in AID-supported programs for over a decade. Technology of this sort can help to make up for shortages of qualified teachers and instructional material in developing countries. Used in such fields as science and mathematics, it can have the important consequence not only of teaching basic skills but also of spreading technical awareness more widely through the population and encouraging aptitudes for scientific and technical work, thus enhancing prospects for self-reliant growth of local science and technology in the future.

One of the most successful examples of AID's work in this area is the radio mathematics project begun in 1973 in cooperation with the Ministry of Public Education of Nicaragua and now carried on without external assistance. This project aims to teach basic mathematics to primary school children. So far, it is reaching 10,000 children in urban and rural schools.

Stanford University's Institute for Mathematical Studies in the Social Sciences was responsible for helping Nicaragua to develop the series of lessons. They adhere to the curriculum of the Ministry of Public Education but also use drama, songs, and jokes to sustain student interest. Since it was found that children paid more attention when they were asked to do something specific, the broadcasters encouraged oral or physical responses from the students. Classroom teachers are encouraged to reinforce the lessons with 30 minutes of related activities.

The first lessons under this program were transmitted to Nicaraguan classrooms in 1975. Today, the project is broadcasting to grades one through four; lessons are being prepared for fifth and sixth grades. The Ministry of Public Education supports the facilities and personnel for the project, including actors and producers who record the lessons at studios of the national radio station for transmission throughout the country.

The radio mathematics program was specifically designed to use a proven, commonly available technology and to achieve results at costs that are affordable by many countries. Thus, the cost of reaching classrooms in rural Nicaragua is only $2.00 (U.S.) per student, including AID developmental costs of $2.4 million. Continuing expansion of the student audience will reduce these unit costs still further.

And instruction is of high quality. Tests conducted in 1976 showed that first-graders were learning 63% more and second-graders 42% more than they did by previous methods. The percentage of students who fail the mathematics course has fallen from 26% to 17%, which reduces the likelihood that students will have to repeat those grades and saves the Education Ministry an estimated $3.25 per student per year for each failure avoided.

No other AID-financed educational innovation in a developing country has produced achievement gains of this magnitude. In the competition for the 1977 Japan Prize, "Lesson 171" in the second-grade math series won the highest award among the 167 entered in the radio division by broadcasting organizations from 49 countries. The Nicaraguan Government intends to use the series in other schools and to try using radio for teaching other subjects.

A 1976 conference in Nicaragua of representatives from 11 developing nations evoked considerable interest in this type of radio instruction. Brazil, Paraguay, and Thailand are either planning or carrying out similar programs. In the United States, several school districts in Texas and California are also looking closely at the Nicaraguan program as an effective, and relatively inexpensive, instructional tool. AID intends to make widely available the educational methods developed in this project and to apply them to prototype curricula in other basic subjects, including science.

AID Participant Training

Each year AID supports approximately 3,500 nationals of developing countries in short-term and academic training programs in the United States and elsewhere if suitable opportunities

are not available locally. By now, these "participant training programs" have contributed substantially to the scientific and technological capacities of many developing countries, and returning participants have used their skills and information to make a notable difference in the lives of many of their compatriots.

Iftikhar N. Hassan, for example, was an assistant professor at the Institute of Education and Research in Lahore, Pakistan, in 1964 when she was selected for postgraduate training in clinical psychology at Indiana University. She returned with a Ph.D. degree. After some years, Dr. Hassan became a Professor at Peoples Open University, responsible for training primary teachers through the mass media. Today, she plans in-service teacher education programs and curricula for about a million-and-a-half primary and secondary teachers in Pakistan, as well as nonformal adult education programs. For over a decade, Dr. Hassan has disseminated her knowledge and experience not only to her students and staff members but also to others through newspapers, radio, and television and through numerous research publications.

Thanks in good part to the AID participant training program, the "Moroccanization" of the Hassan II Agronomic and Veterinary Institute, the only graduate and postgraduate agricultural institution in Morocco, is moving ahead quite quickly. The institute's Moroccan faculty now includes eight former AID participants who, between 1973 and 1976, received academic training in U.S. universities. Apart from their teaching activities, the eight assistant professors are working on curriculum development and research projects in their respective specialties—plant breeding, soil conservation, watershed management, horticulture, range management, soil microbiology, plant virology, and plant production. Collectively, they are contributing materially to the advancement of Morocco's scientific and technical infrastructure.

The number of participants who come for short-term training now exceeds those who receive academic training. The catalytic effect of even 1 month's exposure to fresh approaches can be considerable. Take the case of Bernard Young, a small farmer from Guyana. Mr. Young was trained at the University of Florida in swine production for a month in 1972. On his return, with the help of a government loan, he was able to increase his swine herd from 3 to 423 and, through good management practices, to reduce the piglets' previous high mortality rate. Mr. Young's pigs have won prizes on county and national levels. Today, his farm is a source of breeding stock for his whole district and is used as a demonstration for both farmers and agricultural students. The Government of Guyana recently produced a film about his operations, which is distributed countrywide, to teach others to follow Mr. Young's example.

Another example from Guyana illustrates AID's practice of supporting training in other developing countries, where training can often be better suited to conditions in a participant's home country. In 1974, AID sponsored 5 months of intensive training at the Nigerian Institute for Oil Palm Research for Sam Shivdatt, a horticultural technican with Guyana's Ministry of Agriculture. Guyana now imports large quantities of edible oil, but, it was reasoned, foreign exchange could be saved and employment opportunities in Guyana increased if palm oil were produced within the country. On his return from Nigeria, Mr. Shivdatt worked in two experimental oil palm projects. He has since become project manager of a 40-hectare pilot project which has shown that crude palm oil can be produced and processed economically in Guyana. This project, located in Wauna, is scheduled to expand to 4,049 hectares by 1983, putting Guyana on the path to self-sufficiency in edible oils.

Most courses of study in U.S. institutions are naturally geared to the needs and interests of U.S. society. However, it is sometimes possible to design training experiences tailored directly to the specific needs of participants from developing countries. One such program was developed at San Diego (California) State University, where a decade of AID-supported interchange with the Brazilian Ministry of Education and Culture had produced a core Portuguese-speaking staff familiar with Brazilian education. When Brazil decided to send 25 teachers to the United States for graduate study in educational administration and planning, the Ministry and San Diego State worked together for a year to develop a program that would make the best use of the trainees' time in the United States. For 3 months before their departure in 1974, the participants received intensive language training, background on Brazil's education problems and potentials, and a review of Federal and State expectations for the group. Once in the United States, the participants took standard courses which were replete with Brazilian illustrations. The research and planning methodology was focused on Brazilian problems. Research papers related specifically to individual responsibilities back home. At the end of the year, all participants were awarded a Master of Arts degree and returned to Brazil.

In addition to fostering an added competence in the educational sector, this program has helped to open the field of educational administration and planning to Brazilian women, who have traditionally been confined to the role of teacher. Of the 25 in the group, 22 were women who have since moved into this new area of opportunity.

INFORMATION SHARING

In the modern age, access to and interchange of information is crucial to scientific and technological development. With a well-structured and appropriate supply of technical resource materials, scientists and engineers can save substantial time in preparatory and analytical work and thus produce results more effectively. Services based on printed and electronic media are in themselves a positive tool for knowledge.

Through the National Technical Information Service (NTIS), the United States makes available a high percentage of the scientific and technical information in its possession—research results, patents, data, analysis, and so on. AID support has enabled NTIS to add a small-scale, capital-saving component to its vast array of high-technology information and has helped to make both types of information more accessible to interested users in the Third World. AID's own Development Information Center is engaged in communicating the results of AID-sponsored research to users around the globe. Other U.S. agencies maintain data centers and related activities for sharing specialized scientific and technical information.

Some U.S. information programs are described below. In addition, the United States contributes to many of the new and expanding international information networks of specific concern to developing countries. Collectively, these information services help to get the best of the world's technology into worldwide application much faster than traditional methods have ever been able to do.

National Technical Information Service

NTIS, a unit of the U.S. Department of Commerce, is the central repository of much of the scientific and technical information that the U.S. Government

makes available to business, industry, government, and the general public. Each year NTIS sends out about 4 million documents and microforms of varied origins on subjects ranging from agriculture and business through medicine and zoology. Its computerized bibliographic data file now exceeds 1 million titles, all of which are constantly updated and available to interested purchasers.

Before 1972, NTIS made no special effort to identify the material in its collection that might be useful to developing countries. AID funds have now helped to make this unique collection both more accessible to users in developing countries and more responsive to their needs.

Thus, NTIS publishes the newsletter *Applications of Modern Technology to International Development*, a monthly announcement of technical documents in the greatest demand worldwide. Each 8–12 page issue also includes descriptions of reports of particular interest to developing countries; issue 78–4, for example, dealt with small-scale manufacturing operations, while 78–5 dealt with water supplies. More than 20,000 copies of the newsletter are currently distributed in English, French, and Spanish. New services are being prepared, such as assistance to institutions in developing countries wishing to license commercially exploitable U.S. Government inventions.

NTIS covers a broad spectrum of technology. At one end are those sophisticated techniques that the post-industrialized world has come to depend on for its high-energy-use and capital-intensive products. All general-use computer programs developed by U.S. Government agencies are now available, for example. NTIS is the national marketing coordinator for various special technology groups and information analysis centers sponsored by the Departments of Defense, Energy, and Commerce. Through these centers, NTIS offers the very latest in the state-of-the-art of various technologies. Some private-sector technology is also available. NTIS has always supplied this information, based on the latest scientific research and development, and will continue to do so.

But in the past year or so, NTIS has greatly stepped up its acquisitions of data on low-cost, capital-saving technologies as well. It has become a major clearinghouse for information from worldwide sources in such fields as agriculture, rural development, management, small business administration, health, construction engineering, and energy. New Spanish-language acquisitions have further enriched the data base; one of these, Guatemala's manual *Talla de Madera* is among NTIS' most popular items. Agencies contributing to NTIS' store of information on this sort of appropriate technology include the U.N. Industrial Development Organization and public and private groups in both developed and developing countries.

To promote the accessibility of its data, NTIS has so far appointed 30 local cooperating agencies in developing countries, ranging from the Federal Institute of Industrial Research in Nigeria to the Pusat Dokumentasi Ilmiah Nasional in Indonesia and the Fondo Colombiano de Investigaciones Cientificas in Colombia. Librarians and other information specialists in those organizations have been trained in technical information handling and briefed on the full range of material available from NTIS headquarters. They receive frequent updating via computer, telephone, telex, and mail as well as visits from NTIS experts. The agencies identify potential users in their country; pass on the information they receive to interested institutions and individuals; transmit orders for documents, tapes, microfiche, and other material to NTIS; and clear orders through customs when they arrive, accepting payment in local currency. Many agencies provide user seminars and workshops for specialists, as well as data collection from local sources. In a continuing program, NTIS is translating its most popular appropriate-technology reports into Spanish. Twelve such translations are already available, with titles ranging from *Energy for Rural Development* to a *Guide to Field Crops in the Tropics and Subtropics*.

Despite some problems in delayed receipt of documents and lack of computer search capabilities, clients in developing countries seem to be finding NTIS facilities useful. They are now buying more than $250,000 worth of technical, scientific, and engineering information annually. In Ecuador, a sawdust problem was solved by designing a new product to use this former waste material. In El Salvador, broken glass was recycled in a tile factory. In Korea, a telephone exchange was designed and produced locally. All this was made possible by information from NTIS. A Latin American participant has paid perhaps the ultimate compliment to this expanding network of technology transfer. "We should somehow acknowledge," he said, "that AID's contribution through NTIS is bringing a Latin American information system into operation."

Development Information Center

Over the years, projects supported by AID and its predecessor agencies have generated thousands of technical reports, scientific analyses, and other findings in the search for new approaches to development problems. For example, AID recently sponsored studies of income and employment planning in rural sectors, zinc deficiencies in rice, and rural roads in Africa, among many others. Some of this knowledge is embodied in materials available through existing information systems, library catalogues, commercial data banks, and the like. But much of it is not.

Until relatively recently, AID made only limited efforts to organize the material it had helped to finance so that the findings could be used by development workers outside the confines of the immediate project. While much remains to be done, the Agency has now undertaken to create a "memory" that will make this scientific and technical information more readily available to a worldwide clientele.

The two-volume *Catalogue of Research Literature for Development*, totaling over 1,000 pages, was the first major result of AID's effort to make better use of its extensive technical information data base. The catalogue cites about 6,600 research and development titles produced between 1962 and 1977, cross-referenced as to subject, author, and issuing unit. It functions both as an ordering tool for those who want to obtain copies of selected titles and as a "card catalogue" for library/information centers.

Since July 1973, this basic coverage has been updated by the *AID Research and Development Abstracts*. Each issue of this quarterly series includes summaries of about 150 AID-generated papers, books, and reports containing findings in the fields of agriculture and rural development, nutrition and health, education, urban development and housing, science and technology, and various branches of the social sciences.

The original documents cited in both these publications are available in print and in the more economical microfiche. Full microfiche sets have been given to the Lubin Library of the Food and Agriculture Organization (FAO) in Rome and the Inter-American Institute of Agricultural Sciences in San Jose, Costa Rica, in addition to two U.S. institutions in the Washington, D.C., area. The Development Information Center will supply a limited number of documents, and an unlimited number of microfiche copies, free to developing

country institutions on its mailing list. Others can order documents at cost.

The impetus for the catalogue and the abstracts was the need to increase information exchange within AID. But the publications are proving their value to developing countries. Out of a total mailing list of 7,500, more than 5,500 are government ministries, universities, research centers and associations located in the Third World. New ones are added on request.

If the increasing number of requests for materials described in these publications is an indication of their usefulness, the venture appears to be successful. More than 35,000 copies of various technical publications were ordered in 1978, almost 70% of them by institutions in Asia, Africa, Latin America, and the Middle East. One researcher has written from Africa that this service "is almost like having a personal technical library at my disposal." Another, after requesting information on land reform, wrote from Asia: "We will have a much better understanding of the options available to us."

The Development Information Center is seeking to capitalize still further on AID's resources. The abstracts have become steadily more comprehensive. A new series, *AID Research and Development Summaries,* is being prepared, with each issue to be devoted to materials in a specific subject area. Explorations have begun to identify other centers in the Third World which could act as depositories for full microfiche sets of AID documents. Cataloguing, systems design services, and the like will be available through AID missions to developing countries wishing to upgrade their own information resource base.

Oceanic and Atmospheric Data

Data gathering, research, and research management are included in the mandates of many specialized U.S. agencies. Their scientists participate heavily in international scientific networks, contributing papers to international conferences, answering requests for advice or help from other researchers, and arranging to share research results and basic data.

The National Oceanic and Atmospheric Administration (NOAA), for example, is a division of the U.S. Department of Commerce. It has no less than five separate data centers for sharing information and training in its special fields of expertise.

- The Center for Environmental Assessment Services publishes weekly accounts of weather-induced crop stress for the major world agricultural areas. These reports, as well as printouts summarizing pertinent weather parameters, are provided regularly to the United Nations, the World Meteorological Organization (WMO), and the FAO. The U.S. State Department sends copies of the weekly environmental assessments covering the Sahel and Caribbean areas directly to each country in those regions.
- The National Oceanographic Data Center provides data and 6-month training sessions as part of a cooperative program for "strengthening capabilities of developing countries to acquire, process, and utilize information about ocean resources"; this program is sponsored by several U.S. and international bodies, including the National Science Foundation and the International Decade of Ocean Exploration. Employees of the Center recently visited Egypt to advise on equipment purchases for a new, regional oceanographic data center. Personnel from the regional center will receive training in data processing and data management under the U.S. Center's auspices.
- The National Geophysical Solar-Terrestrial Data Center services hundreds of requests from other countries for data on scientific and technological activities. In exchange, it receives data for its archives from a hundred or more stations and institutions overseas. The Center has loaned six ionosphere monitoring radars to institutions in developing countries and, in some cases, has provided operating supplies.
- The National Climatic Center operates and provides selected meteorological data to scientists or assists those who need unique data not available through the WMO. This Center also exchanges publications with many foreign meteorological services and provides training in data management to representatives of developing countries. Limited data and information services are supplied to foreign governments without charge or by means of UNESCO coupons.
- The Environmental Science Information Center library system provides copies of NOAA publications, formally exchanges publications with about 53 developing countries, conducts computerized literature searches on request, and arranges meetings and orientation for visitors from developing countries. The majority of exchange materials are in the fields of meteorology, climatology, fisheries, and hydrography.

In addition, NOAA's Office of Coastal Zone Management maintains an informal advisory service which provides foreign scientists with information and advice on problems of use, development, and conservation of coastal areas. Under bilateral agreements, NOAA also sponsors exchanges of scientists between its marine research programs and those of other countries for periods lasting from several weeks to a year.

NOAA's fisheries centers participate with other countries of the western central Atlantic on such regional research programs as the International Oceanographic Commission Association for the Caribbean and Adjacent Regions and FAO's Western Central Atlantic Fisheries Commission. The centers also work closely with the Mexican Instituto Nacional de Pesca on fishery assessment. Its scientists took part in a Canada-Peru expedition in 1977 to study the Peruvian anchoveta, and they are now participating in an international billfish tagging program.

And finally, NOAA's polar orbiting environmental satellites provide a direct meteorological readout service known as automatic picture transmission, which is available to users everywhere. One hundred and twenty-one countries have established a total of 800 ground stations to receive this service, which can be used to determine the direction, speed of motion, and growth or decay of major weather systems—an important aid in the evolving art of weather prediction.

LOOKING TO THE FUTURE

Among other things, the advent of UNCSTD has prompted the United States to consider how its programs of scientific and technological cooperation can be made more flexible and responsive to development needs. The extensive AID program will, of course, continue, with its emphasis on serving the needs of the poorest countries and people. Scientific and technical agencies will continue to cooperate with international organizations like WHO, UNESCO, and the International Council of Scientific Unions, releasing experts to work in programs in developing countries and participating in international exchanges of many sorts. In some cases, these agencies have received new authority to work cooperatively with colleagues abroad on problems of mutual interest, and a number of them are reviewing their programs with international development needs in mind.

Department of Agriculture

The Department of Agriculture (USDA) was empowered by the Food and Agriculture Act of 1977 to exchange research materials and conduct

joint research and extension programs with other countries. It established a new Office of International Cooperation and Development in 1978 to handle bilateral agreements with counterpart ministries and liaison with international organizations. USDA has now concluded more than 30 bilateral agreements concerned with scientific and technical exchanges between the United States and other countries, both developed and developing. For each agreement, there is a negotiated program of information sharing and visits by teams of scientists and technicians in various disciplines.

National Institutes of Health

Government agencies have been working since May 1978 to flesh out the international health initiatives proposed at that time by the United States to the World Health Assembly. Aside from expanded activities within AID—on clean water, nutrition, tropical disease research, primary health care, and the like—much of this program will be carried on by the National Institutes of Health, particularly the National Institute of Allergy and Infectious Diseases (NIAID).

For example, NIAID has announced a new program of international collaboration in infectious disease research, which will provide outreach for tropical disease research in the United States through the establishment of "linkages" between U.S. investigators and laboratories and those in countries where infectious diseases are endemic. Over the next 5 years, awards will be made to about six U.S. institutions and five individuals to work with counterparts in developing countries. These grants will allow support for bringing Third World scientists to participate in the research.

This new program is an outgrowth of an earlier one whose purpose was to provide research and training in "exotic" diseases for U.S. physicians and scientists. Under that program, awards were made to the University of Maryland School of Medicine for work with the Institute of Hygiene and Preventive Medicine in Lahore, Pakistan; Johns Hopkins University to establish the Johns Hopkins Center for Medical Research, first in Calcutta, India, and later in Dacca, Bangladesh; Tulane University for work with the Universidad del Valle in Cali, Colombia; the University of California for work with two medical institutions in Malaysia; and Louisiana State University for work with the University of Costa Rica Medical School and Hospital. That program served to provide the United States with a core of expertise in tropical diseases and to train U.S. scientists to do research in foreign situations, but it did not put great emphasis on the establishment of institutional and professional linkages.

NIAID also expects to entertain proposals to establish a series of tropical disease units in the United States, each devoted to a major problem that is thought to be susceptible to multidisciplinary attack. Each unit will be expected to develop programs of basic and applied research within a particular disease area to study such things as the basic biology of the host-parasite relationship, improved diagnostic procedures, immunology and immunoprophylaxis, chemotherapy and chemoprophylaxis, and vector biology and control.

NIAID recognizes that the establishment of centers of excellence in the Third World is also of vital concern. To help expand the skills of junior or midcareer health professionals from developing countries, therefore, it is cooperating with WHO to award from six to eight 1-year postgraduate fellowships in infectious diseases each year, with emphasis on the tropical diseases, for work in U.S. public and private institutions. The first fellows are expected to arrive in autumn 1979.

National Science Foundation

The National Science Foundation (NSF) supported a number of studies in preparation for UNCSTD, and the interest kindled by these preparations has caused the Foundation to focus more attention on the relation of its programs to the needs of developing countries. Hitherto, NSF's international science activities involved working mainly with nations possessing advanced and well-recognized science and technology, although the Foundation has participated in some, mainly AID-financed, programs of technical assistance. Perhaps the most important of the latter is scientists and engineers in economic development (SEED), under which U.S. scholars arrange to work in cooperation, on a one-to-one basis, with counterparts in developing countries doing research, teaching, or both at institutions in the host country. AID funds pay for travel expenses for the American participant and provide some stipend to offset lost salaries and benefits. The SEED scientists seem uniformly to believe, as one reported, that "it's the personal relations over the long haul that are important. You start out by giving them some ideas and listening to their ideas. After a while, you're both smarter than you would be otherwise."

Now NSF, like a number of other U.S. agencies, has begun to make plans for expanding its cooperative activities when resources permit. Its board has endorsed criteria intended to insure that proposed programs focus on problems of priority interest to the participating developing country while also contributing to NSF and U.S. objectives. Programs will be expected to improve the quality of education or research, increase the capability of science and engineering institutions, or improve science policy and management in the cooperating country.

NSF staff has made plans and suggestions for new cooperative programs that would meet these criteria. Among the possibilities being explored are:

- Dissertation research grants to enable Third World students to work on problems of particular pertinence to their home countries;
- Short courses for Third World students in U.S. universities that would "top off" their educational experience and might ease their readjustment when they return home;
- Support for Third World scientists to visit the United States to exchange technical information and develop plans for cooperative activities; and
- Support for continuation of collaborative research projects after the departure of the U.S. partner, through the provision of travel and support funds for developing-country scientists.

These and similar ideas have won Foundation approval, but some are delayed for lack of funds and others until plans mature.

Preparations for UNCSTD have also led the Foundation to take stock of its substantive grant portfolio. Current NSF-supported research includes a sweeping array of projects of likely significance to developing countries, though it should be emphasized that the results of such seemingly relevant research are only *possibly* adaptable to technological innovation in developing countries. A few examples suggest the variety and possible usefulness of these projects: biological research in tropical ecology, biosalinity, and arid lands; local weather predicting; study of monsoons; earthquake engineering and prediction; planning for natural hazards; tropical forest productivity and uses; fermentation techniques; nonconventional proteins; and guayule (see p. 19). NSF has also supported a study of "appropriate technology" which resulted in a director of activities and projects in the U.S. and abroad.

Some NSF-supported research is being carried on in cooperation with scientists from developing countries. For example, there is an evolving partnership in science between NSF

and Mexico's National Science and Technology Council (CONACYT), ranging from investigations of the mineral resources of the Sierra Madre and the ecology of the Mexican dung beetle to studies of the biochemistry of cell-wall differentiation and the classical relativistic dynamics of particles and fields. This program is part of a broader pattern of scientific cooperation between the United States and Latin America. Similar arrangements exist with scientific institutions in Brazil and Argentina, and there are officially supported joint research projects between the United States and 10 other countries of Latin America.

Both NSF and CONACYT appear to be pleased with the results of their cooperation to date. "Results come sooner through joint research," says one Mexican official, continuing: "At the same time, the cooperation increases our capacity to solve problems as our scientists gain more capability." A U.S. official notes: "Each side is contributing its share not only of costs and facilities but also of intellectual input and know-how. The result is significant sharing, a new relationship among equals."

Institute for Scientific and Technological Cooperation

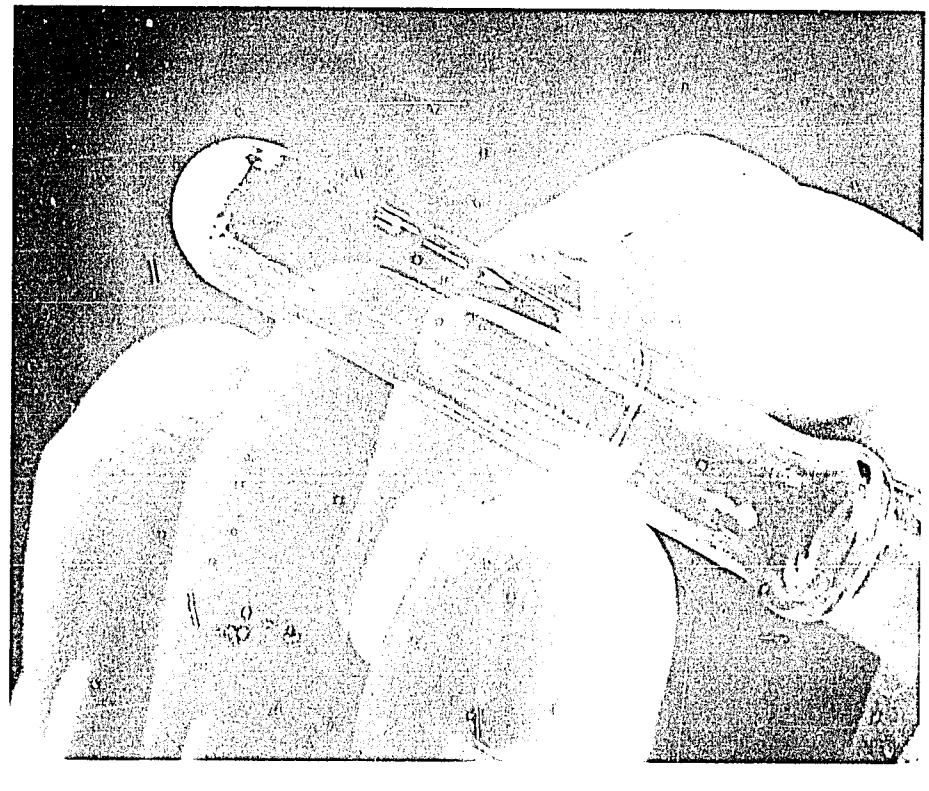
The principal new vehicle for scientific and technological collaboration with Third World countries will be the institute for scientific and technological cooperation, which was proposed by President Carter in a speech to the Venezuelan Parliament in March 1978.

As presently planned, the institute has a dual purpose: to strengthen capacities of developing countries seeking to apply science and technology to meet their needs and to focus increased U.S. scientific and technological research attention on problems relevant to development. It will build on the recognized strength and diversity of U.S. science and technology. Rather than operate programs directly, the institute will make grants and sign contracts with appropriate institutions in developing countries, in the private sector, and the science community. To help insure that its program is responsive to Third World needs, experts from those countries will be included in the small, highly professional and multidisciplinary staff and will comprise about a third of the 25-member advisory council.

Substantively, the institute is expected to promote technical cooperation both on development problems of the poor, such as hunger, disease, and unemployment, and on global problems such as environment, energy, and natural-resource development which affect all countries. The following program areas have been identified as possible targets for intensive effort:

- Increasing agricultural productivity and rural income, with special new emphasis on biological nitrogen fixation; greater photosynthetic efficiency, traditional food crops, and farming systems for marginal lands; and other activities aimed at agricultural technologies of lower cost and greater usefulness to the poor;
- Controlling the most damaging infectious diseases, with special attention to the problems of water-borne and insect-borne diseases (for example, diarrhea, the major cause of child mortality); the development of lower cost treatments and more effective health services delivery; and the potential in traditional medicine for more effective pharmaceuticals;
- Improving population programs, with expanded efforts to develop better contraceptive technology and new initiatives to understand the motivational factors affecting family size and their relationship to other factors;
- Improvement in developing countries' technological skills, with expanded collaboration in the development of science and technology policy, and new initiatives to improve the relevance of technical education received in the United States by students from the Third World; to improve the teaching of science and mathematics in formal and nonformal education systems in developing countries; and to understand more of learning problems which inhibit widespread technological innovation in both rural and urban areas;
- Productive growth of nonagricultural employment in developing countries, with new initiatives in improving entrepreneurial management, industrial standards, and research, and the capacity to develop and use suitable technologies;
- Environmental planning and natural resource management, with expanded efforts to combat desertification and with new initiatives in forestry, coastal zone management, pollution control, and the improvement of skills for developing mineral and other nonrenewable resources; and
- Energy policy and alternative sources of supply, with new or expanded efforts to augment the efficiency of traditional energy supplies and ascertain the technical, social, and economic feasibility for solar, wind, water, biomass, and other energy sources which will meet the demands of the rural and urban populations.

As the previous pages indicate, much U.S. activity has already been undertaken in these fields, both by AID and such other agencies as the National Institutes of Health, the Department of Agriculture, and the like. But the prospect is for added resources, more carefully targeted programs, and much closer collaboration with scientists and engineers in developing countries.



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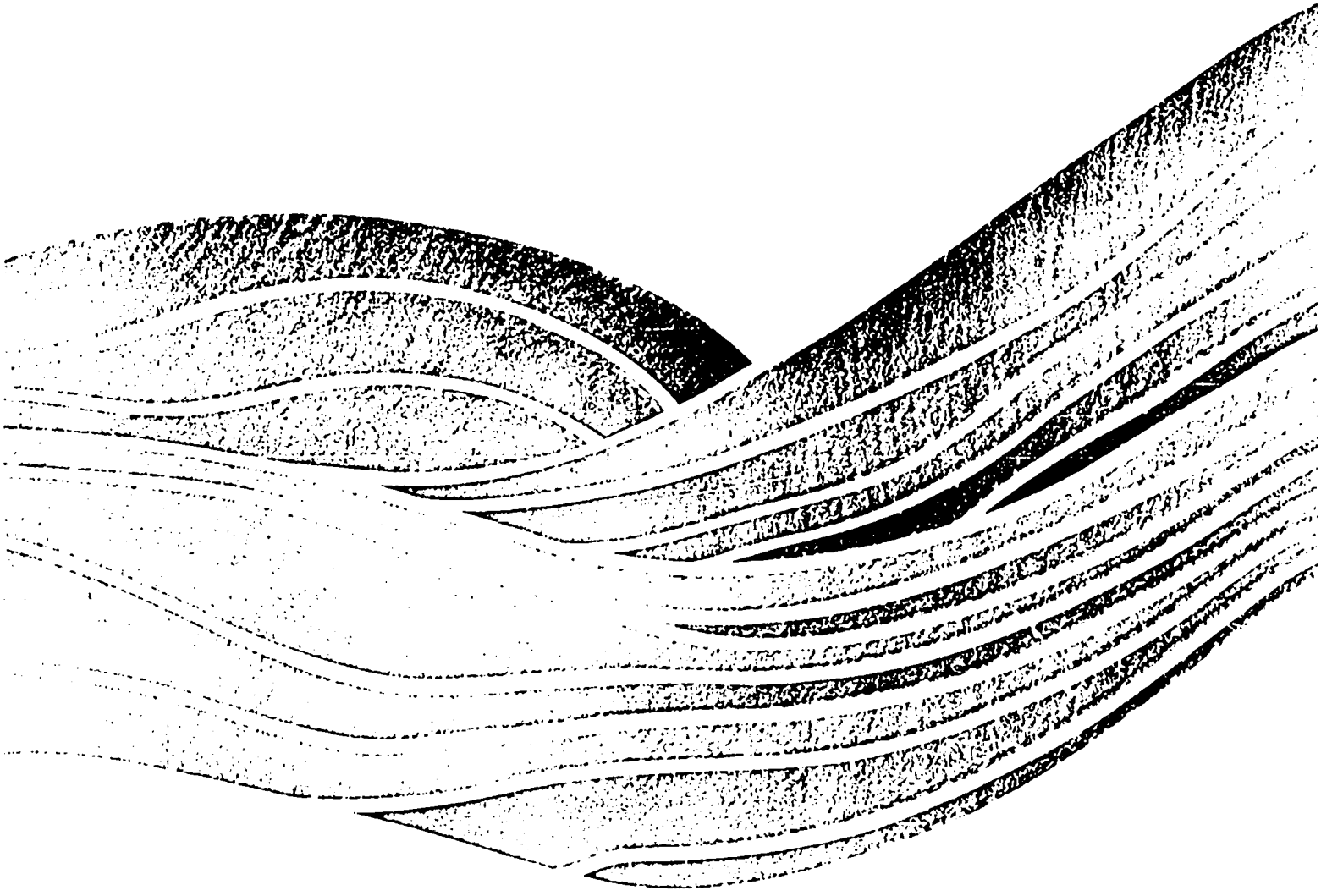
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