PN-ABM-682

CUTTING-EDGE RESEARCH FOR DEVELOPMENT

The A.I.D. Program in Science and Technology Cooperation

Office of Research

U.S. Agency for International Development

Washington, D.C.

Cover: The Program in Science and Technology Cooperation promotes the use of innovative science to solve developmental problems in health, agriculture, industry and the environment. For example, the use of monoclonal antibodies has led to a highly sensitive test that may detect cholera bacteria before they can infect humans, as happened to this Bangladeshi child (left). Several techniques are under investigation for boosting the production of rice (center), the staple food in many developing countries. In Portugal, a new continuous chemostat-type culturing system is being developed (right) to optimize industrial fermentation output. And in another PSTC project, tissue culture is being adapted to quickly regenerate single cells into pine tree plantlets (inset) that can be used for reforestation.

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June 1992

"It is ... in the mutual interest of the United States and the developing countries to increase scientific and technological cooperation and jointly to support long-term research on critical problems that impede development and limit the efficient use of the world's human, natural, and capital resources."

— *International Development Cooperation Act of 1979*

Laboratory technicians in Peru monitor growth of tiny plantlets created by micropropagation techniques.

Preface

As the leading scientific power of the 20th century, the United States has clearly demonstrated how technical innovation leads to social and economic progress. The U.S. example has been followed successfully by Japan and a number of newly industrialized countries.

During its 30-year history of administering the U.S. foreign assistance program, the U.S. Agency for International Development (A.I.D.) has helped other countries establish their own scientific and technological capabilities. Today, A.I.D.'s Program in Science and Technology Cooperation (PSTC)—the Agency's vehicle for cutting-edge research—is focusing the combined expertise of U.S. and developing-country scientists on problems confronting the developing world.

Now in its second decade, PSTC is well established in the vanguard of A.I.D. scientific research. PSTC scientific findings help solve developmental problems, often through private sector applications, and lead into other development programs.

A.I.D.'s role in the future must evolve to reflect the lessons of our own successful experience as well as the unique challenges facing each developing country. Our objective is to assist countries to realize their full national potential through the development of open and democratic societies and the dynamism of free markets and individual initiative. The Agency helps nations throughout the world to improve the quality of human life and expand the range of individual opportunities by reducing poverty, ignorance and malnutrition.

Through its innovative scientific research, the A.I.D. Program in Science and Technology Cooperation contributes substantially to achieving these goals.

Ronald W. Roskens
A.I.D. administrator

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Introduction

"We must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas."

— President Harry Truman,
inaugural address, 1949

The Program in Science and Technology Cooperation (PSTC) was created in 1981 to fund the earliest, most innovative part of the scientific effort A.I.D. brings to bear on developmental problems in the Third World. It is the cutting edge of A.I.D.'s much larger science and technology assistance. Over the past 10 years, PSTC has tapped state-of-the-art technologies such as plant tissue culture and genetic engineering to find innovative solutions for problems in developing countries. In the process, the program has built up and supported the scientific research capacity of host countries, leaving behind a local research infrastructure that is better able than before to solve developmental problems on its own.

Scientific innovation is essential to the solution of many Third World problems. To find truly new approaches to old problems, one must search widely. PSTC generates a steady influx of diverse, creative research ideas by insisting that all projects are initiated by the investigators themselves and not by staff at the A.I.D. Office of Research (AID/R), which administers the program. PSTC solicits original research ideas and has so far screened more than 5,000 of them from investigators in all corners of the world. Today, 75 percent of these ideas come from scientists in developing countries. Experts from outside A.I.D. assess the soundness and relevance of the more promising proposals, and PSTC funds only the best of these.

PSTC's highly competitive, investigator-initiated approach is one of the most important keys to the success of the program. This approach also differentiates PSTC from other developmental programs that are initiated by the funding agency. Certainly, PSTC projects must address serious developmental problems. But investigators choose those problems that seem likely to yield important gains through new technologies such as computers or immunodiagnostics. In addition, PSTC clearly encourages research involving novel scientific techniques, such as tissue culture and genetic engineering, that seem to offer faster or better approaches to Third World problems. The program also focuses its efforts on areas, such as global climate change and preservation of genetic resources, that are of increasing concern around the world.

The developmental problems explored by PSTC research can be placed in the four broad categories of environment, agriculture, health and industry. The following pages describe a sampling of projects from each. In the environmental area, PSTC investigators are trying to understand the operation of complex ecosystems. In the tropics, where many developing countries are located, ecosystems are more diverse and less studied than temperate-zone ecosystems. PSTC scientists have devoted effort to the study of tropical coastal ecosystems that suffer from pollution due to runoff from the land as well as from seaborne pollution, such as spilled oil. The program is also working on the preservation of a number of plant and animal species, which are a treasure of untapped genetic resources for new medicines, commercial products and other uses. An important element of this work is the domestication of wild species that can increase the wealth of developing countries.

In agriculture, PSTC researchers are helping increase food production in Third World countries and develop export crops that will strengthen their economies. In addition, strong efforts are being made, as in the environmental arena, to preserve the diversity of plants and animals as a biological resource and to identify environmentally benign methods of pest

A Peruvian research assistant does micropropagation of potato at the Centro Internacional de la Papa in Lima, where scientists use genetic engineering to develop more nutritious, pest-resistant potatoes.

Outstanding People in PSTC

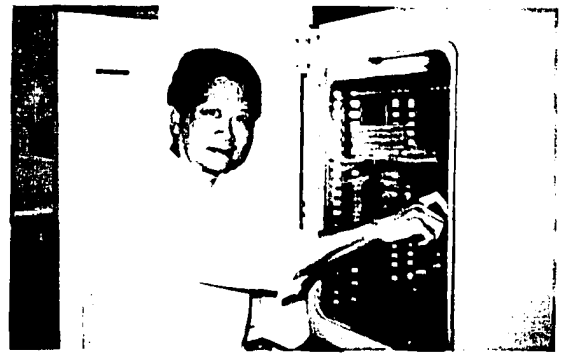
Innovative scientific research is the product of innovative scientists. The foundation of PSTC, therefore, rests upon its people, not only the scientists who compete for grants and conduct research but also others behind the scenes who facilitate that work. We think the PSTC people are outstanding, and so do others.

In Peru, for example, Luis Sumar Kalinowski received the Order of the Sun in 1985 and a United Nations Environment Programme Global 500 Award in 1989 in recognition of his research to improve the productivity of traditional Andean crops and to re-establish the best of them as major crops. Sumar, of the University of Cusco, was first funded by the National Research Council's Board on Science and Technology for International Development (BOSTID) under its PSTC grant to work on the development of amaranth, a highly nutritious grain. More recently he collaborated with U.S. researchers on a PSTC project to develop a computerized geographical information system that will be used to manage the collection of germ plasm for traditional Andean crops. Sumar was the first civilian ever to be awarded the Order of the Sun, the highest of Peruvian honors.

In Thailand, Stitaya Sirisinha was awarded his country's "Outstanding Scientist Award" in 1988. Sirisinha worked with PSTC funding to develop specific monoclonal antibody and DNA probes to use in diagnosing human liver fluke infection. In addition, Robert Barnes, the A.I.D. officer responsible from 1985 to 1989 for Thai participation in PSTC, was awarded the A.I.D. annual Science and Technology Award in 1990 in part for his shepherding of the program. (See "The Thai Science Machine," page 23.)

The president of Pakistan presented that country's Award of Distinction in 1987 to Kauser Malik for his outstanding scientific contributions. Malik, like Sumar, entered PSTC through a research grant from BOSTID. This resulted in the important demonstration of nitrogen fixation in conjunction with kallar grass—a hardy plant that grows well in salt-spoiled land. More recently, Malik's group at the Nuclear Institute for Agricultural Biotechnology has received additional PSTC funding to work on conversion of kallar grass to alcohol. Malik also hosted a meeting of PSTC biomass researchers in conjunction with the first international scientific meeting ever held in Faisalabad, Pakistan.

Anitra Thorhaug, an investigator at Florida International University, led PSTC-funded studies of seagrass restoration and oil spill clean-up impacts in the Caribbean (page 19). She was one of 90 people worldwide in 1987 who were granted the United Nations Environment Programme Global 500 Award for environmental achievement.



Above: *Luis Sumar Kalinowski of Peru has been honored for his research on improving the productivity of traditional Andean crops.*

Below: *Stitaya Sirisinha of Thailand has been recognized for his work on the development of diagnostic tests for human liver fluke infection.*

James Brewbaker and Mike Benge were two of the three recipients of the first International Inventors Award for forestry presented by the king of Sweden in 1986 for their work on popularizing leucaena, a fast-growing tropical tree now grown for a variety of uses in many developing countries. Brewbaker, a University of Hawaii investigator, was an early PSTC grantee funded to collect germ plasm from other leguminous trees around the world. Moreover, he has served as a PSTC reviewer and as a research advisor for other PSTC scientists (photo, page 56). Benge, an A.I.D. scientist, has served as project officer for several PSTC projects.

Ten years—the length of PSTC's existence—is a relatively short time for an investigator to develop and apply a new idea and gain recognition for the work. Since PSTC backs new ideas, it is no surprise that innovative scientists are attracted to the program. We therefore look forward to even more recognition for the outstanding accomplishments of PSTC participants in the future.

management. PSTC has been particularly successful at developing better potato crops in Latin America and improving the production of rice in Asia. PSTC research has also led to improved production of crops, such as rubber and spices, that are economically important to certain developing countries. The program has also strongly supported improvement of farming techniques so that agriculture becomes a sustainable, not destructive, activity.

In health, PSTC is funding projects that use a panoply of advanced scientific techniques to investigate major diseases of the developing world, including malaria, schistosomiasis, onchocerciasis (river blindness) and leprosy. Much of the research involves the development of vaccines, diagnostic tests and measures to control the carriers of these diseases. In health, as in other areas, PSTC grants are building the research capacity of developing countries, giving young scientists the chance to devote themselves to research, equip their labs and break out of the scientific isolation that is all too common in developing nations.

Poor countries need to create millions of new jobs but have little capital. Consequently, many PSTC projects in the industrial area aim to develop affordable manufacturing techniques that will provide employment for growing populations. At the same time, Third World industry must meet demands for manufactured products that meet uniquely Third World needs. For example, one PSTC project involved the development of a solar-powered ice maker (to store medicines and food) simple enough for local manufacture, maintenance and use. Other PSTC research aims at improving the efficiency of manufacturing processes so that manufacturers in developing countries can derive more value from raw materials and waste less. Finally, Third World countries need vibrant industrial communities to develop their economies. The industrial communities, in turn, depend upon the kind of scientific and technological infrastructure that is being built with the help of PSTC.

Science and technology are becoming increasingly important for the progress of developing countries and developed countries alike. The following pages describe the first 10 years of PSTC's efforts and successes in focusing state-of-the-art science on developmental problems in the Third World. We believe that the unique characteristics of the program—its insistence on investigator-oriented research, its highly competitive nature and its emphasis on new methods and approaches—have built the foundation for Third World scientists to launch a fresh assault from within on the developmental problems that plague their nations.

PSTC owes its success to the efforts of many people outside the Office of Research as well as within. Some 50 people in A.I.D. or the National Research Council have worked directly on the program during the past decade. Hundreds of A.I.D. staff have taken on PSTC work as additional duty. Hundreds of scientists outside A.I.D. have volunteered to review proposals, evaluate projects, advise on program directions or visit and assist researchers in the field. Most important, thousands of scientists from scores of countries have offered their best ideas and contributed their greatest efforts to this endeavor.

The PSTC Program

Environment

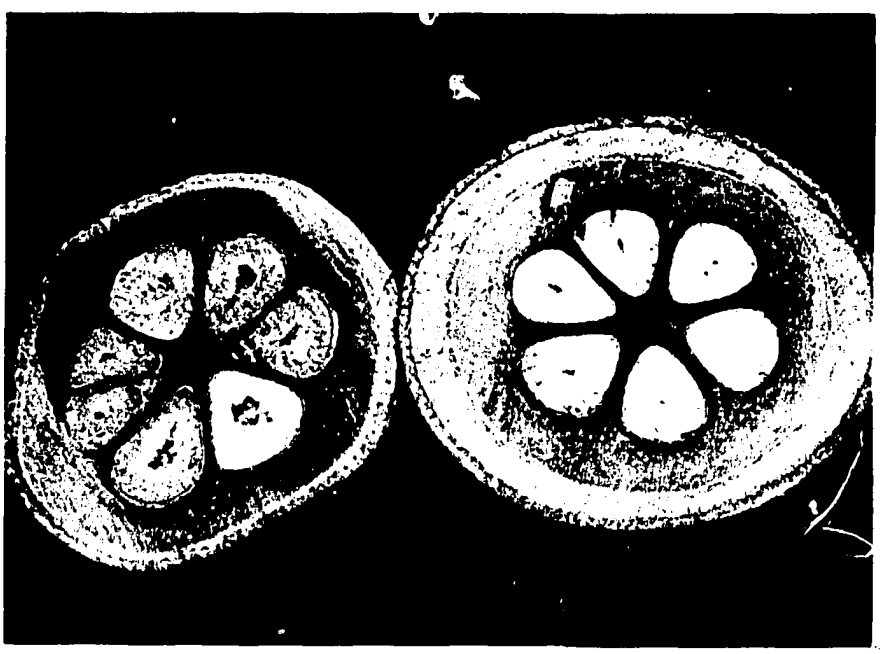
"Concern for the environment is fundamental to everything that we do (at A.I.D.).... Development that depletes renewable resources is not development at all.... Maintaining the natural resource base is a critical requirement for sustainable development."

— Ronald W. Roskens,
A.I.D. administrator

The need to understand the complexity of ecosystems and the philosophy that the environment, with all its biodiversity, should be managed for the sustainable use and conservation of natural resources are two ideas that underlie PSTC activity in the environmental arena. To develop new management technologies for these systems, we need to look beyond current scientific methodology. We need more efficient, specific techniques and more powerful approaches to deal with nature's complexity.

PSTC projects have helped answer these needs. In Sri Lanka, for example, no one really knows what natural wealth exists in the fast disappearing rain forests. PSTC-funded scientists began looking for it in 1985. Historically, local Sri Lankans have gathered a few plant species for food, medicine and other uses in their villages. But the systematic investigation conducted by U.S. and Sri Lankan scientists identified a number of species with excellent potential for regional and, perhaps, international markets. More important, these species can be grown together in commercial stands and forest buffer zones in ways that help conserve the rain forests and their rich, genetic diversity.

The linchpin of this plant combination is *Shorea trapezifolia*, one of a closely related family of teak relatives known as Philippine mahogany. *S. trapezifolia* produces a light, medium-quality hardwood that can be used for plywood veneers and light construction. The tree is particularly valuable because it grows quickly for a hardwood, reaching harvest size in less than 70 years. It also produces seed



Opposite Page: *Apinaye Indian woman collects babassu palm fruits (Orbignya phalerata) in northeastern Brazil. These fruits are cracked by hand and yield a kernal rich in oil similiar to coconut oil. The palm is also an important source of fuel, construction material and industrial feedstock. PSTC scientists are investigating the most promising varieties of babassu.*

Left: *Comparison of cross sections shows differences between fruit from the babassu palm (Orbignya phalerata) on the right and that of a related species (Orbignya oleifera) collected by PSTC researchers during a germ plasm expedition to Minas Gerais, Brazil. Note that the palm on the left has a smaller proportion of mesocarp (pulpy outer layer) and endocarp (woody inner layer), resulting in a much higher kernal/fruit ratio.*

An endangered stand of Vochysia hondurensis, a commercially important multipurpose tree species, grows in eastern Guatemala. U.S. and Central American scientists are conserving its seed and developing the best varieties for use by small- and medium-scale farmers and industrialists.

once, twice or even three times a year, a characteristic that facilitates mass culturing.

The same scientists also found two medicinal plants that mature in two to five years and a rattan that matures in about 10 years. All three can be harvested as quick-cash crops in a stand of more slowly growing *S. trapezifolia*. The Sri Lankan Forestry Department is using this knowledge to develop forest management techniques for regrowing forests as quickly and well as possible. The principal investigators have begun a follow-on project using the initial study as a model for investigating 10 other *Shorea* species.

The problems facing the world's environment are enormous. Twentieth-century human activity is rapidly degrading the environment. Tropical deforestation, desertification—particularly in Africa and Asia—soil erosion, watershed destruction and the loss of species have reached alarming proportions. Global climate changes due to the so-called greenhouse effect (page 16) are expected to increase in the foreseeable future.

In tropical developing countries, environmental problems are acute. Tropical forests, which cover roughly 7 percent of the earth's surface, contain more than 50 percent of the world's species. Despite their extraordinary richness, tropical forests are among the most fragile of all habitats. They grow on poor soils in a climate that remains stable only as long as the forest stands. Tropical forests store much of their nutrients in the trees themselves, whereas temperate-zone forests store nutrients in leaf litter and humus. Once a tropical forest is cleared, rain quickly leaches key remaining nutrients from the soil; seeds that germinate in a few days or weeks cannot survive the sterile soil and do not disperse across the stripped land. For these reasons, management practices developed for temperate habitats, such as U.S. forests, cannot be directly applied to equatorial problems.

Several PSTC projects are developing new methods for investigating the management of tropical forests. Researchers in Rwanda are adapting field techniques for seed dispersal studies to explore the role of primates as well as birds in dispersing tree seeds; with these techniques, investigators will gather knowledge useful in preserving the forest. In the Philippines, scientists are working on a technique that uses root fungi (ectomycorrhizal) to increase the absorption of essential nutrients and water by seedlings being planted in reforestation projects. And in the Dominican Republic, PSTC researchers are developing computer models that will characterize and help predict the effects of land use changes on tropical steepland hydrology. This ambitious study is based on data from previous A.I.D.-funded work and aims to develop a mathematical model of an entire water catchment basin.

The management of tropical ecosystems calls for detailed understanding of environmental processes. PSTC investigators have been particularly concerned about tropical coastal ecosystems, which are important, fragile, relatively unstudied habitats. For instance, researchers developed a novel method for measuring nitrogen loss in estuaries with mangrove forests along the coast of Ecuador. Such techniques will help scientists study how mangroves contribute to the ecology of the estuaries and provide informa-

Worker feeds chicken egg yolks to fries of the mahseer, an indigenous fish being studied in Nepal as a source of high protein food and sport fishing.

*Principal investigator Robert Twilley measures the diameter of a **Rhizophora harisonii** tree in the Churute Ecological Preserve, site of a PSTC mangrove study. Mangrove forest structure is well developed in Ecuador due to a combination of favorable climate near the equator, high river discharge lac :n with fertile sediments and semidaily tides reaching 3 meters.*

tion needed for the best management of these coastal ecosystems. Other scientists combined carbon and sulfur stable isotope techniques to help assess the contributions of mangrove detritus to the production of shrimp fisheries in Malaysia. Anticipating oils spills and clean-up efforts, another group of researchers used a new bioassay for hazardous substances in tropical waters to study the toxicity of various oil dispersants on coral, seagrass and mangroves in Jamaica (page 19).

In the past three years, PSTC has stepped up its efforts in another sector of environmental concern: genetic resources. The global environment contains untold numbers of plant and animal species that should be preserved not only for their own sake, but for their potential use as well. Many hold the genetic material that could one day provide medical cures, better food sources and new products of commercial value. PSTC research therefore concentrates on identifying ways to conserve the biological diversity of the earth's remaining genetic resources and on domesticating wild species of plants and animals with potential value. In 1987, PSTC was extended to fund more research into biodiversity, a project category that now gets priority funding.

PSTC has been especially interested in funding experiments involving tissue culture techniques, which generate new plants from plant tissue rather than from seeds. The technique holds great promise for conserving and exploiting wild species. Although tissue culture has been used extensively in crop plants, its use in woody species is more difficult. PSTC researchers are creating new technologies for these woody species. For example, one group of PSTC researchers is developing tissue culture techniques for the conservation and mass propagation of bamboo, and another is doing similar work with three species of rattan. Bamboo is difficult to propagate by seed, and rattan does not produce seed fast enough to meet the demand for rattan cane.

Tissue culture is also being called on to help with reforestation in the tropics. Researchers in Thailand are developing techniques to mass-produce teak seedlings that can be used to restore the overharvested teak forests of Asia. In Nepal, a PSTC project is using similar methods to develop an economically important pine species for mass planting.

Global Climate Change

Layers of atmospheric gases such as carbon monoxide can trap the sun's heat on the surface of the earth much as glass traps the sun's heat inside a greenhouse. These "greenhouse gases" from cars, factories, the burning of forests and other sources have been building up for decades.

If the buildup continues, what effect will it have? Would it raise the average temperature of the earth's atmosphere? Would the polar ice melt, raising the sea level, changing rainfall patterns and altering the ways of life on earth? If so, to what degree? Or will countervailing processes, such as increased cloud formation and the production of counteracting gases, balance the accumulation of greenhouse gases?

Global climate change is perhaps the most important issue of environmental science today, and it provides a truly worldwide research agenda.

"The study of global change has got to be done on a worldwide basis," said Roger Revelle, a pioneer of global warming studies at Scripps Institution of Oceanography, in an interview. But "the scientific effort is very uneven" in the Third World.

For accuracy and impact, much of the research on climate change has to be done on the vast land areas of developing countries or on the oceans bordering them. The scientific communities in developing countries, however, do not usually have the human, institutional and financial capabilities to carry out all the needed research. PSTC has therefore begun to solicit proposals for collaborative projects to investigate global climate change in developing countries while building the capacity of Third World science to contribute to this vital research.

In 1990, PSTC formally announced global climate change as an area of special funding interest and reviewed the first proposals. However, the issue was already being investigated by several earlier PSTC projects, including ones in India and Africa.

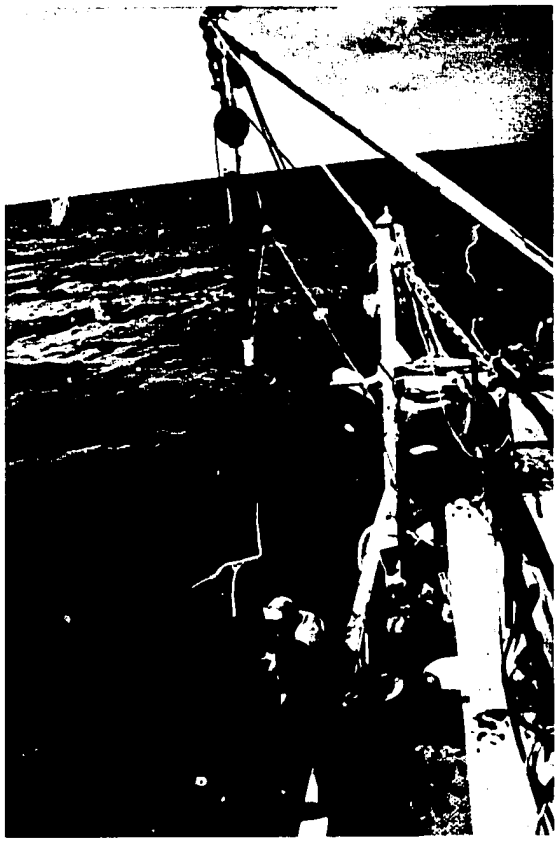
In the Indian study, Gyan Mohan of the Indian Institute of Technology/Kanpur, T. N. Krishnamurti of Florida State University and their colleagues studied the

In Kenya, a volcanic island rises out of Lake Turkana, whose bottom sediments reveal the rainfall patterns over thousands of years.

monsoons that form over the Indian Ocean and bring rainfall to the Indian subcontinent. These rains control the agricultural cycle and affect virtually every aspect of life in the region. Supercomputer power helped the scientists capture some of the complexity of the monsoon in a computer model, which could eventually lead to the ability to more accurately predict the onset of the rains. PSTC support for this research also acted as seed money for the creation of a major monsoon research program later initiated under A.I.D.'s U.S.-India Science and Technology Initiative. The monsoon modeling, in turn, provides a basis for studying the effects of climate change, whose influence on the development of monsoons might greatly affect regional wet and dry spells.

In the African study, John Halfman and Thomas Johnson of Duke University, assisted by Kenyan graduate student Patrick Ng'ang'a, studied the records of rainfall written in the layers of mud on the bottom of Lake Turkana (formerly Lake Rudolf) in northern Kenya. The lake rises and falls according to the rainfall draining from its catchment basin, which stretches north into the Ethiopian Plateau. The rainwater carries sediment, which settles to the bottom of the lake. The quantity and nature of this sediment reflect the amount of fresh water flowing into the lake each year. Thus, the 35-foot-long core samples pulled out of the lake bottom for the study provide a rainfall record over thousands of years. Through sophisticated computer and chemical analyses of this sedimentary record, the investigators found evidence that may link the rainfall in Africa to the El Niño-Southern Oscillation, an ocean and atmospheric condition in the Pacific Ocean off the west coast of South America. They also found indications of dry and wet cycles lasting from decades to centuries. These findings may eventually help determine whether long-term climate change is occurring in sub-Saharan East Africa.

PSTC is focusing on research into global warming and its impacts. This issue, however, is only one of several global-system problems that merit study. Desertification, deforestation, erosion and destruction of coastal-zone ecologies have also reached alarming proportions and, in some cases, are interrelated with global warming. PSTC's new area of special funding interest is therefore open to innovative research on the whole spectrum of global climate change.



At Lake Turkana, Kenya, sediment cores are pulled from the bottom and studied for clues to rainfall and climate changes.

A number of PSTC's biodiversity projects aim primarily at the conservation of genetic resources that might one day have beneficial applications. A consortium of Central American institutions is funding a project to collect seeds from six indigenous tree species that might be valuable sources of wood for fuel and other purposes and to use the best varieties for mass-producing plants at a cost that small-scale farmers can afford. Other scientists are attempting to characterize and collect germ plasm from the most promising species of babassu palm, a Latin American variety that is an important source of food, fuel, construction material and industrial feedstock.

PSTC researchers also seek to conserve and make better use of genetic resources in the animal kingdom. The program, for example, is funding studies on the crossbreeding of the wild Malaysian gaur with domestic cattle, a project that should help preserve the gaur, which is facing extinction. The scientists may develop hybrid animals with beef-cattle capacity for meat production and the gaur's resistance to tropical diseases and conditions. In Nepal, researchers are using advanced radio tracking to investigate the reproductive ecology of the mahseer, an indigenous food and game fish, to learn whether it will thrive in artificial spawning sites when natural sites are destroyed by the reservoirs built for irrigation and hydroelectric power. Successful reintroduction of the mahseer would help alleviate protein malnutrition among many Nepalese and provide sport fishing for the country's tourist industry.

Many of PSTC's animal biodiversity projects seek primarily to preserve biodiversity. Scientists from the U.S. and several Asian countries are investigating the health, genetics and demography of the captive Asian elephant herd as a means of better understanding its genetic diversity; the study will provide knowledge leading to better management of wild and captive populations. This work is being done through the first-ever application of sensitive new genetic fingerprinting techniques to Asian elephants. The genetic pool of captive elephants could be used to diversify the wild herd and re-establish elephants in depopulated areas. And in Nepal, investigators have launched a study of livestock depredation in the mountains in hopes of finding ways to reduce the killings while preserving rare predators such as the snow leopard.

Concern for the environment has become a fundamental issue for U.S. foreign policy, and A.I.D. continues to help developing countries deal with environmental problems. All too often, however, the knowledge to solve many environmental problems simply does not exist. PSTC research into the scientific questions underlying environmental issues is therefore a key to the Agency's efforts.

Investigators examine elephants in India (left) and Nepal (bottom). A PSTC project is examining the demography, genetics, nutrition and health of captive elephants in Asia to provide the scientific basis for the captive management of this endangered species.

Cleaning Up Oil Spills

When a 30-mile-long slick of crude oil—the aftermath of sabotage and military action in Kuwait—began creeping down the Persian Gulf in January 1991, officials concerned about its danger to the fragile coastal ecosystem wanted to know which chemical dispersants might be appropriate to use on the threatening slick. So they turned to Anitra Thorhaug, a Florida International University scientist and PSTC investigator.

Would you use a dispersant? And if so, which one? Can you fax us your data? Who has the dispersant and can ship it to us at a moment's notice?

People who handle oil spills in the tropics have been seeking information from Thorhaug and her colleagues ever since results started coming in from their study on the toxic effects of chemical dispersants on coral, seagrasses and mangroves. The research was funded primarily by a PSTC grant to the government of Jamaica and included scientists from the Jamaican Office of Disaster Preparedness, the Jamaican Natural Resource Conservation Department and other organizations. Scores of dispersant toxicity studies have been performed in temperate and arctic waters, some of them showing the dispersants to be highly toxic to aquatic organisms. But the Jamaican project was the first large-scale study of an array of dispersants, including a more benign generation of dispersants, in the tropics.

The study found that an oil slick will cause less damage to mangroves if the oil is chemically dispersed down into the water before reaching the mangroves. However, oil dispersed off a tropical coast may drop onto coral or seagrasses that are hundreds of times more sensitive than mangroves. The investigators therefore tested 25 representative commercial dispersants for toxicity to these forms of sea life.

"Three that we tested ... are low-toxicity; nontoxic, in other words, to commercial fish, coral reefs, mangrove forests and seagrass meadows in the tropics," Thorhaug said.

Data from the Jamaica project may be useful for sites from Florida to Brazil, owing to the commonality of species throughout the greater Caribbean. Even before the study was completed, the Jamaica Oil Spill Committee incorporated the study results into its draft policy on oil spill cleanup. The results include a resource map showing the location of Jamaica's coral, seagrass, mangroves, and fishing grounds. With this information, the committee is deciding now, before a spill happens, where to disperse or not disperse oil and the type of dispersant to use.

A researcher checks the condition of mangrove plants in a study on the toxic impacts of chemical oil dispersants in Jamaica.

Around the world, agencies concerned with oil spills or tropical environments have been asking to know more about the results of the Jamaica project. The investigators periodically pass their data to the United Nations Environment Programme and other U.N. organizations. Queries have arrived from Guam, Hawaii, Indonesia, Malaysia, Australia, Saudi Arabia, Kenya, Egypt, Morocco, Venezuela and a half dozen other countries. The study data on coral and seagrass have been incorporated into a computerized assessment system that can calculate the probable impact of dispersed or undispersed oil on a wide range of living organisms anywhere in the Gulf of Mexico, information that will help disaster officials decide whether to use dispersants on a particular oil spill. And following the data's presentation at an international conference on oil spills, conferees drafted a petition asking the International Maritime Organization to change its policy on dispersant use near mangroves.

The Jamaica study has raised interest not only for its data, but also for its methodology. The project established a system of standards for testing hazardous substances—not just chemical dispersants—in the tropics. And perhaps more important, it demonstrated how to involve users and regulators (Office of Disaster Preparedness and the Natural Resource Conservation Department) in the development of standards so that agreement can be reached.

"We're informing and participating with all parties each step of the way," Thorhaug said, "so that when we get to the end someone doesn't say we don't like that data or it's not usable. That's one of the reasons (the project results have) already been put into effect."

Agriculture

"Many early reports of the Green Revolution depicted it as a wholesale transfer of high-yield technology from developed countries to peasant farmers in the Third World. This was incorrect. In reality, the Green Revolution was the start of a process of using principles of modern agricultural science to develop technologies appropriate to the conditions of Third World farmers."

— **Norman Borlaug,**
Nobel laureate for peace

In 1985, scientists working under a PSTC grant to the Centro Internacional de la Papa (CIP) in Lima, Peru, infected potato tissue with bacteria carrying a synthetic gene designed to boost the potato's nutritional value. Tiny hairy roots composed of cells carrying the synthetic gene soon sprouted from infection sites on the tissue. The scientists cut these genetically altered roots from the tissue and coaxed them to grow into potato-bearing plants.

The new genetic design increased the essential-amino-acid content of the potatoes by a scant 1 percent. But the experiment was one of the first genetic transformations of the potato—a keystone crop in the tropics—and it triggered a string of other transformation experiments. An improved synthetic gene has since led to potatoes with two to three times the normal content of amino acids. And other genes have been constructed to protect potatoes from bacterial, fungal and nematode diseases that plague potato production and storage in the tropics.

In developing countries today, farms and farmers need to grow more food to meet the needs of an expanding population, and they have to do it by deriving more benefit from what land they have. Poor countries are also depending on greater agricultural output to earn crucially needed foreign exchange. At the same time, agricultural production has to be sustainable. Soil, water and other agricultural resources must be more carefully husbanded; their catastrophic depletion must be halted.

To meet these challenges, developing countries will have to strengthen their entire agricultural edifice. Better policies, stronger institutions and more investment in the work force are important components of this structure, and technology is part of the foundation. History indicates that importing foreign technologies does not work and that developing countries should develop new techniques for themselves. More recent experience suggests that the revolution in biotechnology can give Third World scientists new and powerful tools to create the technologies that will meet their countries' growing agricultural needs.

Throughout its first decade, PSTC has encouraged the use of modern chemistry—often in conjunction with biotechnology—to boost food production. Several chemistry-related projects are attempting to reduce the cost and environmental side effects of fertilizers, which are necessary for successful farming. Researchers in Costa Rica, for example, are seeking the most efficient means of applying phosphorus to various soils so that use of the fertilizer can be kept to a minimum. Philippine researchers are using genetic engineering to develop blue-green algae that

PSTC supports research into methods of increasing the production of rice (left) and other food crops in the Third World. In one experiment (above), rice in first two jars grows slowly without added nitrogen. Ammonia secreted by a genetically engineered strain of blue-green algae grown with the rice helps the plants grow tall in the third jar. Rice in the fourth jar was grown with ammonium as the nitrogen source.

will provide nitrogen directly to rice plants. In Jamaica, local and U.S. scientists hope to genetically engineer more efficient strains of nitrogen-fixing bacteria *(Rhizobium japonicum)* that will naturally fertilize cowpeas and soybeans, two major sources of protein for people in many developing countries.

State-of-the-art chemical analysis is being used by PSTC investigators in Sudan to investigate the biochemical interactions between a parasitic witchweed and sorghum, one of the plants it attacks. They hope to identify parts of the biochemical mechanism that can be interrupted by chemical or biological means, thus reducing damage to the sorghum. Analysis of wheat stored in plastic-lined underground storage pits in Morocco showed that inexpensive sheet-plastic lining can cut losses from pests and water damage to less than 1 percent, as opposed to 18 percent in straw-lined pits. The use of plastic-lined grain storage pits is already spreading among Moroccan farmers and could be adopted in other developing countries.

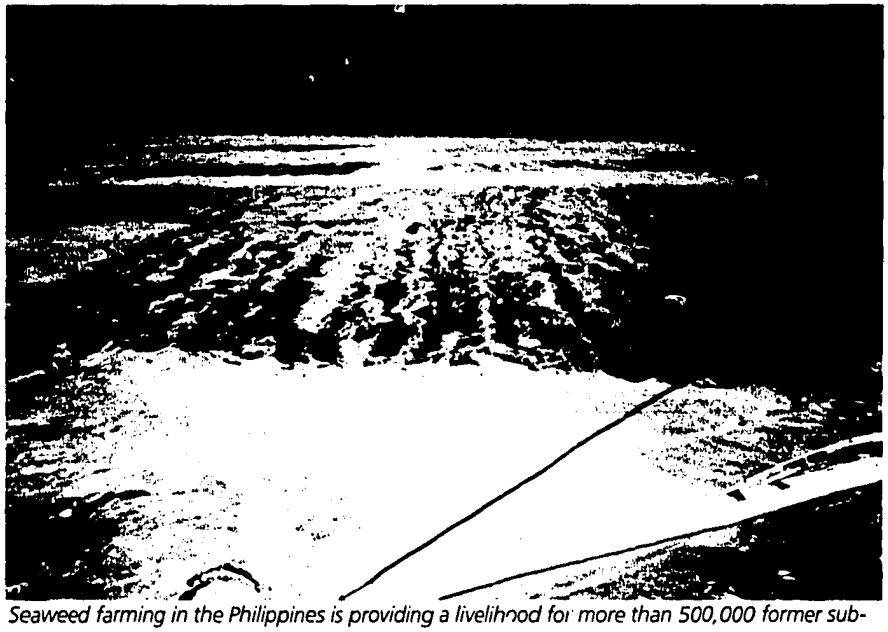
PSTC has also funded the use of new biotechnology techniques for boosting agricultural production. Tissue culture, in particular, has been used by PSTC scientists trying to improve the quality and quantity of plant varieties. The technique can often be used to produce many plantlets from the tissue of a desirable plant. Once the technique is developed, the plantlets are generated in a matter of weeks and contain all the desirable characteristics of their single, genetically identical parent. Plants grown from seeds, on the other hand, often lose desirable qualities through the two-parent breeding required to generate seeds. In addition, many plants take a year or more to produce seed, which often appears in quantities too small for mass-distribution.

Tissue culture techniques of various sorts are being developed by PSTC researchers for the mass-propagation of rice in the Philippines, potatoes in Indonesia and cowpeas in Thailand as well as clove, nutmeg and papaya in Sri Lanka. Others are using similar methods for propagating cacao and a new crop fruit called cupuacu *(Theobroma grandiflora)* in Brazil and another potentially valuable crop fruit, babaco *(Carica pentagona)*, in Ecuador. Also in the Philippines, scientists are adapting the technique for the maintenance of high-quality planting supply of red seaweed, which yields carrageenan, a substance used in food, beverage and pharmaceutical industries.

A researcher cuts up explants of a red seaweed (Eucheuma denticulatum) for micropropagation in multiwell trays in experiments to develop new branch and tissue culture procedures for specific strains of red seaweed.

Other new biotechnolgy techniques are also being used to improve crop plants. In Costa Rica, scientists are using restriction fragment length polymorphism (RFLP) analysis to identify the DNA "fingerprints" of cacao seed stock so that growers can check its quality. In Thailand, researchers are developing an enzyme-linked immunosorbant assay (ELISA) to screen for an enzyme that indicates high-yielding seed stock for rubber plants. And in the Philippines, U.S. and local scientists are using enzymatic and immunological techniques to select better varieties of red seaweed.

PSTC supports the conservation and development of the genetic resources—wild and domestic—needed to revitalize and expand the inventory of crop plants that support the world's agricultural economies, and PSTC scientists are employing a host of advanced technologies to pursue this end. For example, researchers in Mexico, Ecuador and Columbia are using RFLP analysis to characterize the genetic diversity of the wild and domestic bean germ plasm they are collecting. These fully characterized collections will improve the efficiency and effectiveness of future agronomic seed improvement programs. In Peru, U.S. and local investigators are using isozyme assays to characterize the genetic material in potatoes grown on Andean farms and help preserve it



Seaweed farming in the Philippines is providing a livelihood for more than 500,000 former subsistence fishermen as overfishing has depleted natural marine resources. Several PSTC projects aim at improving the seaweed industry.

The Thai Science Machine

The number of Thai scientists winning PSTC grants has been phenomenal, especially in light of their slow start in the program. Thai scientists were not awarded grants in 1981, the first year of PSTC awards, and only one grant in the second. But by 1990, Thai scientists had captured 53 grants, more than twice the total awarded to any other country.

Why such success?

Undoubtedly, the Thais were poised for a technological liftoff. A stable government, a tradition of good universities and a growing economy brought Thailand in the 1980s to the threshold of industrialization. But to cross over, it needed the modern science and technology to support an industrial economy.

In addition, officials at the A.I.D. mission in Bangkok recognized Thailand's economic and technical maturity. They concluded that a science and technology development program would answer many of the country's needs, and in 1984 the mission established a science and technology division. Two years later the mission helped the Thai government launch its Science and Technology Development Board (STDB), which funds research that directly benefits the industrial community.

"We pushed PSTC very strongly because it fit right in with our overall strategy of developing science and technology in Thailand," said Robert F. Barnes, director of the mission's Science and Technology Division from 1985 to 1989. "With the PSTC emphasis on basic, innovative science and the STDB emphasis on immediately applicable science, the two programs dovetailed nicely."

The Thai government has recognized the benefits of PSTC. The minister of science and, occasionally, a member of the royal family participate in ceremonies when PSTC awards are presented to the Thai recipients. "It's prestigious to win a grant," said Kerri-Ann Jones of A.I.D., who has helped monitor the Thai grants. "It's a very honored award. The level of competition is appreciated, and successful grantees are recognized."

The mission staff has also promoted PSTC, mailing announcements to universities and other sources of grant candidates and regularly visiting campuses to tell faculty about the program. Possibly the most effective action taken by the mission was the hiring of a respected Thai scientist, Jaroon Kumnuanta, to help the scientists prepare and submit preliminary proposals (preproposals) and full proposals to PSTC and to monitor the grants. "If you got only four or five of those grants it would justify having an employee around to monitor them," Barnes explained. "With the results we actually obtained, Dr. Jaroon was one of the best investments USAID/Thailand ever made."

Thai scientists use state-of-the-art biotechnology methods to develop rapid new screening techniques for selecting rubber clones (above) that are high-yielding and disease-resistant. In another Thai lab, researchers investigate the molecular mechanism involved in the development of dengue hemorrhagic fever.

Jaroon was hired in 1984, and his presence became obvious the next year when the number of PSTC grants awarded to Thai scientists was tripled. The 12 grants they won amounted to a fourth of all PSTC grants awarded in 1985.

Thai scientists were soon submitting 80 to 90 preproposals a year to the Bangkok mission, which forwarded 60 to 70 of the better ones to the Office of Research. The office later limited the mission to 50 preproposals per year. Nevertheless, over the first decade of the program, the quality and quantity of their research proposals won Thai scientists 13 percent of the PSTC grants.

The common bean (Phaseolus vulgaris L.) represents a major source of dietary protein in developing countries of Latin America, East Africa and the Middle East. Smallholder farmers cultivate a wide diversity of bean varieties to suit their particular needs, as shown by this sample obtained in the market of Otavalo, Ecuador. Several PSTC projects seek to characterize the genetic diversity of wild and domestic bean varieties.

before the traditional crop species all disappear.

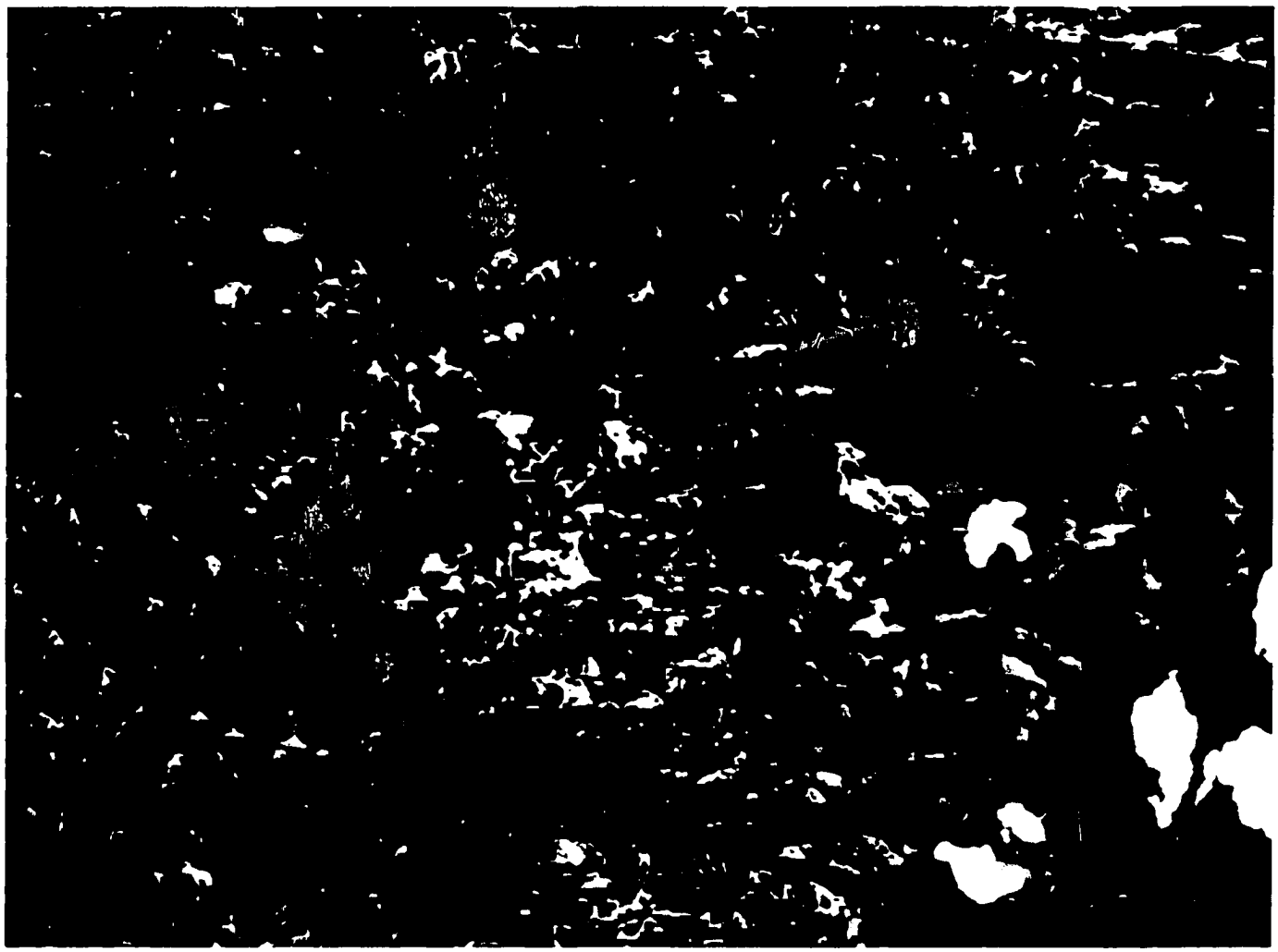
PSTC investigators are also adapting state-of-the-art electronics, such as computers and satellites, for the conservation of genetic resources as well as for the improvement of farming techniques. Peruvian and U.S. scientists are using data from remote-sensing satellites and a computerized geographic information system to analyze the distribution of a half dozen declining traditional crops in Peru and to help in the collection and conservation of their valuable germ plasm. Investigators in Guatemala are using a computer to improve small-scale farming practices by simulating the production of corn and sorghum under local biological, social and economic conditions; they hope to develop a powerful tool for agriculture extension workers. And in Costa Rica, scientists are developing a computer model, based on soil, crop, rainfall and weather data, that will help farmers make better use of their natural water supply.

In animal production, biotechnology is also playing a leading role in PSTC projects. For instance, scientists in Uganda are developing DNA probes to use in diagnostic tests for bovine babesiosis (redwater fever), a tick-borne disease that causes more than $500 million in cattle losses per year in the developing world. They are also working on DNA probes for the diagnosis of theileriosis (East Cost fever), another tick-borne disease that causes more than $50 million in annual cattle losses in Africa. Genetic engineering techniques are being used by African and U.S. scientists to develop vaccines in Zimbabwe against bovine anaplasmosis, a blood-parasite disease that is hindering livestock production in the tropics, and in Kenya against heartwater disease, a major impediment to production of cattle, sheep and goats in large parts of Africa.

A number of recent scientific techniques are being used in PSTC projects to help solve problems in aquaculture. In Thailand, microbiological techniques developed for studying salmon are being adapted for research on kidney disease in sea bass. And in the Philippines, U.S. and local researchers are using radioimmunoassay to help develop methods to control the breeding of sea bass and improve the survival of their larvae.

Agricultural problems in the Third World are daunting. Recently, per capita food production has gone down in Africa. In Asia and Latin America, nations are struggling to maintain enough food production for growing populations. The world's food problem, however, will not be solved by shipping food to the hungry. Developing nations must be helped to feed themselves. In addition, farming is not only a source of food, it is also a source of jobs, and the export of agricultural products is a major source of foreign exchange. The future of these countries clearly demands the best agricultural technology available. Through its funding support and training of Third World scientists, PSTC is already catalyzing the discovery of the new agricultural techniques needed to feed the next generation, create jobs and build exports.

Disease causes hundreds of millions of dollars in cattle losses every year in the developing world. PSTC investigators in Africa hope to develop diagnostic tests and vaccines to reduce these losses.



Above: *Landsat satellite image of the Lake Piuray (upper center) region near Cuzco, Peru, reveals location of traditional crops, such as kiwicha (grain amaranth), which can then be studied bv ground-based research teams.*

Left: *Researchers use a handheld radiometer to take measurements in a kiwicha field near Cuzco.*

New Research at the Centro Internacional de la Papa

PSTC grants have played a significant role in the efforts of the Centro Internacional de la Papa (CIP) to improve the potato through genetic engineering (page 21). Prior to its involvement with PSTC, the potato center did not conduct state-of-the-art genetic engineering, said John H. Dodds, head of CIP's department of plant genetic resources. The grants have helped the center develop contacts and collaborate with other institutions specializing in advanced biotechnology techniques. New genes that boost the potato's nutrition, for example, were developed in collaboration with Jesse Jaynes at Louisiana State University.

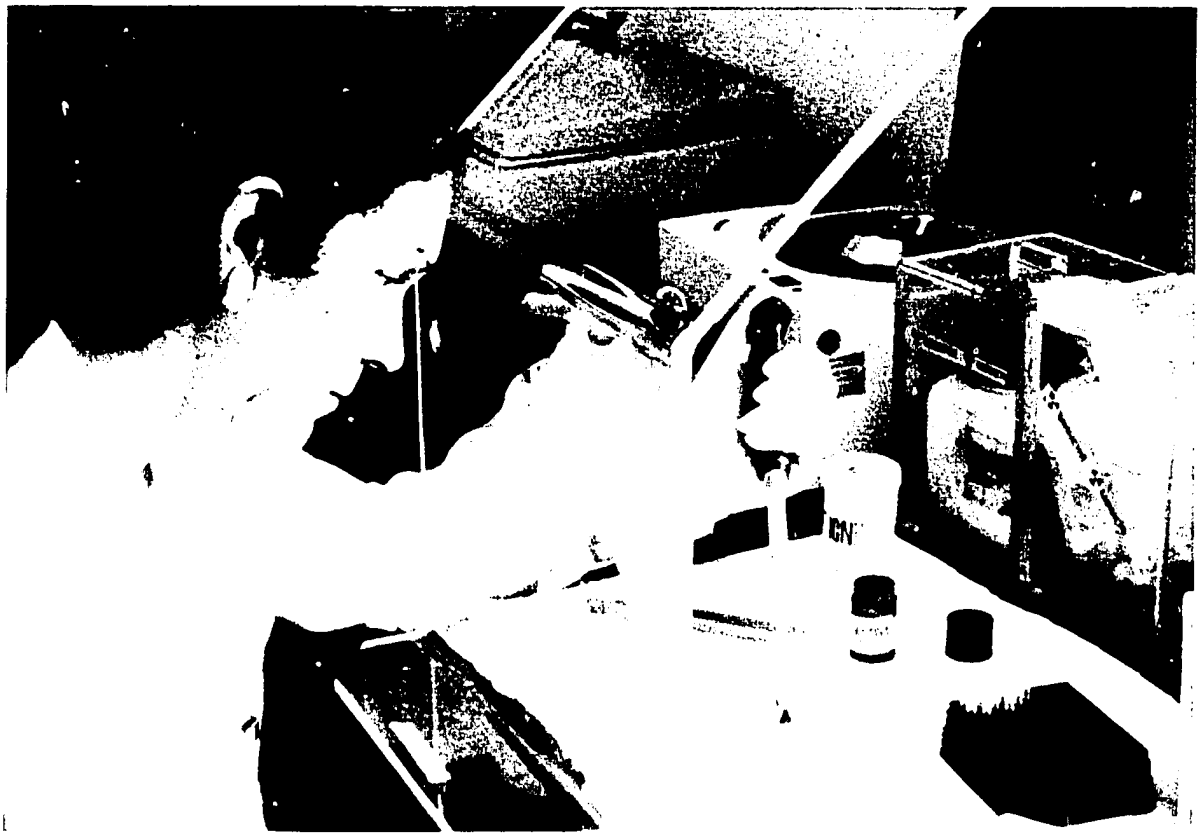
PSTC grants "are allowing us to link into new technologies, like (genetic) transformation or protoplast fusion, without having to build up our whole research capacity," Dodds said.

Jaynes agreed that PSTC has provided important linkage among potato researchers. "It's got us talking about problems, and we've been able to come up with some solutions," he said. "We've developed a number of (research) avenues that I don't think would have been made any other way."

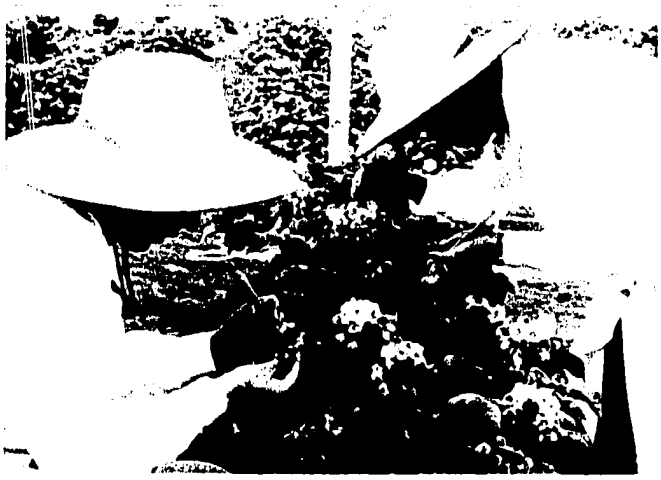
Potatoes are the world's fourth most important food crop behind wheat, rice and corn. Theoretically, a nutritionally improved potato could supply enough calories, proteins and essential amino acids to replace meat in the diet of people who live in areas, such as the Andes, where meat is costly or not available. Improving the potato's resistance to tropical diseases will allow it to be grown in many developing countries that greatly need to produce more food.

CIP's genetically altered potatoes are being grown and studied in the greenhouse. Biosafety regulations are being carefully developed so that altered plants can soon be tested and the new seed stock disseminated to national programs.

A selection of potatoes reveals the genetic diversity of the native germ plasm collection at CIP's Highland Experimental Station in Huancayo, Peru.



A laboratory technician tests for viruses and viroid diseases of potatoes at CIP headquarters in Lima, Peru.



Far left: *Chilean scientists propagate potatoes for production of hybrid true potato seed at a CIP regional station in southern Chile.*
Left: *Scientist emasculates a flower for production of hybrid true sweet potato seed.*

Health

"For the world's most vulnerable people, the benefits of research offer a potential for change that has gone largely untapped."

— John Evans, chairman of the Commission on Health Research for Development

Health officials fighting the cholera epidemics that plague many developing countries have long faced a frustrating riddle. What happens to the cholera bacteria between epidemics? While the disease is raging, culture tests based on growing the bacteria in the laboratory show the microorganisms teeming in local water supplies. Between outbreaks, however, the culture assays indicate the waters are free of growing cholera bacteria. Where are the bacteria that will cause the next epidemic?

The answer, it seems, is that the cholera bacteria are lying dormant in the water, unnoticed because conventional culture tests can detect only bacteria that are growing. But U.S. and Bangladesh scientists, with the help of PSTC funding, developed a monoclonal antibody that can detect cholera bacteria whether they're growing or not. They have also shown that the dormant bacteria can cause cholera. They are now using the antibody test in Bangladesh to learn whether plankton or some other water component stimulates the dormant bacteria to become active and thus triggers an outbreak.

Bangladesh and other developing countries face a Pandora's box of health-related problems, including poor sanitation, infectious diseases, contaminated drinking water and inadequate health care, all of them demanding attention. Per dollar spent, contemporary science has probably most to offer in the field of infectious tropical diseases, and that is where PSTC focuses its health-related resources.

Top: *PSTC scientists record the pH and temperature in a pond under study for the ecology of cholera organisms in Matlab, Bangladesh.*
Left: *A child is treated for cholera in Bangladesh.*

The program concentrates on health problems that are especially serious in developing countries. These include tropical vector-borne diseases such as malaria, schistosomiasis, onchocerciasis, leprosy, dengue, filariasis and leishmaniasis. Malaria and schistosomiasis (a wasting disease) are two of the biggest killers, each claiming a million or more lives per year in Africa, Asia and Latin America. Onchocerciasis blinds 200,000 to 500,000 persons a year. Leprosy, dengue (a viral infection), filariasis (caused by tiny worms carried by insects) and leishmaniasis (a protozoan infection) claim fewer lives but inflict misery and disability on millions. Children in developing countries also face a grave situation with diseases, such as pneumonia, because the children's immunological defenses have been weakened by malnutrition and other complicating diseases. Thus, mortality rates for respiratory infection in poor countries may be an order of magnitude greater than in rich countries.

Scientific research is essential for the control of infectious tropical diseases. The cholera assay, for example, may warn of an impending outbreak in time for health officials to prevent a catastrophic loss of life. PSTC funds the basic research that will lead to assays and diagnostic tests for other diseases and to treatments, vaccines and measures to control the carriers of disease.

Vaccine research is far-ranging, and much of that funded by PSTC involves the use of monoclonal antibodies.

These are molecules that bind to specific antigens (molecules) present on the surface of an invading organism. Antibodies are produced in tiny amounts by white blood cells known as lymphocytes. To get large amounts of antibody, scientists fuse lymphocytes with reproducing cancer cells and select the hybrid cell (called a hybridoma) that produces the desired antibody. The single hybrid cell grows into an expanding colony of clones that produce large quantities of the antibody (called monoclonal, because the clones come from one hybrid cell). PSTC scientists in Thailand, for example, are using monoclonal antibodies to identify the various antigens present in different strains of malaria. The investigators want to identify the most common antigen among malaria strains so that it can be incorporated in a vaccine that would consequently be effective against many strains of malaria. Using monoclonal antibodies, the researchers have discovered considerable antigen diversity among malaria strains in Thailand, findings that will help other scientists in the search for an effective vaccine.

In Cameroon, researchers are using biochemical techniques to gain the scientific knowledge needed for the development of a vaccine against onchocerciasis. They are studying the antigens on the surface of the nematodes (tiny unsegmented worms) that cause the blindness and other symptoms of the disease. If they can discover how the nematodes evade the body's immune system, then perhaps a vaccine can be developed that will thwart the nematodes' evasion mechanism.

PSTC investigators have been particularly successful at developing diagnostic tests, a task often suited for the three-to-five-year span of the grants. Barriers to development of diagnostics have been falling because of techniques discovered in the last 10 to 15 years. Quick, sensitive diagnostic tests can determine who is infected, who needs special medical attention and who does not, allowing health officials to focus their limited medical resources where they are most needed to halt the spread of disease. Simplified diagnostic procedures allow testing in isolated areas far from laboratories. In addition, diagnostic tests play an important role as research tools. Diagnostic tests have been or are being developed for onchocerciasis, leprosy, dengue, leishmaniasis and filariasis.

PSTC researchers in Peru, for example, are seeking to develop a diagnostic test for leishmaniasis, a disease caused by several species of protozoa. The test will use a unique DNA probe, a piece of DNA representing some sequence of the protozoan DNA. The probe will help diagnose leishmaniasis by recognizing the protozoan DNA in infected people.

In Thailand, investigators are using another recently developed technique in a diagnostic test to detect leprosy before its symptoms show, allowing early treatment that would prevent its transmission to others. In this study, an enzyme-linked immunosorbant assay (ELISA) is being used to detect the antibody produced in the patient's

Left: *A field researcher in Thailand collects blood from a child in a leprosy household during a PSTC project to develop an early diagnostic test.*
Below: *In the lab, a technician performs an ELISA (enzyme-linked immunosorbant assay) for an antibody to Mycobacterium leprae in the blood of leprosy patients and their household contacts.*

Opposite page: *A child leads a victim of river blindness (onchocerciasis) in a village in Burkina Faso. In some villages, more than 50 percent of adult males are blind. PSTC projects in Africa and Latin America focus on the development of diagnostic tests and vaccines for this disease.*

Biocontrol with Snail-Eating Fish

After scuba diving in Lake Malawi for some months, Kenneth McKaye began to wonder why he had not gotten bilharzia, the tiny flatworm parasites that seem to infect people wherever water stands in ponds or reservoirs in Africa. Bilharzia-carrying snails certainly inhabited the weed beds along the margin of the lake. But the open waters, where McKaye was studying snail-eating cichlids (fish), were free of the thin-shelled *Bulinus* species of snail that carries bilharzia. Were the ravenous cichlids devouring bilharzia snails that ventured from the safety of the weeds? And if so, could the cichlids be introduced to aquaculture ponds and other impoundments as a natural means of controlling bilharzia?

McKaye, a University of Maryland scientist, fed bilharzia snails and nonbilharzia species to a few cichlids to see what happened. "They immediately went for the bilharzia ones," Mckaye said. "They were just easy to crunch."

Next, to find out whether the cichlids could be introduced to aquaculture ponds, McKaye teamed with Jay Stauffer of Pennsylvania State University and later with Sosten Chiotha of the University of Malawi. The investigators sought funds for the experiment but quickly found that it straddled the no-man's-land between health science and fisheries.

An investigator dissects snail-eating cichlids in Malawi to analyze what the fish have consumed.

"The health people were willing to fund the epidemiological studies of the people being infected with bilharzia, and the fish people were willing to fund aquaculture," McKaye said. "But nobody cared about the fish eating the snails, except A.I.D."

A.I.D., through PSTC, funded the experiment in the aquaculture ponds at the University of Malawi's Bunda College of Agriculture. The problem of bilharzia in aquaculture ponds is particularly serious now in Africa. Development officials look to aquaculture as a means of increasing the local food supply. But health officials worry that more aquaculture ponds will increase the spread of bilharziasis (schistosomiasis), a debilitating disease that afflicts an estimated 300 million people in developing countries.

McKaye and Stauffer stocked the aquaculture ponds at Bunda College with snails, threw in a few cichlids called *Trematocranus placodon* and waited for two weeks. The results were startling.

"We drained the pond, and there were no snails," McKaye said. "We were totally blown away." And they were suspicious. The investigators had expected the fish to eliminate the snails in two to three months, but not this soon. McKaye therefore suggested that the snails being devoured might have given off an alarm chemical that warned the others to flee.

When follow-up research proved the alarm-chemical idea false, the investigators began to suspect ducks. Ducks are raised at the ponds to fertilize them and provide food for the farmers. So the investigators redesigned their experiments to control for ducks. The new results showed that the cichlids can, in fact, wipe out the snails from a pond in four to six weeks. Ducks really aren't necessary to eliminate the snails.

"If you have the snail-feeding fish, within six weeks they clear out the snails and keep any from coming in," McKaye said, noting that fish are usually grown for six months before the ponds are drained and the fish harvested. "There really oughtn't to be any snails for the ducks. But if there are a few stragglers left around, the ducks will clean them up."

Having proved with PSTC help that the cichlids devour bilharzia snails and survive in aquaculture ponds, the investigators hope to raise enough cichlids to determine through widespread field trials whether the introduction of the snail-eating fish really can cut the rate of bilharzia infection in populations living near the ponds. If so, the cichlids may prove to be an inexpensive, environmentally benign replacement throughout the tropics for the chemical pesticides now used to control bilharzia-carrying snails.

Washing and bathing outdoors puts people at risk of schistosomiasis, a wasting disease, in many parts of the world. This Philippine boy's swollen belly shows he is already infected. PSTC research aims at eliminating carriers of the disease.

blood stream in response to infection by the leprosy bacteria.

Many research projects that try to discover improved diagnostics fail to develop a commercial product. This is the nature of innovative research. However, one success often more than justifies a dozen starts—in economic as well as humanitarian terms. Moreover, each of these projects leaves a residual of trained researchers and new technologies for future attempts.

Much of PSTC's health-related research has aimed at the carriers (vectors) of infectious tropical diseases. In the past, health officials have relied on chemical pesticides to eliminate vectors such as flies, mosquitoes and snails. Today officials increasingly emphasize biological means of control, usually by another organism that is harmless to humans.

PSTC has funded biocontrol projects for the vectors of malaria and other diseases. But the biggest and, perhaps, most imaginative effort involves control of schistosomiasis, a wasting disease caused by schistosomes (trematodes, or tiny flatworms) carried by fresh-water snails in Africa, Latin America, Asia and parts of the Middle East. At Lake Malawi, U.S. and local investigators are studying five varieties of snail-eating fish to see whether they can be used to keep ponds and reservoirs free of schistosome-carrying snails (page 32). In Kenya, investigators are studying local and North American crayfish as possible biocontrol agents to reduce snail populations. In Haiti and Kenya, scientists are investigating harmless-to-humans snails that compete with or prey on snails that carry schistosomes. And in Egypt, researchers are using a harmless-to-humans trematode that sterilizes host snails and competes with the schistosomes in a manner that reduces their reproduction rate.

In another research area, Bolivian and U.S. scientists hope to reduce the incidence of hepatitis, diarrhea and other intestinal diseases by inactivating the viruses and bacteria that inhabit drinking water in many developing countries. They have demonstrated that a device containing copper can inactivate microorganisms that come in contact with the metal. Low-cost devices made of local materials could be built to disinfect drinking water at each home, even in the absence of costly centralized water treatment plants and supply systems. With the success of the PSTC-funded basic research, the investigators have been able to secure other funds to build and field-test a prototype of the disinfection device.

*A field assistant in Kenya examines enclosure cage experiments that test the ability of the North American crayfish **Procamarus clarkii** to eliminate the snail **Biomphalaria pfeifferi**, which carries the tiny flatworm that causes schistosomiasis.*

Many of the health problems affecting developing countries are limited to the tropics. Diagnostic tests and treatments used in temperate zones often cannot be directly applied to Third World health problems. PSTC helps scientists in developing countries devise new solutions to the particular health problems of their countries. And PSTC experience over the past decade indicates that the medical research capacity in these countries is improving.

*An investigator samples snails in experimental ditches at the Snail Research Station near Cairo during PSTC research to test whether a trematode harmless to humans can reduce the transmission of schistosomiasis via the snail **Biomphalaria alexandrina**.*

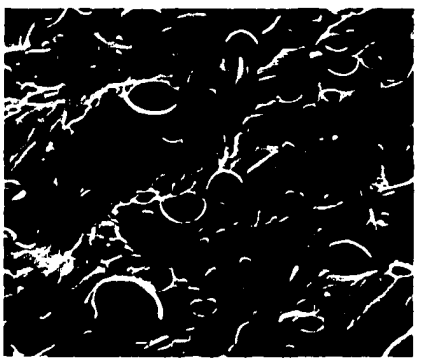
Industry

"Science and technology lie right at the heart of the development effort."

— Frank Press,
president of the National
Academy of Sciences

In the fall of 1990, a handful of farmers in Zimbabwe harvested the small first commercial crop of *Vernonia galamensis*, a thornless, thistlelike plant with pink flowers and mouse-brown seeds that produce a remarkable oil. The few thousand pounds of vernonia oil expected from the harvest will be parceled out for developmental testing to research groups and companies that make solvent-based paints and varnishes. If, as PSTC-funded research suggests, the oil can be successfully substituted for the solvents in these coatings (page 38), a new industry will be born. And the demand for vernonia production in Zimbabwe, Kenya and other developing countries of the tropics will blossom.

Mesquite is also a potential feedstock for agroindustries in many developing countries. It grows in arid, agriculturally marginal areas, especially in cool deserts, like those found in Mexico and Chile, where PSTC has funded mesquite research. Its wood can be used for fuel or furniture, its leaves for fodder and its bean pods for animal or human food. For example, researchers in Mexico and the United States have found a way to process the pods into a nutritious flour high in natural sugar and fiber with some protein. A Mexican company produced about 1,000 kg of mesquite flour in 1989 for test marketing as a sugar substitute and nutritional food additive.



Opposite page: *At the Chiredzi Research Station in Zimbabwe, U.S. Department of Agriculture botanist Robert Perdue (left) and agronomist C.T. Nyati of the Ministry of Lands, Agriculture, and Rural Resettlement, inspect a field of Vernonia galamensis. PSTC-funded research indicates that vernonia is the source of a potentially valuable oil that could be produced by developing tropical countries.*

Above: *PSTC researchers Stoil Dirlikov (right) of Eastern Michigan University and Isabelle Frischinger (left) of the University of Mulhouse, France, introduce vernonia oil into brittle epoxy resins to add toughness at Eastern Michigan's Coatings Research Institute.*
Upper Right: *Scanning electromicrograph of two-phase material, which consists of brittle epoxy matrix and rubbery vernonia particles.*

In Portugal, investigator L. Santos uses the Hungate technique to inoculate flasks with Methanosarsina barkeri and other methanogenic thermophilic isolates in a PSTC project to optimize the growth and production of these microorganisms and their metabolites.

The creation of industries that transform agricultural and forestry products into more valuable products provides a major path to economic development in the Third World. Agroindustrial development provides economic benefits to farmers, foresters and loggers who grow and harvest raw materials such as vernonia seed. It is also an area where access to the raw materials provides a comparative advantage to the Third World industrialist.

Many developing countries have an abundance of inexpensive raw material in the form of biomass—organic material. Much of it goes to waste as material cast off by the forestry and agricultural industries. But science can turn much of that waste into valuable commodities. PSTC, therefore, has funded a number of projects aimed at converting biomass to valuable products or converting products with low value to ones with higher value. If biomass conversion techniques can be perfected, they will undoubtedly stimulate a demand for biomass plantations.

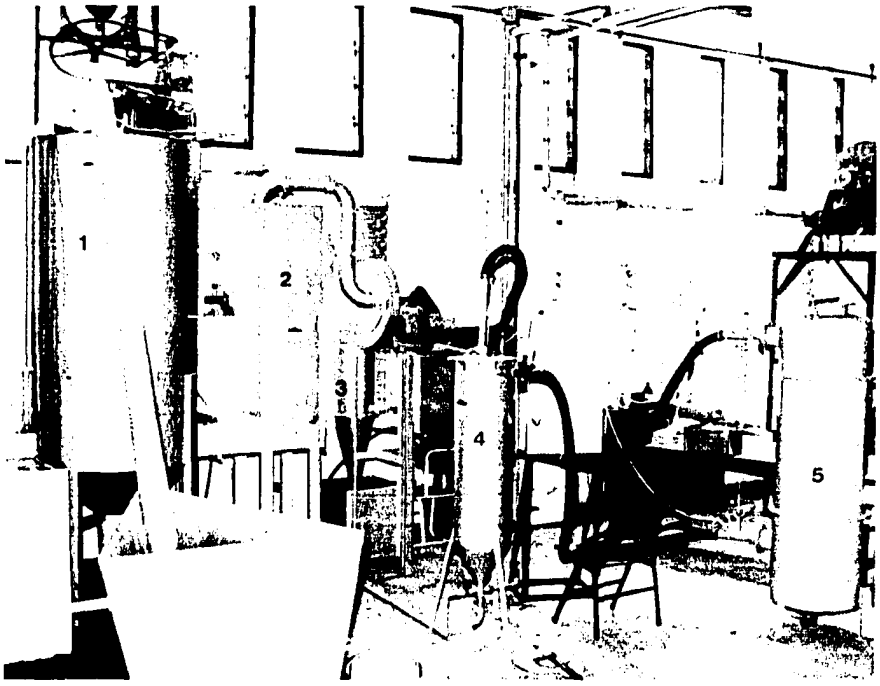
Woody biomass is generally a mixture of three kinds of polymers–cellulose, hemicellulose and lignin. Each is valuable when purified. Cellulose, for example, is the raw material for cellophane and the celluloid of photographic film; hemicellulose is used to produce sweeteners, resins and solvents; and lignin can be turned into an adhesive. Most woody biomass, however, is used for soil additives, low-quality fuel, animal feed and similar applications. There are currently few processes known that efficiently produce high-value products from woody biomass.

In Haiti, graduate student Timothy Wojtusik measures a tall, straight, thornless, fast-growing Peruvian mesquite. Several PSTC projects are investigating the potential use of mesquite as a feedstock for agroindustries in developing countries.

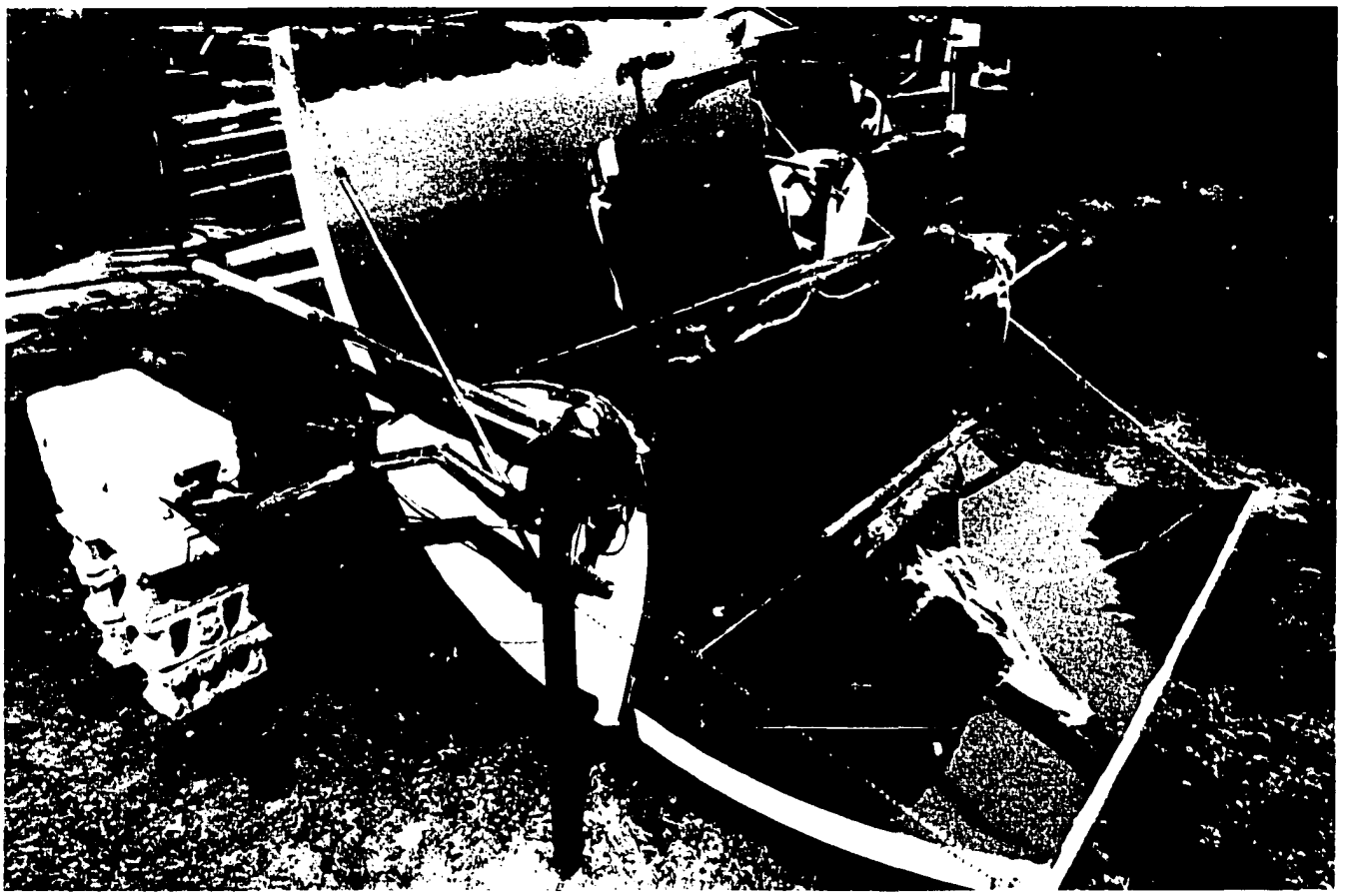
Much of the PSTC work on biomass conversion is based on the realization that microorganisms have evolved efficient ways to chemically separate and use the polymers in woody biomass. By learning how this microbial chemistry works, it may be possible to replicate the processes in industrial systems, perhaps even to modify and harness the microbes to do the processing themselves.

PSTC has funded research on how white rot fungi degrade lignin and leave cellulose and hemicellulose as products. It has also funded research on how brown rot fungi digest the cellulose and hemicellulose and leave the lignin. PSTC has funded research on the transformation of cellulose into more valuable products and on innovative processes that transform hemicellulose into alcohol.

The program has also supported projects aimed at turning agricultural wastes into marketable products. In



Thai researchers developed a five-step process for converting organic waste products (in particular, rice hulls) into a valuable gas.



U.S. and Thai scientists are developing a solar powered ice maker, based on this design, that can be easily manufactured and maintained in developing countries.

Thailand, investigators are developing a device to clean ash and tar from the gas produced by controlled burning of rice hulls, thus making it practical to produce a high-value engine fuel from this waste product. Other Thai scientists are investigating a process to turn soybean whey into a fermented health-food drink, a process that would consume all the whey now being thrown away.

In Pakistan, PSTC scientists are developing a biomass conversion technique as a step in turning salt-spoiled land into productive acreage. With an initial grant (via BOSTID), they studied kallar grass, which can grow in saline soils that will not support other crops. In a second project, they are using recombinant DNA techniques to develop a bacterium for an industrial fermentation system that turns kallar grass and other woody biomass into ethanol, methane and protein.

Other PSTC investigators hope to develop processes that increase the value of export products. In Portugal, for instance, one group of scientists has explored a new continuous industrial system for culturing bacteria that converts methanol into methane gas and produces vitamin B12. Their results are already in commercial use. Another group is developing a high-temperature, high-pressure fluid extraction system for recovering valuable products from natural raw materials and fermentation broths. Their initial goal is to extract very pure cineole—used by the pharmaceutical and cosmetic industries—from eucalyptus oil. Portugal has been exporting eucalyptus oil that is 85% cineole for about $4/kg; oil that is 98% cineole has been selling at 10 times that price.

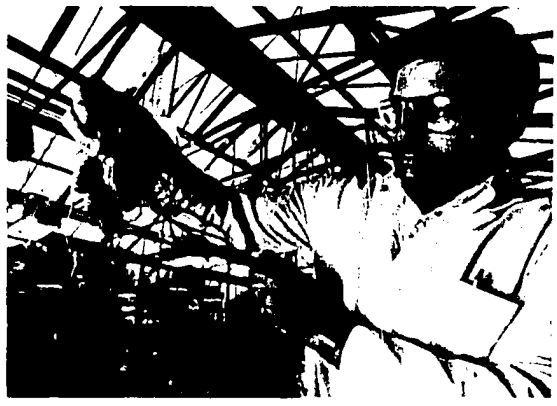
Industrial processes based on microbial transformation of biomass substrates are particularly suitable for developing countries. Such fermentation processes take advantage of available, low-cost materials and tend to be efficient, even when operated at relatively small scale and at relatively low pressures and temperatures. Thus, they are potentially more affordable and more manageable in developing countries.

Research into biomass conversion technologies holds promise for developing countries that are often poor in fossil fuels but rich in biomass. In the long run, PSTC's biomass conversion technology research may prove to be

PSTC Benefits for the United States

PSTC aims at solving development problems in the Third World. But the program's research often generates knowledge that also benefits the United States. For example:

— Synthetic genes developed through PSTC-funded collaboration between the Centro Internacional de la Papa in Lima, Peru, and Louisiana State University (page 26) are being tested through the U.S. Department of Agriculture in Russet Burbank potatoes, which account for 40 percent of U.S. potato acreage, and other varieties grown in the United States. The antibacterial gene produces a protein that is toxic to a broad spectrum of bacteria that damage tens of millions of dollars worth of U.S. potatoes each year.



In Albany, Calif., U.S. Department of Agriculture microbiologist David Rockhold harvests potato tubers for field trials. The tubers contain an antibacterial gene developed under PSTC funding.

"As far as the American market is concerned, the two diseases we're most worried about are bacterial soft rot ... and bacterial ring rot," said Bill Belknap of the USDA Western Regional Research Center in Albany, Calif. Field tests of the transgenic potatoes were being planned for Idaho, Maine and the Red River Valley region of North Dakota and Minnesota.

— A highly sensitive test for detecting cholera bacteria in water, developed under PSTC-funded collaboration between the University of Maryland and the International Centre for Diarrhoeal Disease Research, Bangladesh (page 29), may be useful for detecting salmonella and other bacteria in U.S. waters. The test uses monoclonal antibodies to detect dormant but potentially disease-causing bacteria which do not show up in conventional culture tests that detect only growing bacteria. The new test has detected dormant cholera bacteria in waters around Dhaka, Bangladesh. It has also found dormant salmonella bacteria in Chesapeake Bay and the New York Harbor region.

"We find that the numbers of salmonella discharged into streams and estuaries are actually much, much higher than the culturable count indicates," said University of Maryland investigator Rita Colwell. "This has important implications for drinking-water and waste-water management. It means the techniques of culturing for determining water quality may not be totally reliable."

— Vernonia oil, whose beneficial properties are being investigated through PSTC-funded collaboration between Eastern Michigan University and the University of Nairobi (page 35), may help the U.S. coatings industry meet current and future antipollution regulations. Nonreactive organic solvents in freshly applied conventional coatings quickly evaporate in the form of hydrocarbons, which cause air pollution and give fresh paint or varnish its characteristic harsh smell. The Environmental Protection Agency and other air quality regulators are requiring the reduced use of these solvents by the coatings industry. Vernonia oil, it turns out, reacts chemically with other components of a coating to become part of the coating film without giving off the offending hydrocarbons.

"We're finding good results on using (vernonia oil) in a commercial way," said P.K. Martin of the U.S. arm of Rhône-Poulenc, which is gearing up to produce vernonia oil. "In certain types of coatings we think it can be used as it is and incorporated as a part of the formula with an appropriate reduction of solvent. Generally, it would be a diluent for solvent-based paints formulated with alkyd, epoxy and other resins."

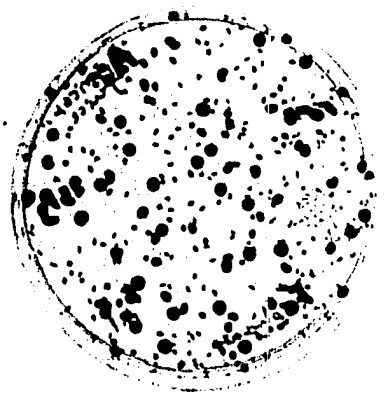
Rhône-Poulenc should soon be ready to offer limited amounts of the oil to coatings companies for developmental research, Martin said. Vernonia oil could begin appearing in commercial coatings about two years later.

more valuable still for the United States as alternatives to petrofuels are sought.

Beyond biomass conversion research, PSTC funds projects that respond to local industry needs and conditions. Researchers in Thailand and the United States, for example, are developing a solar-powered ice maker that can be manufactured and used in developing countries. The ice-maker would have immediate wide-spread use in the tropics for preserving foods and medicines. In another project, U.S. and Puerto Rican researchers developed and tested, in part with PSTC funding, a wave-powered device that turns sea water into drinking water by pumping it through a filter. By 1990, the first half dozen of the devices were each pumping 2,000 gal. of fresh water a day onto an island off the south coast of Puerto Rico.

In Thailand, investigators are developing the use of steel-mesh-reinforced earth embankments for roadbeds and housing foundations. The embankments are simple to build and would cost up to 50% less than concrete retaining walls. In Turkey, investigators are developing a new technique of reinforcing adobe buildings with local bamboo. The new technique will provide a practical, inexpensive means of keeping houses from collapsing during earthquakes.

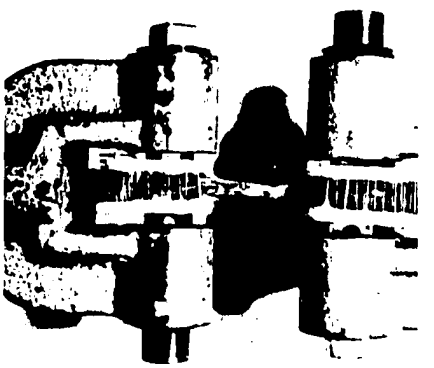
Thai scientists test a reinforced embankment designed under PSTC funding. The embankment uses locally manufactured steel reinforcements and locally available cohesive backfill soils. It is easier to construct and less expensive than concrete retaining walls.



Petri dish contains high-phytase yeast cells (dark) obtained through induced mutation by growing yeast on high-phytate media. PSTC researchers in Jordan hope the mutant yeast will reduce the phytic acid content of whole-meal bread. Phytic acid has been implicated in several health problems.

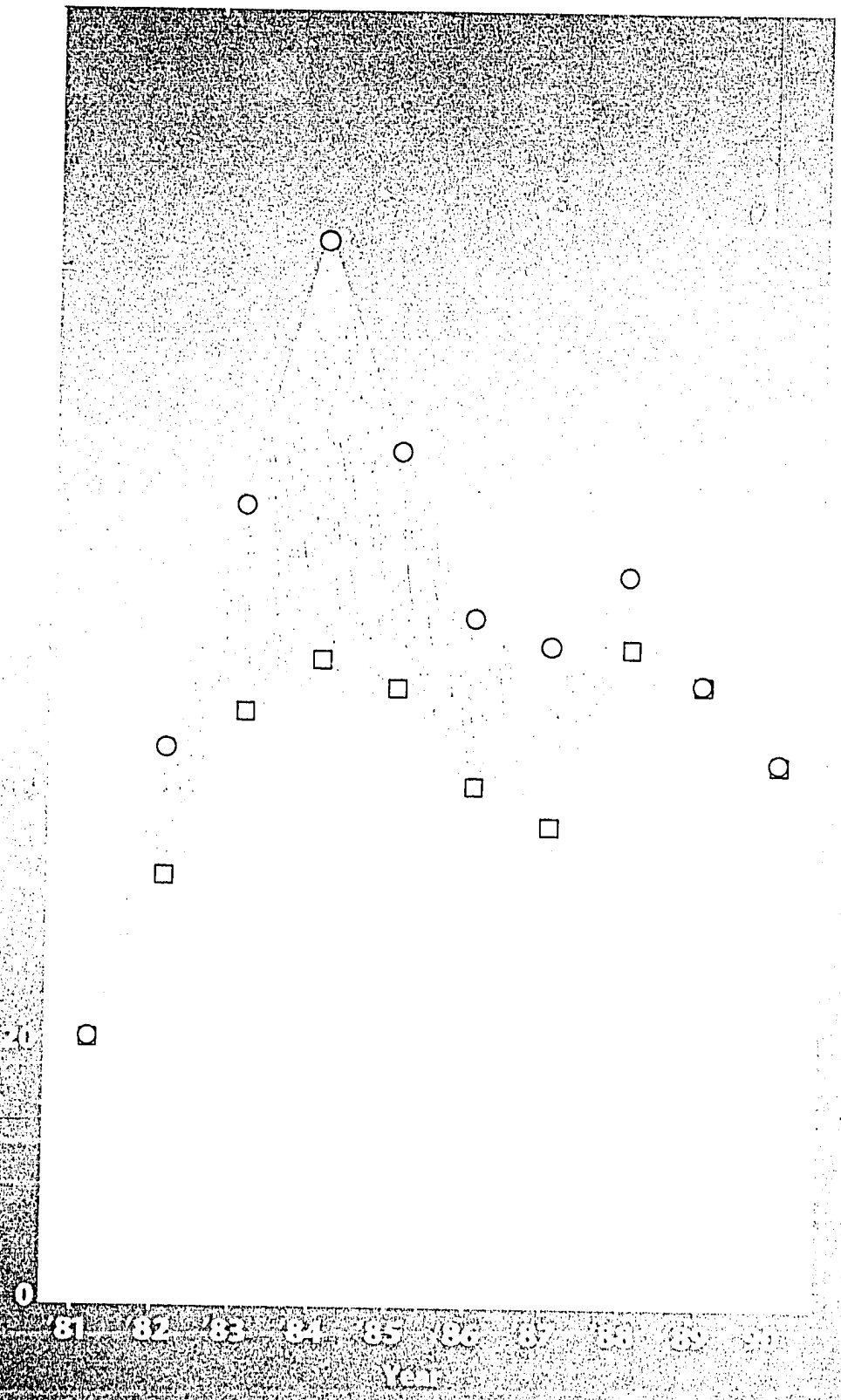
In Jordan, researchers are developing a baker's yeast high in an enzyme that breaks down phytate, a compound that is found in whole-meal Middle Eastern bread and that prevents the absorption of zinc, iron, calcium and other essential minerals. The improved baker's yeast would result in more nutritious bread and, it is hoped, reduce anemia, growth retardation and other health complications that afflict many people in this region. In Chile, investigators are refining a system that separates the desirable white meat from dark meat and fatty tissue in small ocean fish. Small fish netted as a "by-catch" with larger, more valuable fish are often turned into meal for fertilizer or animal feed; the separation system could preserve the more edible white meat for human consumption. And a Sudanese researcher has applied for patents to a process, developed with PSTC funds, for preserving meat at room temperature by boiling the meat and wrapping it in plastic. The process is inexpensive enough for even the poorest village.

Industrial capability is the most visible mark of a country's economic development, and scientific research is the key to building that capacity. As it strives to develop industrial capacity, each Third World country will need to tailor the industries to its own particular needs and resources. The first 10 years of PSTC have shown that, with a little help getting started, scientists in developing countries can meet their own scientific and technological needs.



The interfibrillar strength of fish muscle is tested by Chilean researchers in a PSTC study on more efficient means of separating light and dark meat. Such a process would allow better use of fish meat in developing countries.

Program Operation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Evolution of PSTC

"Science and technology ... are a shared heritage of all mankind. East and West, South and North have all equally participated in their creation in the past as, we hope, they will in the future—the joint endeavor in science becoming one of the unifying forces among the diverse peoples on this globe."

— Abdus Salam,
Nobel laureate in physics

Over the decades that the United States has provided assistance to developing countries, it has become increasingly clear that a number of development problems will not be solved with existing technology nor with simple adaptation of developed-country technology. For example, prevention of schistosomiasis and malaria requires new immunological knowledge and technology. And major improvements in the agricultural productivity of developing countries, typified by the Green Revolution, require advances in plant sciences. Recognizing this fact, Congress in 1981 mandated creation of the Program in Science and Technology Cooperation (PSTC) to pursue cutting-edge research on development problems.

The outline of PSTC actually began taking shape during U.S. preparations for the United Nations Conference on Science and Technology for Development two years earlier. In preparing for the meeting, U.S. scientists and White House aides concluded that a need existed for a more innovative, more collaborative program of research with developing nations than was then managed by A.I.D., and they recommended the creation of PSTC. The planners' recommendation was based on the need to make such a program free from the bureaucratic processes required in A.I.D. for managing large financial transfer projects and to attract scientific talent to its management. Congress accepted this proposal but instructed that it be administered by a single A.I.D. office. A.I.D. created the Office of the Science Advisor in 1981 and assigned it that responsibility. The office was later renamed Office of Research (AID/R).

During its early, formative years, AID/R split the administration of PSTC funds with the National Research Council's Board on Science and Technology for International Development (BOSTID; see NRC's 1991 publication "Research for Development"). BOSTID selected and administered research projects separately. Since 1988, however, AID/R has managed all projects funded under PSTC. BOSTID, through a special cooperative agreement, complements AID/R's work by providing research support services—such as help for Third World investigators to locate modern lab equipment—by building communication networks among the investigators and by publishing books about PSTC research (page 44).

In 1985, Congress established and gave AID/R another grants program, the U.S.-Israel Cooperative Development Research Program (CDR), which draws on the expertise of the Israeli scientific community. Like PSTC, this program promotes research to develop new knowledge and technology for solving development problems in developing countries. CDR also encourages host-country institutions to develop the sustainable capacity to carry out this innovative research. (See AID/R's 1987 publication on CDR.)

Development of PSTC Guidelines

When AID/R opened for business in 1981, PSTC was in many ways an experiment. But in 10 years, after reviewing more than 5,000 research ideas and granting funds for 415 scientific projects with a value of more than $70 million, the program has become one of the better research efforts in the development community.

The content of the program evolved rapidly as AID/R listened and responded to the concerns of scientists from developing countries and as the need to build research capacity and address developmental problems in these countries became more apparent. Advances in science and technology, especially biotechnology, have also greatly influenced the choice of projects to be funded.

The number of submissions to PSTC has increased from just over 100 the first year, to more than 600 per com-

NRC/BOSTID Studies

How does PSTC decide where the most fruitful areas of developmental research are? In part, PSTC simply observes the activity in the scientific community. But it also delves into promising research areas through studies conducted and published by the National Research Council (NRC)—the operating arm of the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine. The studies are produced by NRC's Board on Science and Technology for International Development (BOSTID).

The BOSTID publication of "Priorities in Biotechnology Research for International Development" in 1982 was a landmark for PSTC. The book came out of a conference, sponsored by PSTC and NRC, of 75 scientists from around the world who met to define research priorities for the program. The book became the basis for three PSTC research modules—biomass resources, biotechnology/plants and biotechnology/immunology—and stimulated health and agriculture projects in A.I.D.'s Bureau for Research and Development (formerly the Bureau of Science and Technology). The book has also influenced the direction of science policy in many other countries.

The BOSTID studies examine a range of issues involving science and technology in development efforts such as tropical forestry innovations, the potential for alcohol fuels, and underexploited tropical plants such as grain amaranth. The resulting publications provide state-of-the-art information that is disseminated around the world. In fact, BOSTID has distributed more than 600,000 copies of some 50 studies since it was founded in 1969.

Recent BOSTID studies have highlighted different aspects of biological diversity. Studies such as "Quality-Protein Maize," "Lost Crops of the Incas" and "Saline Agriculture: Salt-Tolerant Plants for Developing Countries" focus on the need to fully use local resources and native crops. A monograph on underexploited African crops aims to bring the potential of such traditional crops to the attention of the world's research community. A more general upcoming monograph will identify "research priorities in biodiversity for development agencies."

Some studies review more complex applications of science and technology to development. A series of four monographs drew on computer experts from Mexico, Portugal and Sri Lanka to examine the role of microcomputers in development. Another study in preparation will explore potential benefits in materials science research for developing countries.

BOSTID's study reports are distributed free in developing countries and at cost in developed countries. The reports are sent initially to a specifically targeted audience that includes scientists, researchers, administrators, planners, development assistance workers and government officials. BOSTID staff continue to respond to about 100 requests each week for publications.

petition (Figure 1). This number may underestimate the increase, since many USAID missions screen preproposals and send only the best to AID/R. The number of grants made per year (page 42) increased rapidly until 1984, but has decreased in subsequent years due to lack of resources. This decrease has led to stiffer competition for grants. Currently, only about one in 15 applications is actually funded.

PSTC was the first program in A.I.D. to be based on external peer review of investigator-initiated proposals (Figure 2). Unlike many grants programs, PSTC designed its review process to encourage the success of unproven but talented investigators with good research ideas. The preliminary proposal (preproposal) required for the first round of review is only two or three pages long, so that investigators do not waste months preparing a detailed proposal for a research idea that does not fit program guidelines. When research ideas are rejected at the preproposal or full proposal stage, reviewers write instructive critiques so that the investigators learn from the experience. When proposals are accepted for funding, reviewers usually write detailed comments and suggestions that strengthen the proposal and help ensure its success. Other grants programs usually accept or reject proposals without comment.

Guidelines for submission of PSTC preproposals and proposals have evolved over the years as staff adapted and expanded instructions based on peer-reviewer comments. During that time, other A.I.D. programs have adopted PSTC's review mechanism, often using it as a model.

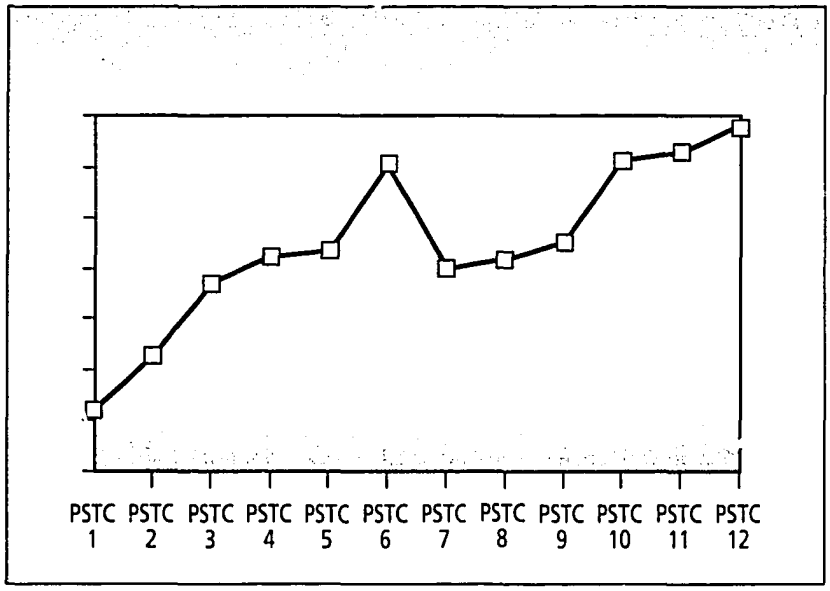


Figure 1

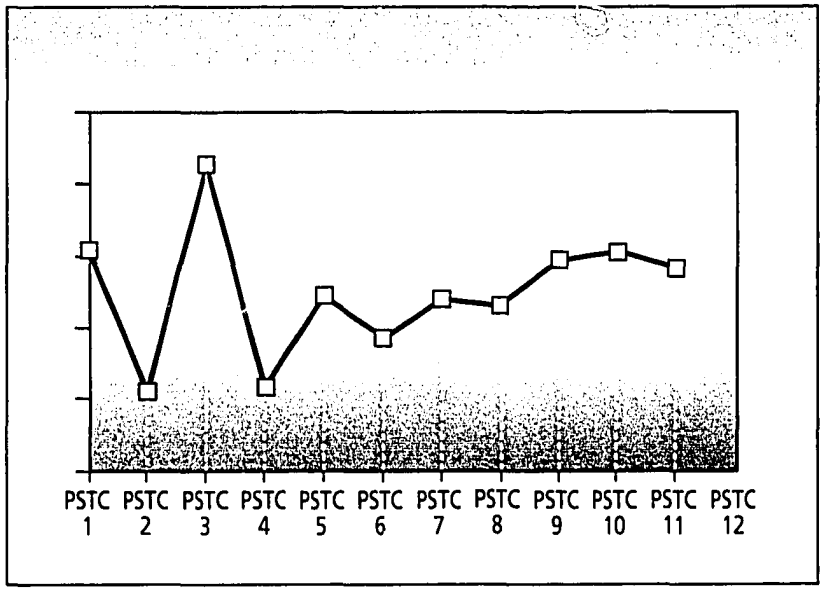


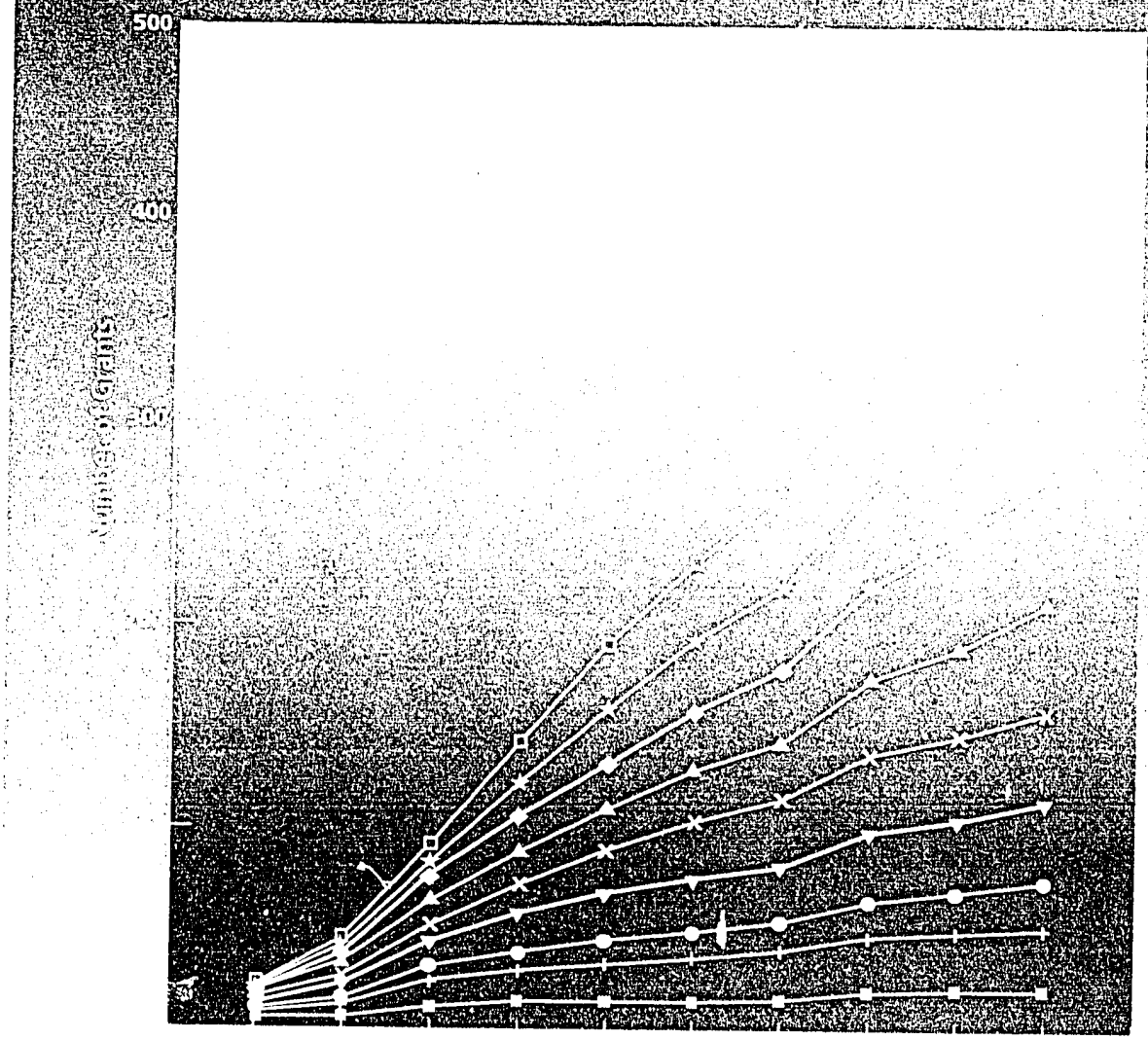
Figure 2

Research Modules

Analysis of the research ideas submitted as preproposals to PSTC over the first three years showed that their number had nearly tripled and that many involved subjects seemingly inappropriate for PSTC investigation. Therefore, AID/R invited U.S. and Third World scientists as well as A.I.D. staff to indicate which new research areas might be most fruitful in solving development problems. The results of these discussions and the earlier analysis prompted AID/R in 1984 to designate several categories of research that it was interested in funding through PSTC. The announcement led to a steep drop in the overall number of preproposals submitted in the seventh competition but to an increase in the number of research ideas appropriate for the program.

Originally, AID/R named five major areas of investigation, called research modules, that it considered suitable for PSTC funding: biotechnolgy/immunology, biotechnology/plants, chemistry for world food needs, biomass

Cumulative Numbers of Grants by Research Module



resources and conversion technology, and biological control of selected vectors that carry disease-causing organisms. The program also designated three minor areas called premodules: engineering; earth and marine sciences; and genetic resources. Unless of exceptional quality, research proposals outside these eight areas were not funded.

The classification and definition of PSTC's research areas have evolved over the years in response to interests, needs and new developments in the scientific arena. For example, as preservation of biological diversity—nature's trove of genetic resources—became more urgent, AID/R upgraded the genetic resources premodule to a full module called "diversity of biological resources." Since 1987, the average number of grants awarded each year in this research area has doubled.

PSTC has also expanded the earth and marine sciences premodule to include atmospheric science and in 1989 began asking for proposals concerned with global climate change. The following year the module's name was formally changed to "global climate change."

Although PSTC solicits research projects that fall within its research modules, the program does not interpret the modules narrowly nor does it mechanically grant the same number of awards in each module. PSTC wants to fund the projects with the most scientific merit, innovative character, relevance to development and potential to enhance research capabilities in developing countries. If funding unequal numbers of projects per module improves the overall quality of the portfolio, then it is done (page 46).

Participants

The increase over the years in the number of preproposals submitted to PSTC has, in the opinion of reviewers, been associated with a parallel improvement in the quality of submissions. AID/R staff have actively recruited talented Third World scientists through regular visits to scientific conferences, A.I.D. missions and scientific institutions in developing countries, where they explain and promote the program. These efforts and the growing number of preproposals have helped PSTC move toward its goal of awarding the large majority of its grants directly to scientists in developing countries. In its first year, PSTC awarded 75 percent of its grants to U.S. scientists and 25 percent to Third World scientists. But by 1989, the annual numbers were reversed. Over the life of the program, 58 percent of the grants have been awarded to scientists in developing countries and 42 percent to U.S. investigators collaborating with colleagues in the Third World. The number of countries participating in the program has more than doubled to 59 in 1989 from just 26 in 1981.

AID/R is also pursuing greater participation and competitiveness from a regional perspective. African scientists have fewer proposals submitted and funded than scientists from other regions. Much of the problem is caused by inadequate communications and seemingly simple difficulties—lack of typewriters, supplies and copy services—unknown to scientists in other parts of the world. AID/R therefore recently initiated a series of actions designed to improve the participation and competitiveness of African scientists in PSTC. For instance, instead of requiring the usual 15 copies of a proposal, PSTC now allows African scientists facing submission difficulties to send fewer copies and have more time for their delivery. And in 1989, AID/R assigned an AAAS fellow to bolster African participation by making promotional visits and conducting workshops on how to write grant proposals (page 48).

Research Capacity

Building the scientific capacity of a developing country requires an approach from several directions. AID/R believes that sustainable development in the research arena is best achieved by helping Third World scientists actually do innovative research. Therefore AID/R funds research capacity building—by providing training, equipment and expert consultation—only where it supports Third World investigators in their work on a PSTC project.

PSTC's emphasis on building research capacity in developing countries affects the role U.S. scientists and institutions play in the program. Often when working with Third World scientists in the past, U.S. scientists actually controlled much of the project. Today, the emphasis is on true collaboration. If the project has a U.S. scientist as principal investigator, then AID/R scrutinizes the proposal to ensure it includes meaningful collaboration with a Third World scientist. Proposals from U.S. scientists that do not include this collaboration are simply not funded.

To U.S. institutions, the program provides an opportunity for learning and expanding their expertise and a source of funding for truly collaborative efforts with peers in developing countries. Doing science in developing countries often requires a great amount of resourcefulness and ingenuity, a situation that often leads to new and sometimes better ways of doing science. In addition, scientists in developing countries are often an invaluable source of information about the conditions of research and the applicability of results.

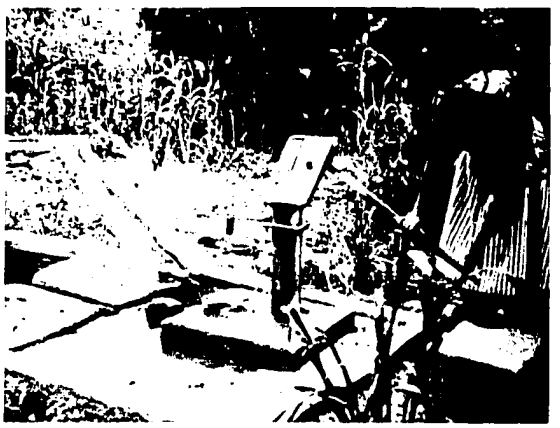
AAAS Fellowships

As an experiment in 1982, PSTC funded a postdoctoral fellow through the American Association for the Advancement of Science (AAAS) to spend a year at A.I.D. The experiment succeeded beyond expectations. Since then, 82 fellows have spent one to two years at A.I.D., including the 31 serving in the 1990-91 year. The program is administered by the Office of Research (AID/R).

Most of these fellows have been supported by other A.I.D. bureaus, which increasingly see them as a vital link to the U.S. scientific community and to state-of-the-art scientific know-how. Current and former AAAS fellows play an expanding role as the vital link between PSTC's innovative research portfolio and the problem-oriented, technology-transfer operations throughout the rest of A.I.D.

In fine-tuning the operation of PSTC, AID/R frequently turns to an AAAS fellow. When, for example, AID/R wanted to find out why relatively few preproposals were being submitted to PSTC from African countries, AAAS fellow Jill Conley was sent to investigate in Zimbabwe, Kenya, Cameroon, Congo, Ivory Coast, Ghana and Senegal. Said Conley: "It turns out that most people didn't know about the program."

Conley therefore placed PSTC announcements in the newsletters of regional organizations such as the African Academy of Sciences, explained the program at several universities and organized a seminar in Cameroon to teach African scientists how to write competitive preproposals. She returned from the seminar with 18 preproposals for the current year's competition and left behind directions for competing in the next year's round.



AAAS fellow Rita Kees evaluates an A.I.D. project in Mali, leading a discussion with villagers (facing page) about water-related health conditions and inspecting drinking-water supplies (left) in the Dogon region.

AAAS initiated the Science, Engineering and Diplomacy Fellowship Program in 1980 as a means of incorporating more science and technology expertise in the development of U.S. foreign policy. The fellows at A.I.D. work on scientific or technical projects in international development areas such as energy, environment, population, biodiversity, tropical forestry, tropical diseases, and food and agriculture.

The AAAS fellows "bring a much-needed refreshing perspective and an infectious enthusiasm to applying the scientific disciplines to development problems," says Jim Hester, A.I.D.'s chief of environment, energy and science for Latin America and the Caribbean. "At the same time, the Agency's development experts challenge the fellows into blending technical, economic, political, social and bureaucratic considerations into a solution that can work in the harsh reality of a less developed country."

Prior to beginning their A.I.D. assignments, the fellows undertake a three-week orientation program arranged by AAAS and AID/R. The orientation explains executive branch and congressional operations, the policy process, and science and technology policy issues at A.I.D. Throughout the following year, the fellows participate in seminars and other activities to augment work-related learning. This training, coupled with their previous science training, makes the fellows valuable commodities inside and outside A.I.D.

"By the time their fellowship ends, they all have a great deal to offer to international development, and the Agency has a great deal to lose when they leave," Hester says. "So if we can't keep them in A.I.D., then (we) try to find ways to place them in an organization that does A.I.D.-type work." Fellows with backgrounds in environmental sciences have, for example, gone on to positions at The Nature Conservancy, World Wildlife Fund, Smithsonian Institution and World Resources Institute as well as at A.I.D.

February 1

Deadline for PSTC preproposals to AID/R

Preproposals are screened by AID/R

May

Mailing of invitations for full proposals

Provisos and special concerns are negotiated by AID/R

Mission clearances are obtained

April

Dispatch of funding documents to Procurement

How PSTC Works

"It is the lone worker who makes the first advance in a subject: the details may be worked out by a team, but the prime idea is due to the enterprise, thought and perception of an individual."

— Sir Alexander Fleming
address at Edinburgh University, 1951

The Program in Science and Technology Cooperation (PSTC) seeks new research ideas in the natural sciences and engineering that can be readily adapted and applied to serious problems facing developing countries. It emphasizes eight research categories for priority funding. Seven of these, called research modules, are biotechnology/plants, biotechnology/immunology for humans and animals, chemistry for world food needs, biological control of selected vectors, biomass resources and conversion technology, diversity of biological resources, and global climate change. One other of secondary interest, called a premodule, is engineering technology.

PSTC welcomes innovative research ideas from the widest possible spectrum of scientists. About two-thirds of the more than 5,000 research ideas submitted so far have come from developing countries; the rest have come from the United States and advanced developing countries such as Mexico.

PSTC grants range up to $150,000. The money may be used for salaries, equipment, travel, training and consultants, but the expenditures must be directly related to reaching a specific research goal. The program targets countries receiving A.I.D. development assistance. Investigators from these developing countries may conduct PSTC-funded research alone or in collaboration with scientists from the United States or an advanced developing country. U.S. investigators who receive PSTC grants, however, must collaborate with Third World scientists to ensure that the grants also build research capacity in the developing country.

PSTC normally finances three to five years of the initial, risky, hypothesis-testing phase of an investigation. The grants are usually not renewable, and scientists are expected to tap other sources of support for follow-up research. PSTC does not continue projects begun by other A.I.D. units or fund the transfer of conventional technology, a task more appropriate to those units. Also, PSTC does not support activities not directly involved with research, such as planning or policy studies, international conferences, core support for institutions, travel grants, surveys, baseline data collection and the preparation of books or courses. Finally, PSTC does not support projects whose potential benefits are limited to a single country; rather, it seeks research projects whose findings could be useful to many developing countries and to advanced countries, such as the United States, as well.

Selecting Projects

The concept of impartial technical peer review is central to PSTC. All PSTC proposals pass through a rigorous two-stage process of internal and external review. Currently, only about one submission in 15 survives the complete review and is funded.

Every year now more than 600 scientists around the world respond to PSTC's invitation to send a three-page "preproposal" summarizing their project's objectives, work plan and relevance to international development. Some 120 of them are asked to prepare full proposals for external PSTC review. Around half of these are recommended for approval, but current budget levels allow only about 40 grants to be finally awarded. (See "History of a PSTC Project," page 52.)

Preproposals are screened initially by the A.I.D. missions and later by the A.I.D. Office of Research (AID/R) in Washington. These internal reviews determine whether the proposed research is relevant to development and potentially useful to A.I.D. They also consider duplication, complementarity and synergy with other A.I.D. projects. Successful investigators are given the reviewers' comments and asked to submit detailed proposals for subsequent external review.

At the next stage of review, specialized external panels of 10 to 20 experts evaluate full proposals for scientific and technical merit and make recommendations regarding research plans and funding. Panelists are often leading scientists in government, industry and academia and are tapped for their specific expertise. Although the mix of

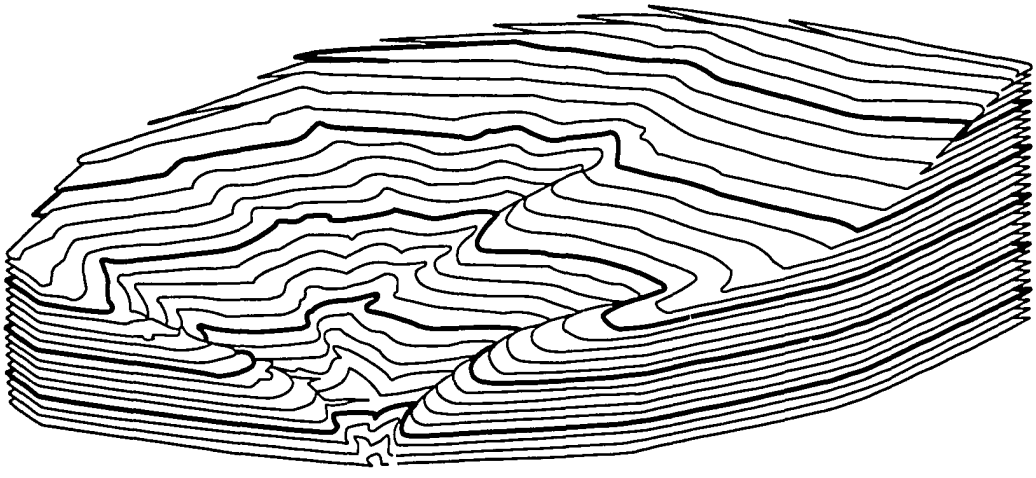
History of a PSTC Project

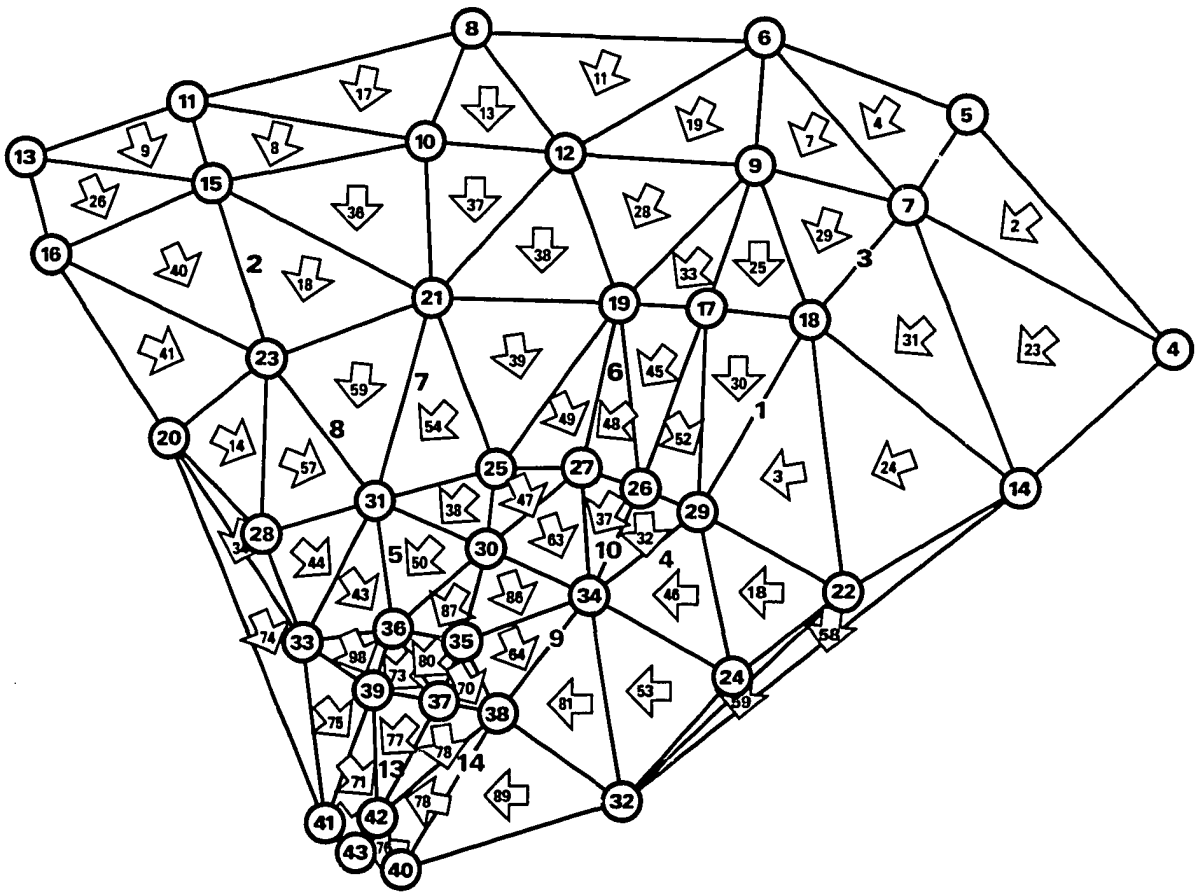
How does the PSTC process really work in terms of scientists and their research? Most funded projects proceed smoothly and directly from conception to final report. The project undertaken by Oscar Palacios and his fellow scientists at the Graduate Research Institute in Chapingo, Mexico, demonstrates the usual flow of a PSTC project as well as some of the unusual situations that can arise.

In January 1983, the investigators submitted a PSTC preliminary proposal (preproposal) to develop a computer-aided design (CAD) system for surface water engineering works, such as flood control barriers. Their innovation—triangular grids of elevation points rather than the usual rectangles—would decrease the amount of data needed for the system and thereby reduce the need for computer storage capacity and computational power. Because the model can be run on a microcomputer (as opposed to a mainframe), it could be used in Mexico and other developing countries to extend scarce engineering resources to meet the enormous demands for public works.

The Office of Research (AID/R) accepted their preproposal, and Palacios and his collaborators submitted a full proposal well before the August deadline. A panel of reviewers met in October and recommended that the project be funded, contingent on a satisfactory response to their provisos. The researchers answered all the concerns raised by the reviewers by March 1984. However, not enough money was allocated to PSTC that year to fund all approved projects. So AID/R informed Palacios at the end of June that his project would remain "approved but unfunded."

Despite this disappointment, the Palacios team submitted another successful preproposal for the project in January 1985 and an improved full proposal the following August. The October review panel again recommended it for approval, contingent on a satisfactory response to its provisos. These were answered through correspondence by April 1986. In June, AID/R awarded a grant of $143,544 to Palacios and his team, which now included two collaborators from the U.S. Department of Agriculture. Following the provisos, the





investigators also enlisted graduate students from Peru and Bolivia to develop specific segments of the CAD software. The project was to be completed by December 1988.

A delay in transferring funds caused the project to start late, so six months after receiving the grant Palacios asked for and received a project extension to June 1989. Later, to get more time to complete the work, Palacios asked for a second extension to June 1990 and an additional $4,000 to present their CAD system at workshops in Peru and Bolivia (total for the project was still under the $150,000 limit). PSTC seldom grants additional funds. But because the reports were up to date and the work was progressing well, the project officer concurred with the request, which was granted by AID/R.

In July 1990, Palacios demonstrated the completed system to A.I.D. in Washington and discussed possible follow-on activities with A.I.D.'s water management experts. He also presented it to a technical meeting in San Francisco where it could be compared with the best competitors in the field. And in October, nearly eight years after sending AID/R his initial research idea, Palacios submitted his final report as well as two computer diskettes containing the new Chapingo CAD system.

panels varies yearly—depending on the specific scientific areas represented by the proposals—they generally correspond to the research modules and premodule described above.

Reviewers rate the proposals for each of the competition's criteria: innovation, scientific merit, relevance to development and ability to improve research capacity in developing countries. They consider the scientific strengths and weaknesses of the proposed experiments and the probability of obtaining significant new findings. Innovation is particularly important; simply providing new data does not make a project innovative. Similarly, collaboration among all parties in a proposal is important and is assessed by the panel.

The reviewers also rate the competence of principal investigators (including training, academic credentials, research experience and publications), as well as the quality and availability of research facilities and collaborative arrangements. They also judge whether the budget is realistic and reasonable.

The panelists specifically review how the proposals treat special concerns of A.I.D., especially in the areas of ethics, the environment and intellectual property rights. They review the projects to ensure that the proposed research meets applicable regulatory standards. While researchers have the ultimate responsibility for their own conduct, the proposing institutions accept the responsibility for the review and monitoring of research to ensure that it meets relevant standards and regulations. Grant provisions are written to formalize this responsibility.

Critiques of PSTC

Experts inside and outside A.I.D. have evaluated segments of PSTC or the entire program from time to time. Findings of several major evaluations are summarized here.

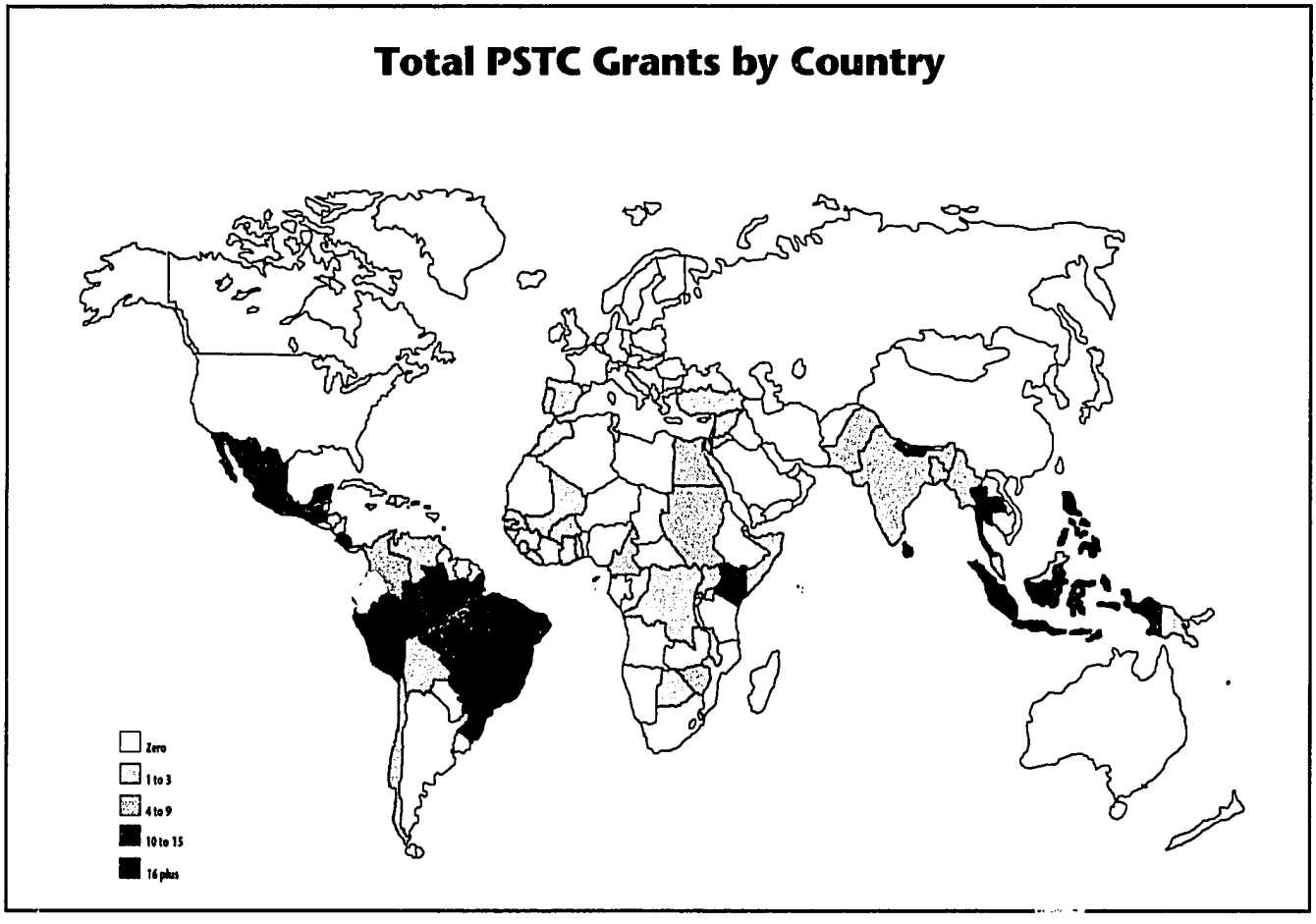
— In 1985, A.I.D.'s Research Advisory Committee reviewed the PSTC funding administered by the Office of Research (AID/R). "This portion of the PSTC program is well conceived and innovative in approach," the committee wrote. "Although it is too early to judge its success, we believe some good answers to old problems can be generated by this approach."

— In 1988, an A.I.D. team reviewed the management of AID/R. The reviewers found overall management was of "high quality" but added that "there was room for improvement in the monitoring of grants, and more could be done to reduce management overhead and to provide support and training services to science collaborators."

In response to the review, AID/R arranged with the National Research Council's Board on Science and Technology for International Development to provide more support and training for collaborators. The office has also implemented better grant monitoring procedures, including the preparation of a streamlined manual explaining how to administer PSTC grants more efficiently.

— Also in 1988, AID/R began a series of external evaluations to measure the impact of PSTC grants on individual countries. The initial findings on the first countries studied show that "a majority" of PSTC grants "have had at least a moderate effect on capacity strengthening." The evaluator found that four of the seven projects reviewed in Ecuador and Costa Rica received a "strong to very strong" rating; eight of nine projects in Nepal scored either a "moderate to strong" or a "strong to very strong" rating.

— Over the past five years, AID/R has commissioned evaluations of the scientific work in four of the eight research areas that PSTC funds. External experts conducted three of the reviews, and an A.I.D. senior scientist conducted the fourth. Projects in all four areas received generally high marks. For example, "PSTC health/biotechnology projects have produced state-of-the-art research resulting in internationally read publications and subsequent research funding opportunities," one review team wrote. "PSTC health/biotechnology grants have also contributed to strengthening research institutions and potentially produced new tools in the struggle against tropical diseases."



The PSTC review procedure provides investigators with impartial, expert feedback that strengthens their research plans and increases their probability of success. Panels often condition their approval with specific technical provisos or caveats. They also encourage the resubmission of some proposals that, although rejected as submitted, do contain ideas worthy of further consideration.

Monitoring Projects

To promote integration of PSTC projects into the mainstream of A.I.D. activities and to take advantage of expertise within the Agency, AID/R staff usually ask other A.I.D. officers to monitor the projects. Projects headed by Third World investigators are usually monitored by project officers at the A.I.D. mission in the country where the research is performed. Projects headed by U.S. investigators are most often managed by staff in the A.I.D. Bureau for Research and Development or the appropriate regional bureau within A.I.D./Washington. The PSTC project officer becomes the main point of contact between the principal investigator and A.I.D. If an A.I.D. mission wishes, AID/R arranges for a technical backstop officer from Washington to help with technical questions that may arise.

The PSTC project officer keeps abreast of the project through semiannual progress reports from the investigator. Project officers may visit research sites to review the findings and ascertain their potential use or may ask AID/R to arrange site visits by an expert. The PSTC project officer is thus in an excellent position to gauge the potential for integrating the results into ongoing A.I.D. programs.

In addition, officers at the National Research Council's Board on Science and Technology for International Development (BOSTID) monitor each PSTC grant from inception to completion. By following the progress of the projects, BOSTID officers ensure that technical help is provided to projects that need it. Frequently they arrange for U.S. scientist volunteers to review reports or visit grantees to help with the projects.

PSTC evaluates completed projects in a number of areas for different reasons. For example, several projects in the research modules on biomass conversion, biotechnology/plants and biotechnology/immunology have been evaluated to assess overall progress in these areas. And when a former PSTC investigator asks for funding of a new project, the peer review panel examines the results of the first project to judge the scientist's productivity.

Help from the U.S. Scientific Community

Right: *Gerald Reed advises Indonesian researchers in Sumatra about protein production on casava substrate by continuous production.*
Below: *James Brewbaker discusses new methodologies with developing-country scientists at a conference on research into fast-growing trees.*

The Program in Science and Technology Cooperation would literally not be possible without the generous cooperation of U.S. scientists. In the United States, scientists recognize that they have a professional responsibility to science and the scientific community that goes beyond the specific duties of a faculty position or a government laboratory post. This sense of professional responsibility is frequently combined with humanitarian concern to help poor countries deal more effectively with the needs of their populations and with the deterioration of their environments.

The main contribution of U.S. scientists to PSTC is their collaboration in individual research projects. They often participate without salary or other remuneration. Even where modest salary support is necessary, U.S. collaborators almost always spend more time and effort than required. In many respects, a true sharing—of problems and successes in innovative research, of by-lines in scientific publications and of rights to inventions—occurs among U.S. and Third World investigators.

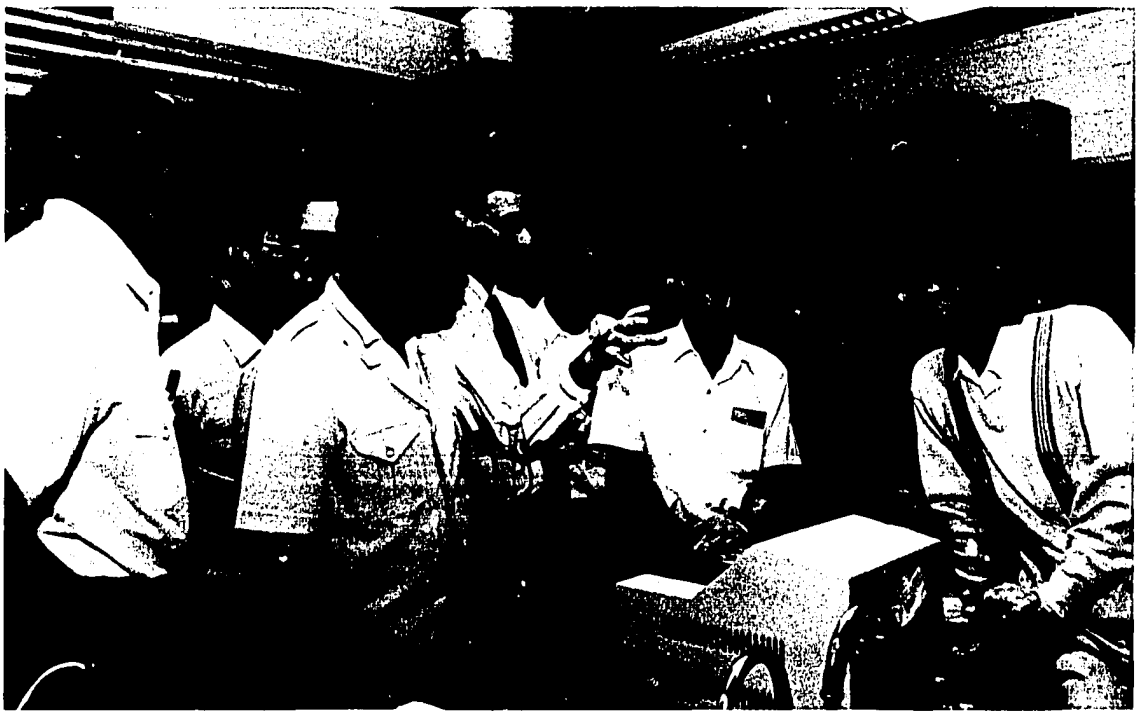
To identify the best proposals, A.I.D.'s Office of Research seeks scientists actually engaged in research to review every project proposal submitted. To date, more than 200 scientific panels averaging 15 experts each have met to review PSTC project proposals. Such review does not involve simply reading the proposal and discussing it at the panel meeting. It requires carefully evaluating the proposed methods and approaches, looking up references and, frequently, locating other experts to consult on fine points of the techniques. Literally tens of thousands of days of expert services have been donated to the program in the peer review process. Moreover, the panelists pay their own travel expenses to Washington meetings, and some have come from as far as New Mexico and California. As one observer pointed out, no one could afford to buy the quality of review that is donated to PSTC.

The National Research Council (NRC) also helps mobilize U.S. scientific support for the program. It recruits experts generally from the scientific community and particularly from members of the National Academy of Sciences and the National Academy of Engineering (NRC is the operating arm of NAS, NAE and the Institute of Medicine). Some experts volunteer

to review the progress of research projects and suggest solutions to the problems Third World scientists encounter in their research. Others visit grantee laboratories in Asia, Africa or Latin America to give them direct, hands-on assistance. NRC experts sometimes help developing-country investigators deal with the complexities of applying for PSTC grants, even when the U.S. scientist is not planning to collaborate in the resulting project.

Distinguished U.S. scientists also contribute to NRC networking meetings for PSTC investigators in specific research areas: they lecture on research frontiers, critique individual projects and offer informal assistance to the PSTC grantees. At other times they bring PSTC grantees to their own laboratories for training in new scientific techniques. In addition, U.S. scientists participate in panels that help define PSTC research priorities or that help evaluate the accomplishments of individual projects or groups of projects in particular research areas.

The U.S. research community is probably the strongest in the world and constitutes one of the major resources of the country. Increasingly, it operates on an international level, and many U.S. scientists are greatly interested in the role of science in developing countries. They have translated their interest into the donations of expertise that make PSTC possible. Their donations have not been limited by lack of generosity, but by the limited size of the program.



Carl Dieffenbach explains how to use the PCR (polymerase chain reaction) technique during a conference of PSTC investigators in Washington.

PSTC Projects Funded in 1985-1990, by Research Module

(For projects funded in 1981-1984, see earlier booklet.)

KEY:
HOST COUNTRY. Grantee Institution; PRINCIPAL INVESTIGATOR. Grant year. Title. Description. PSTC file number

Biological Control of Selected Vectors

CHILE. U. Chile; NIEMEYER, H. 1988. Role of Hydroxamic Acids in Cereal-Aphid Interactions. Study the involvement of hydroxamic acids of wheat in the control of aphid populations and transmission of barley yellow dwarf virus by aphid vectors. 7.404

COLOMBIA. U. Florida; HIEBERT, E. 1990. Development of Monoclonal Antibodies for Serological Differentiation of Bean Golden Mosaic Virus Isolates. Develop monoclonal antibodies useful for specific identification of bean golden mosaic virus isolates of importance to bean production in Latin America. 9.303

Left: *In Peru, an investigator dispenses culture media into culture plates. The technique of growing plant tissues and cells in vitro has become a valuable tool in the hands of Third World scientists.*

COSTA RICA. Ohio State U.; GORDON, D. 1986. Ecology of a Virus and Mollicutes of Maize and of Their Dalbulus Vectors in Costa Rica and Mexico. Determine the influence of the environment on the interactions of plant viruses and mollicutes, insect vectors and host plants and of these interactions upon the ecological specializations of pathogens, vectors and hosts. 6.375

COSTA RICA. U. Costa Rica; GAMEZ, R. 1986. Managing Plant Virus/Mycoplasma Complexes in Maize/Bean Cropping Systems. Observe the relationships among pathogens, vectors and bean/maize cropping systems. Create a simulation model to help discover crop-management alternatives appropriate to the biotic interdependent system. 5.142

COSTA RICA. U. Costa Rica; RAMIREZ, P. 1989. Cloned DNA to Study Molecular Biology, Host-Vector Relations, Control of Maize Rayado Fino Virus. Investigate the relationship between maize rayado fino virus, its insect vector and tolerant and susceptible cultivars of maize. Study DNA structure of virus, reproduction and distribution of insect virus and host. 9.198

COSTA RICA. U. Illinois, Urbana; IRWIN, M. 1990. Natural Systems as Reservoirs of Agriculturally Important Plant Viruses and Mycoplasmas. Determine whether native wild plant species in the neotropics harbor and serve as reservoirs of agriculturally important or potentially important viruses and mycoplasmas and as reservoirs of their insect vectors. 10.236

ECUADOR. U. Washington; GARA, R. 1990. Natural Compounds to Manage a Serious Forest Pest: The Mahogany Shoot Borer. Investigate natural relatively species-specific, non-polluting materials to be used in an integrated pest management system for *Hypsipyla grandella*, which would allow the use of valuable meliaceae in agroforestry. 10.302

EGYPT. Theodor Bilharz Research Inst.; YOUSIF, F. 1986. A Small-Scale Field Testing of *Echinostoma liei* as a Biocontrol Agent Against *Schistosoma mansoni* in Egypt. Test the effect of *E. liei* on the population density and infection rate of *Biomphalaria alexandrina*, the snail host of *S. mansoni*. 6.202

EGYPT. U.S. Naval Medical Research Unit-3; HOOGSTRAAL, H. 1987. Hormones and Pheromones in the Control of Mating in Camel Ticks. Identify the chemistry of ecdysteroids and juvenile hormones and their role in different tick developmental stages in order to develop a means of biological control of *Hyalomma dromedarii*. 5.065

HAITI. U. Medical Service Association; SODEMAN, W. 1985. *Thiara (Tarebia) granifera* (Lamarck): An Agent for the Biologic Control of Intermediate Hosts of *Schistosoma mansoni*. Introduce *T. granifera* into a river valley to determine the environmental parameters in which it can act as a biological control for *Biomphalaria glabrata*. 5.168

INDIA. U. Wyoming; BULLA, L. 1985. Introduction and Expression of the Mosquito Toxin Gene of *Bacillus thuringiensis israeliensis* in Cyanobacterium *Anacystis nidulans*. Develop a biological control agent to reduce populations of a variety of mosquitoes without the usual high costs of production and environmental damage associated with chemical insecticides. 5.052

INDONESIA. Cornell U.; PIMENTEL, D. 1986. Biological Control of the Cowpea Aphid in Indonesia. Search for and select parasites and predators of aphid species closely related to *Aphis craccivora* and *A. glycines* from climatic regions similar to Indonesia in order to develop "new association" biological control methods. 6.133

INDONESIA. Lembang Horticultural Research Inst., Bandung; DURIAT, A.S. 1987. Biological Control of Cucumber Mosaic Virus (CMV), an Important Disease-Causing Agent of Horticultural Crops in Indonesia. Develop a "vaccine" consisting of a combination of live CMV and its associated satellite. Test the vaccine on a large scale with pepper and tomato under controlled conditions in geographically separated areas of high CMV infestation. 5.254

INDONESIA. Michigan State U.; WHALON, M. 1988. Identification and Cloning of Esterase Gene Responsible for Insecticide Resistance in Brown Planthopper. Identify and clone the esterase gene responsible for insecticide resistance to certain organophosphates and synthetic pyrethroids. Develop a gene probe for evaluation as a tool in resistance management of brown planthopper. 8.395

INDONESIA. Ohio State U.; WRENSCH, D. 1990. Control of Scarlet Mite on Tea Using Massed Reared Predaceous Mites. Develop elements of an integrated pest management strategy to control scarlet mites on tea using mass releases of beneficial predaceous mites, specifically modified sampling methods and a predictive computer model. 10.594

ISRAEL. Hebrew U.; ZOMER, E. 1985. Effects of *Bacillus thuringiensis israeliensis* and *Bacillus sphaericus* Endotoxins on Mosquito Vectors. Compare the physiological and biochemical effects of b.t.i. and *B. sphaericus* toxins on mosquito larvae and study the mechanism of their mode of action. 4.423

JAMAICA. Coconut Industry Board; BARRANT, C. 1985. Management of the Insect Vector of Lethal Yellow Disease of Palms by Management of the Ground Cover in Palm Plantations. Screen and test various grasses for combined use in vector control and cattle intercropping. 5.350

KENYA. U. Maryland; OKEYOO-WOUR, J. 1990. Management of Maize Stalk Borers in Kenya: The Interaction of Genotypic and Crop Species Diversity. Determine the interactions and relative importance of genetic diversity and crop species diversity as they affect crop protection from maize stalk borers. Develop guidelines for reducing losses from maize stalk borers. 9.239

KENYA. U. New Mexico; LOKER, E. 1985. Biological Control of Snail-Borne Parasites in Kenya. Assess the potential of waterfowl ecto-nosome species to control snail-borne *Schistosoma* parasites. 5.186

KENYA. U. New Mexico; LOKER, E. 1989. Role of Abiotic and Biotic Factors in Controlling Disease-Transmitting Snails in Kenya: An Experimental Study. Evaluate the idea of controlling schistosome vector snails in small dammed impoundments by introducing predatory decapod crustaceans alone or in combination with ampulariid snails that may compete with the vector species. 9.413

LIBERIA. Johns Hopkins U.; SHIFF, C. 1989. Detection of Schistosome Carriers in Natural Waters. Develop a trap for the detection of schistosome cercariae in water. Investigate cercariae on a substrate—impregnated with lipids similar to those on human skin that stimulate penetration response—that can be immersed in water at contact points. 8.065

LIBERIA. Johns Hopkins U. TRPIS, M. 1985. The Development of Biological Control Strategies for Anopheles Mosquitoes Breeding in Rice Fields in Liberia. Study the effects of *Bacillus thuringiensis israeliensis* and three species of consumable fish upon anopheles larvae in rice fields. 4.417

MALAWI. U. Maryland; MCKAYE, K. 1986. Experimental and Field Studies on Possible Biological Control Agents of the Human Disease Bilharziasis (Schistosomiasis). Study the biological control of bilharzia-carrying snails by stocking snail-infested ponds with a native fish species, *Cyrtocara placodon*, a predator of snails. 6.187

NEPAL. Royal Nepal Acad.; REGMI, C. 1985. Research on Citrus Greening Vector in Pokhara Valley. Determine the natural host plants of *Diaphorina citri*, insect vector of the citrus greening pathogen, and identify predatory and parasitic insects that attack this vector. Provide information on controlling *D. citri* using predatory insects. 5.423

PAKISTAN. National Agricultural Research Council; INAYATULLAH, C. 1988. Evaluation of Wheat, Barley and Sorghum Germ Plasm for Resistance to the Greenbug *Schizaphis graminum* (Rondani). Identify the best sources of greenbug resistance in wheat, barley and sorghum germ plasm in Pakistan to determine biotype status of greenbugs. Evaluate native germ plasm and cultivars for resistance for later evaluation with electronic feeding monitors. 7.137

PANAMA. Rutgers U.; GAUGLER, R. 1985. Development of Insect-Parasitic Nematode *Neoplectana carpocapsae* for White Grub (*Phyllophaga* sp.) Control in Panama. Identify physical soil factors crucial to nematode survival and compare lab and field efficacy of nematodes to milky spore and isofenphof, the leading chemical control agent. 5.187

PHILIPPINES. U. California, Berkeley; GUTIERREZ, A. 1985. The Development of Stable Pest Control in Rice Using Moderately Resistant Cultivars. Create a computerized model of crop growth and development in order to assess the influence of resistant plant cultivars on the balance between maximum sustained yields and development of new strains of insect pests. 3.F40

PHILIPPINES. U. Philippines, Los Baños; TRUNG, L. 1988. Improving Performance of Grazing Dairy Cattle Through Biological Control of Bovine Ticks Using *Stylosanthes* spp. Determine *Stylosanthes'* suitability in mixed pastures, its feeding values and its economics as a means of tick control and protein supplementation. 6.567

SWAZILAND. U. Swaziland; MAKHUBU, L. 1987. Testing the Potential Use of Plant *Phytolaca dodecandra* as a Molluscicide, Pesticide and Detergent. Cultivate three types of *P. dodecandra* and study their effects against snail intermediate hosts of schistosomiasis. 5.054

THAILAND. Kasetsart U.; SUTABUTRA, T. 1988. Preimmunization of Tomato Seeds to Protect Against the Whitefly-Transmitted Tomato Yellow Leafcurl Virus. Control tomato yellow leafcurl disease in Thailand by developing a mild strain of TYLCV to cross-protect plants, producing in vitro tomato seedlings immune to TYLCV and developing a method of seedling inoculation with TYLCV using whitefly *Bemesia tabaci.* 7.314

THAILAND. Kasetsart U.; THAVEECHAI, N. 1987. Biological Control of Bacterial Wilt of Ginger by Coupling Resistant Cultivars With Genetic Transformant Bacteria. Demonstrate the possibility of coupling resistant cultivars derived from plant cell culture technology with genetically transformed beneficial rhizobacteria or antagonistic bacteria against *Pseudomonas solanacearum smith,* causal agent of ginger bacterial wilt. 7.313

ZIMBABWE. Johns Hopkins U.; SHIFF, C. 1990. Prevention of Snail-Miracidium Interaction by Use of Controlled Release Copper to Reduce ... Schistosomiasis. Evaluate the feasibility of attacking schistosomiasis by introducing plant materials and controlled release metals in foci that kill miracidia or interfere with their ability to infect snails. 9.301

Biomass Resources and Conversion Technology

BANGLADESH. Colorado State U.; KARIM, M. 1990. Preferential Degradation of Lignin in Water Hyacinth Using White Rot Fungi for Animal Feed Production. Increase the digestibility of water hyacinth by preferentially degrading lignin, which is not digested by ruminants. 10.027

CHILE. U. Chile; AGOSIN, E. 1988. Saccharification of Lignocellulosic Materials by Brown Rot Fungi: Mechanisms and Potential Applications. Use fungi to degrade wood. Study the conversion of lignocellulosic materials to fermentable sugars, using brown rot fungi. Study the basic mechanisms involved in the depolymerization of lignin as adhesive in particleboard industry. 7.079

CHILE. U. Concepción; GNECCO, S. 1988. Utilization of Hydrocarbon-Producing Plants Native in Arid Areas. Develop an efficient method for converting extracts from hydrocarbon-producing plants native to arid areas to energy-rich fuels or valuable chemicals. 8.051

COSTA RICA. Dynatech; WISE, D. 1986. A New Source of Cooking Fuel for Developing Technology. Study conditions for producing dense fuel from grass. Design and test a machine for that purpose. 5.311

GHANA. Forest Products Lab.; JEFFRIES, T. 1990. Continuous Fermentation of Xylose by *Pichia stipitis.* Learn how fermentative metabolism is regulated in *Pichia stipitis.* 10.299

GUATEMALA. Inst. Centroamericano de Investigación y Technología Industrial; DE CABRERA, S. 1985. Alcoholic Fermentation of Sugar Cane in a Highly Solid State System. Reduce the amount of water needed for fermentation in order to achieve a minimal spent wash, a concentrated ethanol stream and a molecule with a lower weight than sucrose. 5.150

KENYA. Eastern Michigan U.; DIRLIKOV, S. 1989. Reactive Diluents for High Solid Coatings Based on Vernonia Oil. Develop new high solid alkyd and epoxy-ester coating formulations by replacing conventional solvents with reactive diluents from vernonia oil. 9.035

MEXICO. U. Washington; ALLAN, G. 1988. The Conversion of Lignacious Biomass Into Nonleaching Nitrogenous Fertilizer by Ammoxidation. Convert indigenous biomass into substantially water-insoluble nitrogenous polymer for use as a fertilizer suited for heavy occasional rainfall and hot weather conditions. (Also involves researchers in Spain.) 8.108

PAKISTAN. Nuclear Inst. for Ag. and Biology; RAJOKA, M. 1988. Bioconversion of Lignocellulosic (LC) Biomass Produced on Saline Lands by *Cellulomonas.* Use biomass produced on saline lands to produce end products of higher economic value, such as ethanol and single cell proteins. Establish a process for bioconversion of LC biomass, using indigenous *Cellulomonas* strains. 6.163

PHILIPPINES. Forest Research Inst.; HALOS, S. 1985. Improvement of Cellulose Degradation by *Cellulomonas* Through Recombinant DNA Techniques. Develop an improved *Cellulomonas* fermentation system for efficient conversion of cellulosic substrates into ethanol and single cell protein, using a low-tech process appropriate to developing countries. 4.083

PHILIPPINES. U. California, Berkeley; LAETSCH, W. 1988. Biotechnological Evaluation of Phycocolloid Quality for Marine Algal Product Improvement. Develop a rapid, sensitive molecular assay for the gelling quality of the phycocolloid carrageenan. Phycocolloid-producing plants are the main marine export of the Philippines. 8.236

PHILIPPINES. U. Missouri; FLANIGAN, V. 1985. A Fluid Bed Gasifier/Engine System Using Rice Hulls. Develop a totally integrated fluid bed system, requiring only an external input of rice hulls, for gasifying rice hulls and producing mechanical energy in the form of shaft rotation. 5.062

PHILIPPINES. U. Philippines; QUIMIO, T. H. 1986. Maximal Utilization of Rice Straw for Food and Feed by Mushroom Production. Investigate the use of rice straw as a substrate for growing straw mushrooms (volvariella) for food and the subsequent use of the spent mushroom compost as animal feed or as the substrate to grow pleurotus, another edible mushroom. 5.070

PORTUGAL. Gulbenkian Inst. Science; VAN UDEN, N. 1988. Roles of Acetic Acid and Lactic Acid in Yeast Fermentations; Biochemical and Biophysical Mechanisms. Develop optimization strategies for traditional and novel yeast fermentations by identifying biochemical and biophysical mechanisms. 7.144

PORTUGAL. National Lab. Engineering and Industrial Technology; DUARTE, J. 1985. Growth of *Methanosarcina barkeri* in Continuous Culture Systems. Study the kinetics and energetics of *M. barkeri* to improve design of methane-producing biomass digesters. Develop new reactor designs for the use of methanogenic bacteria in industrial effluent treatment. 5.220

PORTUGAL. New U. Lisbon; DA PONTE, M. 1987. Supercritical Fluid Extraction of Natural and Biological Products. Study the supercritical extraction of bioproducts from eucalyptus oil and fermentation broths by Gram-positive *Propionibacterium*, using carbon dioxide as the solvent. 7.143

THAILAND. Asian Inst. Technology; LITTLE, D. 1990. Use of Leguminous Tree Leaves as Fish Pond Inputs. Provide a quantitative basis for the use of four species of legume leaves in tropical freshwater fish culture. 10.461

THAILAND. Chiang Mai U.; PINTHONG, R. 1987. Degradation of Undesirable Components in Soybean Whey. Cultivate microorganisms that can remove bean flavor and flatus-inducing oligosaccharides from soybean whey. Develop a fermented, nutritious beverage from the whey. 7.303

THAILAND. Kasetsart U.; LIMTONG, S. 1985. Hybridization of Halotolerant Yeast for Alcohol Fermentation. Fuse halotolerant and industrial alcohol production strains to create a yeast hybrid able to produce high ethanol concentration in high salinity molasses mash. 5.238

THAILAND. King Mongkut Inst. Technology; CHAIYANAN, S. 1990. Improvement of Bacterial Strains for the New Fish Sauce Fermentation Technique. Increase the efficiency of a new technique in fish sauce fermentation by selecting and improving the activity of bacterial strains used in the system. 10.462

THAILAND. King Mongkut Inst. Technology; JONGJITIRAT, P. 1986. Improved Producer Gas Cleaning System. Develop a producer gas cleaning system that eliminates impurities larger than 0.5 micron and mechanisms for collecting fine impurities by impinging high velocity gas on liquid surface. 5.245

Biotechnology/ Immunology

BANGLADESH. U. Alabama Medical School; KHALED, M. 1990. Development of Methods to Assess Marginal Vitamin A Status in Human Children in Bangladesh. Develop an accurate method to assess vitamin A (R) status in malnourished children. 10.293

BANGLADESH. U. Maryland; JOSEPH, S. 1987. An Assessment of the Role of Enterotoxin and Other Virulence-Associated Features in Aeromonas Human Infections. Assess the role of enterotoxins and other virulence-associated features in aeromonas infections, specifically, gastroenteritis syndromes. Determine if specific characteristics are correlated with strain-isolate sources. 6.333

BOLIVIA. U. Arizona; GERBA, C. 1986. Development of Gene Probes for Rapid Detection of Enteric Viruses in Water and Sewage. Develop biotinylated probes for detecting enteroviruses (hepatitis A and rotavirus) in water. 6.299

BRAZIL. National Inst. Allergy and Infectious Diseases; SHER, A. 1989. Genetic Characterization by Means of Cloned DNA Probes of Parasite Populations Involved in Transmission of Human Schistosomiasis. Employ recently developed cloned DNA probes to distinguish populations of *Schistosoma mansoni* involved in transmission of human infection. Determine whether variations in schistosome-induced disease are influenced by genetic differences. 5.130

CAMEROON. U. Yaounde; TITANJI, V. 1988. Mechanisms of Survival of *Onchocerca volvulus* in the Human Host. Determine the role of surface antigens in host-parasite interactions in onchocercia-

sis. Specifically, identify the surface molecules (including carbohydrate and protein antigens) of the developmental stages of *O.volvulus*. 6.341

CHILE. U. Católica de Chile; LEIGHTON, F. 1989. Genetic, Molecular and Immunological Study of *Salmonella typhi* Porins in Pathogenesis, Diagnosis and Prevention of Typhoid Fever. Develop methods for diagnosis and control of typhoid fever. Establish groundwork for vaccine development employing *S. typhi* porins or porin fragments and characterize porin responses. Porins are hydrophobic proteins from cell membrane of Gram-negative bacteria. 6.537

GUATEMALA. U. del Valle de Guatemala; LUJAN, R. 1987. Analysis of Immunogenic Proteins of Adult *Onchocerca volvulus*. Identify immunogenic proteins associated with microfilariae, adult worms and excretory/secretory products of *O. volvulus* for use in development of diagnostic test for onchocerciasis. 6.225

GUATEMALA. U. del Valle de Guatemala; LUJAN, R. 1989. American Cutaneous Leishmaniasis: A Model for Vaccine Development Against Human Disease. Evaluate development of cutaneous leishmaniasis and immune response to *Leishmania brasiliensis* using primate model for vaccine development against American cutaneous leishmaniasis. Compare nonhuman model with human model of development. 9.378

JORDAN. Yarmouk U.; ABDEL, S. 1986. Development of Monoclonal Antibodies for Immunodiagnosis and Characterization of *Echinococcus granulosus* Antigens. Investigate the use of monoclonal antibodies raised in the mouse system in characterizing various antigenic preparations from the strobilate adult worm stage of *E. granulosus* as well as hydatid cyst fractions in infected animals in Jordan. 6.132

KENYA. Eastern Virginia Medical School; ISAHAKIA, M. 1990. Development of an Immunocontraceptive Vaccine: Immunization of Female Baboons With Affinity Isolated Sperm Antigens. Use monoclonal antibodies to define sperm-specific antigens that have a role in one or more steps in the fertilization process. Provide a basis for identifying potential sperm immunogenic determinants for contraceptive vaccine development. 8.136

KENYA. Kenyan Trypanosomiasis Research Inst.; NJOGU, A. 1986. Evaluation of Polyamine Synthesis Inhibition as Therapy for *Trypanosoma rhodesiense* Infection. Evaluate efficacy of DL-alpha-difluoromethylornithine (DMFO) and other antitrypanosomal drugs on model *T. brucei rhodesiense* infections. 6.317

KENYA. Washington State U.; MCGUIRE, T. 1987. Development of a Recombinant Subunit Vaccine for Heartwater in Domestic Ruminants. Develop a vaccine to control African heartwater. Purify *Cowdria ruminantum* from ticks and construct a genomic library. Select *Escherichia coli* transformants expressing *C. ruminantum* surface proteins and immunize cattle with *E. coli* lysates with *C. ruminantum* proteins. 7.240

KENYA. Washington State U.; RURANGIRWA, F. 1990. Identification of a Recombinant Mycoplasma Protein That Protects Against Contagious Bovine Pleuropneumonia. Identify *Mycoplasma mycoides* subspecies surface proteins that induce a protective immune response against contagious bovine pleuropneumonia. 8.326

MALAYSIA. Uniformed Services U. Health Sciences; LAL, R. 1990. Development of Monoclonal Antibodies to 'Filaria Specific' Antigen; Their Use in Immunodiagnosis of Lymphatic Filariasis. Develop a sensitive and specific assay for detection of circulating filarial antigen in body fluids by isolating filaria-specific protein antigens. 9.270

MEXICO. U. Nacional Autónoma de Mexico; XIMENEZ, G. 1990. Anti-*Entoamoeba histolytica* Monoclonal IgA, Its Role in Protection Mechanism—In Vitro and In Vivo. Use in vitro, in situ and in vivo methods to study the possible role of IgA in the immune response to amoebiasis caused by *E. histolytica*. 9.130

NEW GUINEA. Papua New Guinea Inst. Medical Research; ALPERS, M. 1985. Transmission-Blocking Immunity and Infectivity of Human Populations to Mosquitoes During Malaria Transmission. Field test (using in vitro methods) antigamete antibodies already shown to block the infectivity of human malaria in lab studies. 3.F34

PAKISTAN. U.S. Dept. Ag.; LEWIS, G. 1988. Prostaglandin Metabolite in Blood and Milk of Water Buffaloes: Evaluation of a Possible Indicator of Uterine Infection. Study changes in concentrations of PGFM in jugular blood plasma and milk, that can be used to improve endometritis diagnosis in water buffaloes. 8.156

PERU. Inst. Medicina Tropical "Alexander von Humbolt"; BELLATIN, J. 1989. Cellular Immunity in Patients With Leishmaniasis in Peru. Study human cell-mediated immune responses to *Leishmania brasiliensis brasiliensis*, the etiological agent of American mucocutaneous leishmaniasis. 8.312

PERU. Johns Hopkins U.; GILMAN, R. 1987. Cysticercosis: New Opportunities for Targeting Detection and Treatment Using ELISA Technology. Develop assay for the diagnosis of cerebral cysticercosis in developing countries. 7.208

PERU. Johns Hopkins U.; SPIRA, W. 1989. Piglet Model to Study *Campylobacter pylori* Gastritis: Association of Infection With Hypochlorhydria. Establishing a piglet model for *C. pylori* gastric infection. Study the effect of infection on gastric acid secretion and document the host's local and systemic immune response. Assess animal proclivity to enteropathogens after *C. pylori* infection. 8.154

PERU. U. Alabama; ALVAREZ, J. 1989. Role of Nutritional Status in the Early Loss of Passive Immunity and Response to Measles Immunization. Study whether increased rate of degradation of maternally acquired measles antibodies in infants in developing countries is a function of infant nutritional status or specific nutrient deficiencies. Study malnutrition and child immune response to measles vaccination. 9.271

PERU. U. Peruana Cayetano Heredia; GUERRA, H. 1987. Proteolytic Enzymes: Evaluation as Purified Antigens in Diagnosis of Fascioliasis in Peru. Purify proteolytic enzymes from adult worms of *Fasciola hepatica* by standard biochemical methods, including chromatographic procedures. Examine usefulness of specific parasite products to serve as antigens for diagnosis of disease. 7.075

PERU. U. Peruana Cayetano Heredia; NARANJO, J. 1987. Studies in Transmission of *Cryptosporidium:* A Pathogen Associated With Both Malnutrition and Infant Mortality. Study transmission of *Cryptosporidium* in a Peruvian shanty town. Evaluate differences between *Cryptospordia* isolated from children with diarrhea and those from children asymptomatically infected. 7.234

PERU. U. Peruana Cayetano Heredia; ROMERO, G. 1985. Rapid Diagnosis of Human Leishmaniasis: Use of Biotinylated K-DNA Probes in the Detection of New World *Leishmania* Species. Develop procedure for the routine diagnosis of human leishmaniasis, using subspecies specific DNA probes and nonradioactive DNA detection procedures for the detection of K-DNA. 5.203

PHILIPPINES. Leonard Wood Leprosy Research Center; CRUZ, E. 1990. Rapid In Vitro Detection of Drug Resistant *Mycobacterium leprae.* Establish a rapid in vitro method for the detection of drug-resistant *M. leprae* in patients with lepromatous leprosy. 10.099

PHILIPPINES. U. Hawaii; FAST, A. 1985. Innovative Fish Seed Stock Culture Techniques: The Spotted Scat *(Scatophagus argus).* Develop culture techniques and environmental manipulation regimes to control gonadal maturation and spawning. Develop artificial rinses and diets to increase growth and survival of the scat. (Also involves researchers in Thailand.) 5.335

PHILIPPINES. U. Philippines; GARCIA, E. 1985. Groundwork for Development of Vaccine Against Severe Hepatosplenic Disease in Schistosomiasis Japonica. Study the feasibility of developing a vaccine against severe hepatosplenic disease in schistosomiasis japonica, based on the hypothesis that specific antibodies inhibit egg production or accelerate egg destruction. 5.002

PORTUGAL. National Lab. for Veterinary Research; VIGARIO, J. 1987. Immunological Study as a Basis for Differentiation of African Swine Fever Virus (ASFV) Types. Study immunological characteristics and pathogenicity of a naturally occurring, nonhemadsorbing, low virulent ASFV isolate, as well as cellular-mediated immunity ASFV infection. 6.150

SIERRA LEONE. U. Sierra Leone; GBAKIMA, A. 1985. Immunochemical Characterization of Immunogenic Proteins of *Onchocerca volvulus* Adult Worms, Microfilariae, and Infectious Larvae. Use research on identification and characterization of *O. volvulus* antigens that induce protective immunoresponse to develop a possible vaccine by use of DNA technology and monoclonal antibody production. 5.189

SRI LANKA. U. California, Riverside; PLATZER, E. 1987. Molecular Diagnostics for Filarial Nematodes in Mosquito Vectors. Study the detection of clinically important *Brugia* filarial nematodes, using mitochondrial DNA as the source of species-specific DNA for hybridization probe development. 6.309

SUDAN. Medical Research Council; GHALIB, H. 1985. Immunological Characterization of Host Response to *Schistosoma mansoni* in Occupationally Exposed Laborers in Sudan.... Determine whether host-protective mechanisms develop in canal workers who are hyperexposed to *S. mansoni.* 5.148

SUDAN. U. Khartoum; BAYOUMI, R. 1989. Is Resistance to *Plasmodium falciparum* Malaria in Sickle Cell Trait Carriers Due to Acquisition of Enhanced Immune Response? Clarify the difference in development of specific acquired immunity between Hb AS and Hb AA individuals to help understand protective immunity to falciparum malaria and the relative contribution of humoral and cellular immunity. 7.036

THAILAND. Chiang Mai U.; MAKONKAWKEYOON, S. 1985. Evaluation In Vitro of Interleukin-1 (IL-1) and Interleukin-2 (IL-2) as Possible Immunotherapeutic Agents in Leprosy. Determine whether monocytes and lymphocytes from leprosy patients produce or respond to IL-1 and IL-2. 5.140

THAILAND. Chiang Mai U.; MAKONKAWKEYOON, S. 1985. Immunodiagnosis and Immunoregulation in Tuberculosis. Look for newly defined saccharides and lipids that are species-specific antigens for *Mycobacterium tuberculosis.* Use these antigens to develop ELISA test for seroepidemiologic/diagnostic studies of tuberculosis in developing countries. 5.224

THAILAND. Chiang Mai U.; SITTISOMBUT, N. 1989. Correlation of Dengue Virus Virulence With the Ability to Stimulate Helper T Lymphocytes. Isolate dengue virus from patients with dengue fever and dengue hemorrhagic fever and test their ability to stimulate T-lymphocytes to secrete interleukin-2 and gamma interferon. Examine differences in stimulatory capacity. 9.322

THAILAND. Chiang Mai U.; SURIYANON, V. 1988. Seroepidemiology of Leprosy. Determine the prevalence of serum antibodies to *Mycobacterium leprae* in household contacts of leprosy patients and controls without known household exposure to leprosy. Test efficacy of filter strips with dried blood in detecting *M. leprae* antibodies in people. 8.700

THAILAND. Chiang Mai U.; THEE-TRANONT, C. 1985. Development of Immunoperoxidase Test for Early Diagnosis of Acute Reactional States in Leprosy Patients. Develop a test for predicting acute reactional episodes in leprosy patients. Test would associate patterns of shifts in lymphocyte subsets with impending reactional episodes. 5.141

THAILAND. Chiang Mai U.; THEE-TRANONT, C. 1988. Development of an Immunodiagnostic "Spot" Field Test for Acute Reactions in Leprosy. Measure intracutaneous levels of *Mycobacterium leprae* antibodies and soluble IL-2R in leprosy patients at high risk of developing *Erythema Nodosum leprosum* and reversal reactions. Improve methods of predicting and monitoring runs, using intradermal fluid from slit-skin smears. 8.183

THAILAND. Chulalongkorn Hosp.; HANVANICH, M. 1989. Antigen Specific B Cell Frequency in Malarial Patients. Determine antigen specific B cell frequencies in *Plasmodium falciparum* patients during various phases of illness. 8.191

THAILAND. Mahidol U.; CHURD-BOONCHART, V. 1987. Studies for Dengue Viral Antigens and Antibodies in Sera of Dengue Hemorrhagic Fever (DHF) Patients. Test whether more severe forms of dengue infection have an immunopathogenesis. 7.269

THAILAND. Mahidol U.; CHUSAT-TAYANOND, W. 1987. Early Detection of Lymphatic Filariasis and Attempt at Defining Protective Antigens. Develop immunodiagnostic tests for lymphatic filariasis and new tests for the detection of early infection of lymphatic filariasis, based on stage-specific antigens in serum and urine. 7.272

THAILAND. Mahidol U.; KHUSMITH, S. 1985. Antigenic Diversity of *Plasmodium vivax*. Determine whether antigenic diversity exists among different strains of *P. vivax*, using indirect fluorescent antibody test and a panel of monoclonal antibodies. Investigate whether distribution of different antigenic types is related to their locations. 5.232

THAILAND. Mahidol U.; RATANA-BANANGKOON, K. 1985. Development of Immunodiagnosis and Improvement of Immunotherapy of Snake Venom Poisoning. Develop immunodiagnostic methodology for identifying and differentiating the various venoms of poisonous snakes indigenous to Thailand. Produce monoclonal antibodies against principal toxins of various snake venoms. 5.221

THAILAND. Mahidol U.; SARASOM-BATH, S. 1985. Production of Monoclonal Antibodies to *Salmonella typhi, S. paratyphi* A, *S. paratyphi* B, and *S. paratyphi* C. Produce monoclonal antibodies to salmonellae for development of a sensitive serodiagnostic test for enteric fever infection. Antibodies will be used to develop ELISA test kits for accurate diagnosis and epidemiological monitoring of enteric fever. 5.227

THAILAND. Mahidol U.; SIRISINHA, S. 1986. Development of Methods for Immunodiagnosis of Liver Fluke Infection. Develop immunoassay for the diagnosis of human liver fluke infection caused by *Opisthorchis viverrini*. In particular, detect specific antibody in the serum or body fluids and develop method for detecting specific parasite antigens. 6.392

THAILAND. Mahidol U.; SOBHON, P. 1986. Identification and Cloning of Surface Antigens and Genes of *Schistosoma japonicum* (Chinese and Philippines). Identify surface antigens able to elicit concomitant immunity in hosts and produce monoclonal antibodies against these antigens in order to develop new immunodiagnostic methods and vaccines. 6.390

THAILAND. Mahidol U.; SUVATTE, V. 1986. Immunopathogenesis of Dengue Hemorrhagic Fever/Dengue Shock Syndrome. Investigate immunopathological mechanisms of dengue hemorrhagic fever/dengue shock syndrome to obtain a better guide to therapeutic intervention and development of a dengue vaccine. 6.391

THAILAND. Mahidol U.; THAMMA-PALERD, N. 1986. Application of Monoclonal Antibodies Against *Entoamoeba histolytica* in Tropical Medicine Research. Develop a typing scheme for differentiation between invasive and noninvasive strains of *E. histolytica* and a definitive diagnostic test using radioimmunoassay or enzyme immunoassay. 6.419

THAILAND. National Inland Fisheries Inst.; BOONYARATPALIN, S. 1988. Kidney Disease of Sea Bass (*Lates calcarifer*). Determine causes of kidney disease in sea bass and possible methods for its control. 7.276

UGANDA. Makerere U.; KAGON-YARAM G. 1989. Bovine Babesiosis Mass Screening and Diagnosis. Develop and evaluate two types of reagents: DNA hybridization probes that hybridize to abundant, species-specific parasite oligonucleotides and peptide antigens that detect *Babesia*-specific antibodies in the serum of carrier animals. 9.312

UGANDA. Makerere U.; SENNYON-GA, G. 1989. Rapid Diagnosis of Bovine Theileriosis in Uganda. Develop two types of diagnostic reagents for chronic theileriosis in cattle: probes that hybridize with distinct *Theileria* oligonucleotides and diagnostic antigens for conventional serology. 9.229

ZIMBABWE. U. Florida; PALMER, G. 1987. Development of a Synthetic Peptide Vaccine for Protection Against Bovine Anaplasmosis. Generate synthetic peptides (based on the Am 105 gene DNA sequence) that mimic the Am 105 epitope and are able to induce protection against anaplasmosis. 7.384

ZIMBABWE. Veterinary Research Lab.; FOGGIN, C. 1985. Investigation Into the Status and Epidemiology of Mokola Virus Infection in Zimbabwe. Development of procedures to differentiate Mokola virus from rabies virus during routine diagnosis and of an efficient serological test to study the kinetics of antibody to Mokola virus in experimental and survey species. 5.038

Biotechnology/ Plants

BARBADOS. U. West Indies; DALES, R. 1989. Development of Recombinant DNA Techniques for a Vesicular-Arbuscular Mycorrhizal (VAM) System. Develop transformation, regeneration, genetics and molecular biology techniques in the VAM fungus *Gigaspora gigantea*. Search for mutants resistant to the fungicide benomyl. 8.117

BRAZIL. Hershey Medical Center; FRITZ, P. 1987. *Theobroma cacao* DNA as Marker for Plant Breeding. Use DNA to identify and classify *Theobroma cacao* germ plasm. Use RFLP analysis to develop a fingerprinting technique useful to cacao breeders in determining the genetic status of their germ plasms. 7.095

BRAZIL. Oregon State U.; MOK, D. 1986. Unconventional Gene Transfer and Somatic Cell Manipulation of Food Legumes. Develop methods of gene transfer between species and genera of beans via embryo and cell culture techniques. Obtain plant regeneration from tissue cultures of food legumes. 6.185

BRAZIL. Purdue U.; JANICK, J. 1986. Propagation and Improvement of *Theobroma* spp. by Cell and Tissue Culture. Study factors that induce asexual embryogenesis from embryogenic-competent callus of cacao and factors that affect embryo development and seedling establishment. 6.234

CHILE. U. Católica de Chile; JORDAN, M. 1989. In Vitro Propagation and Improvement of Fruit Species With Economic Potential for Semiarid Zones. Study propagation systems of three semiarid-zone fruit species—*Annona cherimola, Carica candamarcensis, Pouteria obovata*—focusing on conditions that affect regeneration responses of different ecotypes and/or varieties of each species. 8.007

CHILE. U. Chile; CARDEMIL, L. 1988. Gene Expression of Thermotolerance and Injury Resistance in Underused Trees of Chile, *Prosopis chilensis* and *Araucaria araucana*. Study genes responsible for the synthesis of plant proteins that appear to be present and protect against damage from temperature stress and injury in *P. chilensis* and *A. araucana*. 7.068

COLOMBIA. Centro Internacional de Ag. Tropical; VALLEJOS, C. 1987. Development of Molecular Genetic Markers in *Phaseolus* as Breeding Tools: Disease Resistance. Construct a saturation linkage map in *Phaseolus vulgaris* using isozymes and DNA RFLPs. Use markers to map and tag, by linkage analysis, genes conferring resistance to bean common blight and common mosaic virus. 7.393

COLOMBIA. Ohio State U.; SAYRE, R. 1990. Development of Transgenic Cassava Having Reduced Cyanide Toxicity. Generate transgenic cassava plants having reduced cyanide toxicity in the food product but maintaining the capability for cyanogenesis in the field as a defense against herbivores. 10.222

COSTA RICA. U. Florida; GRAY, D. 1990. Somatic Embryos for Germ Plasm Storage and Clonal Propagation. Utilize somatic embryos as "synthetic seeds" for clonal germ plasm conservation and propagation of two model species (coffee and grape). 10.278

COSTA RICA. U. Florida; PLOETZ, R. 1990. Identification of Resistance in Banana to Races of the Fusarial Wilt Fungus. Characterize isolates of *Fusarium oxysporum cubense* (FOC) for genetic diversity by comparing vegetative compatibility, isozyme polymorphisms and DNA RFLPs. 9.093

COSTA RICA. U. Florida; PURDY, L. 1989. Heritability of Resistance to Witches' Broom in Progeny From Crosses of Selected Clones of *Theobroma cacao*. Establish responses of *T. cacao* clones to the witches' broom basidiomycete fungal pathogen *Crinipellis perniciosa* to help identify resistant clones and determine heritability of resistance. 9.174

COSTA RICA. U. Wisconsin; AHLQUIST, P. 1989. Use of Cloned Viral cDNAs in Characterization, Epidemiology and Control of Bean Golden Mosaic Virus (BGMV). Improve control of BGMV, determine extent of pathogenic variability, identify prevalent genotypes in Latin America and distribute and provide data to breed BGMV-resistant beans. 9.175

DOMINICAN REPUBLIC. U. Puerto Rico; SCHRODER, E. 1988. Biocontrol of Bean Ashy Blight by Improved Rhizobium Biotechnology. Identify and select rhizobium strains that inhibit root rot-producing fungi in vitro and in vivo. Evaluate the biological-control effect of rhizobium inoculation on bean genotypes susceptible to ashy stem blight. 8.158

ECUADOR. Medio Ambiente y Desarrollo; ROJAS, J. 1988. Regeneration of Babaco (*Carica pentagona*, Hielborn, Badillo) via Tissue Culture. Use tissue culture to produce somaclonal variations that develop resistance to specific pathogens and to upgrade fruit and tree quality in babaco. 7.340

EGYPT. Assuit U.; MAHMOUD, S. 1985. Transfer of Hydrogen Uptake (Hup) Genes From *Rhizobium leguminosarum* to Fast-Growing, Salt-Tolerant *Rhizobium japonicum*. Transfer genes that confer nitrogen-fixation efficiency to a salt-tolerant, inefficient strain of *R. japonicum* to produce a strain capable of surviving in saline soils and nodulating soybeans. 5.068

GHANA. Pennsylvania State U.; FURTEK, D. 1990. Genetic Transformation of the Cocoa Tree, *Theobroma cacao*. Develop a transformation system for the species *T. cacao*. 10.139

HONDURAS. Fundación Hondureña; MOLINA, G. 1989. Utilization of a Host-Specific Phytotoxin in Black Sigatoka of Plantain and Banana. Culture *Mycosphaerella fijiensis* to improve toxin production and compare phytotoxic activity of varying purifications of toxin. Develop bioassay technique to quantitatively evaluate various germ plasms of plantains and bananas resistant to Black Sigatoka. 9.395

INDONESIA. Bogor Agricultural U.; WATTIMENA, G. 1986. In Vitro Microtubers as an Alternative Technology for Potato Production. Evaluate the use of in vitro microtubers as an alternative technology for potato production in Indonesia. Evaluate field performance of microtubers of different potato genotypes. 6.509

INDONESIA. Tea Research Inst.; GAMBRIL, B. 1989. Commercialization of Clonal Micropropagation of Superior Tea Genotypes Using Tissue Culture Technology. Develop superior genotypes of tea through micropropagation. Determine methods for the ini'atic and establishment of in vitr and for a somatic embry in callus derived from stock. (Work also in Singa

MEXICO. CINVESTAV-I.P.A. (Centro de Investigaciones y Estudios Avancados); BAILEY, A. 1988. Generation of Bean Plants (*Phaseolus vulgaris* L.) Resistant to Phaseolotoxin. Construct a line of *P. vulgaris* L. resistant to halo blight disease by introducing into the bean genome a gene for ornithine carbamoyltransferase (OCTase) that is insensitive to phaseolotoxin. 8.281

NEPAL. Native Plants, Inc.; GARTON, S. 1985. Tissue Culture and Microbial Inoculation Technologies for the Improvement of *Alnus nepalensis* Planting Stock. Develop means of identifying and rapidly propagating superior varieties of this valuable fuelwood crop (alder) for reforestation programs. Investigate and improve its symbiosis with nitrogen-fixing frankia. 4.396

NEPAL. Research Lab. for Agricultural Biochemistry and Biotechnology; AGRAWAL, V. 1987. Clonal Propagation of Pine Trees (*Pinus roxburghii* and *P. wallichiana*) by Methods of Tissue Culture. Regenerate *P. roxburghii* and *P. wallichiana* plantlets from explants (seed, cotyledons, hypocotyls, epicotyls and young shoot tips). 6.262

NEPAL. Tribhuvan U.; CHAUDHARYM, R. 1990. Identification of *Choerospondias axillaris* Roxb. Seedlings With Fruiting Capacity. Determine early the sex of dioecious trees for their enhanced productivity. 10.270

PAKISTAN. Pakistan Council of Science and Industrial Research; SHAH, F. 1987. Regeneration of *Pistacia vera* and *Phoenix dactylifera* Female Plants by Tissue Culture Technique. Develop high-yielding female date palm *P. dactylifera* and female pistachio plant *P. vera* and investigate their potential for production through rapid shoot proliferation. Improve produce quality, drought resistance, aflatoxin resistance. 5.075

PAKISTAN. U. Punjab; RIAZUDDIN, S. 1988. Host Range Specificity of *Agrobacterium tumefaciens* Strains Isolated From Crown Gall Tumors on Fruit Trees in Pakistan. Characterize various strains of *A. tumefaciens* from crown gall tumors. Investigate whether unusual host-range plasmids allow transformation of plants normally resistant to infection by *Agrobacterium* strains. 8.275

PANAMA. Inst. Investigación Agropecuaria de Panama; PONS, S. 1985. Tissue Culture for Plantain and Banana Improvement. Assessing the feasibility of perfecting the ovule, cell and protoplast culture technology which would permit the production, screening, selection and multiplication of cooking and dessert plantains that are resistant to Black Sigatoka and other diseases. 5.264

PERU. Centro Internacional de la Papa; DODDS, J. 1988. Conferring Resistance to Potato Viruses and Viroid by Molecular Interference Sequences Incorporated Into Potato by Agrobacteria. Develop protection system for susceptible potato cultivars by incorporating into the plant genome the molecular interference sequences to perturb normal replication of pathogens and confer increased resistance to plant. 6.553

PERU. Cornell U.; PLAISTED, R. 1988. Development of Broad Spectrum Insect Resistance in Potatoes. Use somaclonal variation to speed the development of insect-resistant potato varieties. Develop systematic testing programs to apply the results of this work to developing countries. (Also involves Colombia and the Philippines.) 7.113

PERU. U. Massachusetts; MULCAHY, D. 1986. Improvement of Plant Crops by Means of a Biotechnology Suitable for Developing Countries. Demonstrate the effectiveness of potato pollen selection in plant breeding, focusing on heat stress resistance in the potato and improved quality of potato seed. 6.218

PHILIPPINES. International Rice Research Inst.; ZAPATA, F. 1987. Rice Somatic Embryogenesis: A Tool for the Production of Planting Materials for Hybrid Rice. Study rice somatic embryogenesis. 7.032

PHILIPPINES. U. South Florida; DAWES, C. 1989. Branch and Tissue Culture of Philippine Species of the Red Seaweed, *Eucheuma*. Develop branch and tissue culture procedures for selected strains of two species of *Eucheuma* farmed in the Philippines. Produce standard, inexpensive culture procedures and callus tissue of the strains for intensive propagation. 7.150

PHILIPPINES. Virginia Commonwealth U.; FISHER, R. 1986. Induction of Sexual Reproduction and Tissue Culture in the Nitrogen-Fixing Fern Azolla for Genetic Strain Improvement. Develop methods for hybridization of the nitrogen-fixing water fern azolla and for development of new genetically improved strains to be used in Third World farming. 5.316

SRI LANKA. Ceylon Inst. Science; GUNETILEKE, K. 1985. Mass Propagation of Selected Papaya Plants. Develop tissue culture technology for the clonal propagation of selected papaya trees as a means of overcoming viral infection and the inability to detect nonproductive male plants at early growth stages. 5.377

SRI LANKA. U. Peradeniya; YAPABANDARA, Y. 1985. In Vitro Propagation of Clove and Nutmeg. Study the feasibility of the clonal propagation of superior cultivars of two important spice trees, clove and nutmeg, through tissue culture techniques. 5.399

SYRIA. International Center for Agricultural Research in the Dry Areas; ACEVEDO, E. 1989. Assessment of C-13 Discrimination as an Indirect Selection Criterion for Barley in Dry Environments. Increase efficiency of selection for drought-resistant varieties by using transpiration efficiency as a selection criterion in barley. Assess usefulness of C-13 discrimination as a predictor of drought resistance and/or as a predictor of transpiration efficiency and, thus, of yield under stress. 9.385

THAILAND. Chiang Mai U.; SMITAMANA, P. 1987. Selection and Developing of Virus-Resistant Potato by Using Protoplast Culture and Fusion Techniques. Select potato varieties resistant to PLRV (potato leaf roll virus). Produce dihaploid plants to be used for breeding and somatic hybridization. Develop new potato cultivars resistant to PLRV and suitable to tropics. 6.401

THAILAND. Kasetsart U.; SUWANARIT, P. 1985. Ri Plasmid Induced Root Culture as a Potential Substrate for In Vitro Propagation of *Mycorrhizae* Fungi. Develop a technique for in vitro culture of vesicular-arbuscular mycorrhizal (VAM) fungi that could be applied to large-scale production of VAM inoculant. Use of the VAM inoculant would improve plant nutrition, reduce Third World dependence on chemicals and lower production cost. 5.244

THAILAND. Khon Kaen U.; SURIYAJANTRATONG, P. 1986. Production of High Methionine Cowpeas by Tissue Culture. Use tissue culture methods to produce new mutant cowpea cell lines that overproduce a limiting amino acid, methionine, and thereby improve cowpea protein. 6.399

THAILAND. Plantek International, Ltd.; GAMBRIL, B. 1989. Cloning of Elite Cashew Trees by Generating Juvenility Through Micrografts Using Tissue Culture Technology. Develop tissue culture technique for rapid clonal multiplication of high-yield selections of cashew. (Work also in Singapore.) 7.086

THAILAND. Prince of Songkla U.; WITITSUWANNAKUL, R. 1986. Biotechnology Application for Characterization and Selection of Better-Yielding Rubber Clones. Develop a practical method for early and rapid screening of high-yielding potential and disease-resistant rubber clones in the breeding program to replace traditional, tedious, time-consuming methods. 6.400

THAILAND. Prince of Songkla U.; WITITSUWANNAKUL, R. 1989. Molecular Mechanism of Yield Stimulant Ethylene on Rubber Production of *Hevea brasiliensis*. Develop a practical method for prolonging the latex flow of existing mature rubber trees and for early screening of rubber clones with good flow potential upon tapping to replace etephon, which has adverse systemic effects and shortens tree life span. 9.374

THAILAND. Silpakorn U.; CHAIMANEE, P. 1990. Enzyme-linked Immunoassay for the Determination of Brucine and Related Quassinoid Compounds in *Brucea javanica* (L.). Develop an immunological method to detect antiparasitic bruceolides (which act against *Plasmodium falciparum* and *Entoamoeba hystolytica*) and study brucine distribution in tissue extract of *B. javanica*. Produce high-yield polyclonal antibodies. 9.334

THAILAND. Teak Improvement Center; KAOSA-ARD, A. 1986. Tissue Culture of Teak (*Tectona grandis* Linn. f.). Develop methods for use in mass propagation of elite clone of teak, evaluate the field performance of propagated plants and develop advanced techniques of callus and anther culture for the genetic improvement of fast-growing teak varieties. 6.427

THAILAND. U.S. Dept. Ag.; DAVIS, R. 1989. Development of Monoclonal Antibodies for Rapid, Accurate Indexing of Sweet Potato for Mycoplasma. Develop rapid and accurate means for detection of mycoplasma-like organisms (MLOs) in sweet potato germ plasm. Use the techniques to investigate the elimination of MLOs from sweet potato and the relationship between MLOs in sweet potato and other crops and weeds. 8.359

TUNISIA. Montana State U.; STROBEL, G. 1985. A Novel Approach in Using *Agrobacterium rhizogenes* as an Aid to Agriculture in Tunisia. Explore the potential for arid-zone agriculture of soil microorganism *A. rhizogenes*, which

is capable of transforming roots of certain plants and causing a proliferation of secondary roots. 5.114

TURKEY. Oregon State U.; HAYES, P. 1989. Application of Doubled Haploid and Tissue Culture Techniques to Winter Barley Germ Plasm Enhancement. Develop winter hardy barley germ plasm urgently needed for the development of winter hardy varieties that will allow small-scale marginal farmers to practice sustainable agriculture in marginal stress environments of developing countries. 9.171

Chemistry for World Food Needs

BARBADOS. U. West Indies; CARRINGTON, C. 1989. Post-Harvest Physiology of Some Underexploited Tropical Fruit. Develop a methodology for extending the preclimacteric life of soursop and breadfruit and for inducing controlled ripening of soursop. 8.116

BOTSWANA. U. Botswana; WOOLLARD, J. 1989. Natural Antifeedants for the Corn Cricket, *Hetrodes pupus.* Develop a preparation based on *Rhus* species that can be used as a simple and cheap antifeedant by local farmers to protect their crops from the corn cricket. Isolate and identify chemical constituents responsible for *Rhus* unpalatability. 8.388

BRAZIL. Centro Nacional de Pesquisa de Defensivos Agrícolas; ESKES, A. 1986. Control of Coffee Leaf Rust by *Verticillium lecanii* or Its Metabolites. Isolate and cultivate strains of *V. lecanii.* Compare their effectiveness in combatting *Hemileia vastatrix* in lab and greenhouse testing. 6.589

BRAZIL. Purdue U.; BUTLER, L. 1990. Low-Tannin, Bird-Resistant Sorghums. Develop sorghums with broad-based bird resistance that are low in tannin and have good nutritional quality. 10.060

BRAZIL. Rutgers U.; FRENKEL, C. 1985. Regulation of Chilling Sensitivity in Warm-Zone Crops. Determine whether oxygen toxicity is the metabolic basis for the oxygen effect in chilling injury. Alleviate deleterious chill responses by antagonizing oxygen activity in tissues. 5.143

BURKINA FASO. U. Ouagadougou; TRAORE, A. 1987. Influence of Sulfur Cycle Reducing and Ethanogenic Bacterial Interactions on Equilibrium of Lowlands Rice Ecology. Investigate the interrelations, physiology and biochemistry of sulfur cycle-producing bacteria and methane-producing bacteria to determine their potential to reduce sulfide production and improve nitrogen fixation in rice fields. 6.041

CHILE. U. Concepción; BAER, D. 1989. Evaluation of the Genetic Stability and the Potentiality of a Low-Alkaloid Strain of "Tarwi" (*Lupinus mutabilis*). Establish the incidence of genetic and environmental aspects on the adaptability, quantity and quality of the most relevant components of the low-alkaloid tarwi seed. 9.386

COSTA RICA. Centro Agronómico Tropical de Investigación y Enseñanza; CHAVES, C. 1989. Use of Poro (*Erythrina* sp.) and Madero Negro (*Gliricidia sepium*) Source for Dairy Cattle. Analyze both foliages for nutritive value. Study cattle consumption patterns and foliages' effect on the milk yield quality of lactating dairy cows. 7.204

COSTA RICA. Centro Agronómico Tropical de Investigación y Enseñanza; KASS, D. 1985. Development of Appropriate Technologies for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils. Classify soils by their phosphorus-fixing mechanisms. Develop and test various methods of supplying phosphorus to beans according to these soil classifications. 5.249

COSTA RICA. U. Costa Rica; ALVAREZ, R. 1989. Survival of Plant Pathogenic Bacteria in Tropical Soils Traced with Monoclonal Antibodies. Determine limits of survival of soil-borne pathogens in tropical acidic soils and under what conditions plant pathogenic bacteria will perpetuate disease. 7.138

COSTA RICA. U. Virginia; BLUM, L. 1986. Microbial Antagonisms: Potential for Selected Strains of Rhizobium to Inhibit Legume Root Pathogens. Select and test rhizobium strains capable of decreasing the incidence of rhizoctonia damping-off. 6.250

EGYPT. Montana State U.; VISSCHER, S. 1985. Plant Growth Hormones and Locust Phase Transformation. Test whether changing concentrations of plant growth hormones precipitated by environmental changes cause physiological, morphological and behavioral changes associated with transforming locust offspring from solitary to gregarious phase to plague formation. 4.034

GUATEMALA. Colegio de Postgraduados; LAGUNES, A. 1989. Search of Powders and Water Extracts of Wild Plants With Insecticidal Activity to be Used in Small-Scale Farming. Test powders and water extracts of certain wild plants against the fall army worm, Mexican bean beetle, Mexican bean weevil, common bean weevil, corn weevil and the larger grain borer, which are common pests of corn and beans. (Also involves Mexico.) 9.125

HONDURAS. Rutgers U.; DAIE, J. 1987. Regulation of Drought Tolerance in Bean. Determine the roles played by genotype variations, soil amended minerals and turgor regulation of sugar in osmotic adjustment and drought tolerance. 7.216

HONDURAS. U. Wisconsin; BLISS, F. 1988. Control of Bruchid Seed Weevils of Common Bean Using Unique Seed Proteins Having Insecticidal Properties. Develop methods for utilizing the insecticidal properties of arcelin, a unique protein found in seeds of some wild *Phaseolus vulgaris* for control of bruchids that attack cultivated beans. 8.166

HONDURAS. U. Wisconsin; HANDELSMAN, J. 1990. Optimizing the Rhizobium-Host Symbiosis for Increased Bean Production. Increase bean production by establishing an effective bean-rhizobium symbiosis through genetic manipulation of the plant and microsymbiont. 10.189

INDIA. U. Chicago; HASELKORN, R. 1988. Molecular Basis of Salt Tolerance in Nitrogen-Fixing Cyanobacteria. Clone the genes encoding ATPase, K+ uptake and betaine synthesis from salt-tolerant *Anabaena torulosa*. Compare their expression in salt-tolerant and salt-sensitive strains of cyanobacteria. 7.082

INDONESIA. Cornell U.; MEINWALD, J. 1986. Anti-insectan Compound From the Tropical Tree Family *Dipterocarpaceae*. Investigate the interactions between anti-insectan terpenoids found in the resins of dipterocarp trees and termites and other insects in order to develop defensive compounds for biorational control of pest species. 6.492

INDONESIA. Gadjah Mada U.; APT, S. 1986. A Study of Insecticidal Principals of Seeds of *Annona* Species Found in Indonesia. Isolation, testing, and characterization of insecticidal compounds found in *A. muricata* L., *A. reticulata* L. and *A. squamosa* L. 6.562

JAMAICA. Battelle-Kettering Lab.; BHUVANESWARI, T. 1986. Genetic Engineering of Rhizobia to Increase Efficiency of Nodulation. Construct a gene bank of *Rhizobium japonicum* strain 61A76 into a broad host range vector, pRK293. Introduce isolated efficiency genes into other strains of *R. japonicum* for use as inoculants. 6.233

JAMAICA. U.S. Dept. Ag.; AMES, R. 1988. Selection of Compatible VA Mycorrhizal Fungi, Rhizobia and Inoculation Methods to Increase Cowpea Yields in Jamaica. Increase the yield of cowpea by increasing effectiveness of rhizobium and vesicular-arbuscular mycorrhizal fungi. Select rhizobia and fungi for ability of root colonization and compatibility with each other and define conditions necessary for successful symbioses. 8.052

JORDAN. U. Jordan; AMR, A. 1989. Development of a High-Phytase Bakers' Yeast. Develop whole-meal, half-leavened breads with low phytic acid content in order to alleviate health problems caused by low zinc and other mineral levels associated with high phytic acid. 9.051

MALI. Inst. Rural Economy; TRAORE, M. 1987. A Study of Physiological Mechanisms Associated With Drought Tolerance in Sorghum and Pearl Millet Grown in Sahel Regions of Mali. Evaluate roles of abscisic acid, stomatomal response, photosynthesis, leaf and canopy temperatures, osmotic, water and turgor potential and other mechanisms and responses in order to improve production of dryland sorghum and pearl millet. 6.451

MEXICO. U.S. Dept. Ag.; BETHLENFALVAY, G. 1988. Crop Enhancement Through Direct Transfer of Nutrients Between Legumes and Cereals by Mycorrhizal Fungi. Demonstrate magnitude of growth and yield effects due to direct transfer of nutrients by vesicular-arbuscular mycorrhizal fungi between plants. Establish their biological and agronomic significance in controlled and field conditions. 8.055

MEXICO. U. Nacional Autónoma de Mexico; PALACIOS, R. 1989. Organization, Dynamics and Manipulation of Genetic Information in Rhizobium. Define the general organization of different replicons (chromosome and plasmids) of the rhizobium genome, the stability of genetic information in rhizobium and the limits of exchange of genetic information among different natural strains. 8.600

NEPAL. Inst. for Ag. and Animal Science; ADHIKARI, T. 1987. Pathogenic Variability of and Bacteriocin Production by *Xanthomonas campestris oryzae* in Nepal. Investigate the biological control of leaf blight disease of rice through bacteriocin produced by the bacterial pathogen in vitro or by selected nonpathogenic strains in plants. 7.093

PAKISTAN. Pakistan Agricultural Research Council; JILANI, G. 1988. Studies on the Possible Use of Plants/Plant Products as Stored Grain Protectants. Evaluate crude extracts and biologically active components of *Annona squamosa* L., *Acorus calamus* L. and *Curcuma longa* L. for their repellant/antifeedant/insecticidal properties against insect pests of stored grains. 6.322

PHILIPPINES. U. Florida; SHANMUGAM, K. 1988. Genetically Altered Cyanobacteria (Blue-Green Algae) as Nitrogen Fertilizer Supplier for Growth of Rice Plants. Evaluate the potential agronomic use of ammonia-excreting mutants of cyanobacteria by determining the optimal conditions needed for supporting growth of rice plants in nitrogen-free medium. Enhance rice production through characterization of nitrogen-fixing *Anabaena*. 7.065

PHILIPPINES. U. Maryland; ANGLE, J. 1990. Influence of Soil Populations of *Aspergillus flavus* on Aflatoxin Contamination of Corn. Determine whether a correlation exists between the soil population of *A. flavus* and aflatoxin contamination of corn and ascertain how spores of *A. flavus* migrate from the soil to corn. 10.402

PHILIPPINES. U. Philippines, Los Baños; DE LA CRUZ, R. 1986. The Effects of Mycorrhizal Inoculation and Other Nursery Preconditioning Treatments on Field Survival and Growth of Bare-Root-Planted *Eucalyptus* and Dipterocarps. Develop a bare-root planting technology for eucalyptus and dipterocarp seedlings, combining mycorrhizal fungi with various silvicultural, preconditioning treatments. 6.575

PHILIPPINES. U. Philippines; QUIMIO, A.J. 1986. Biological Control

of Seedborne Bacterial Pathogens With Bacteriocins. Test efficacy of nonvirulent mutants of bacteriocin-produced strains in the biological control of bacterial spot of tomato, bacterial blight of cotton and bacterial pustule of soybean. 6.032

RWANDA. Inst. Sciences Agricoles de Rwanda; KAYITARE, J. 1988. Evaluation of the Indigenous Plants Used by Rwandans as Protectants Against Insects in Dry Edible Beans. Investigate use of Rwandan indigenous plants to prevent loss of stored and growing kidney beans, mainly to bean weevil, by intercropping and use of extracts. Study effects of plants on bean weevil development. 7.346

SRI LANKA. Inst. Fundamental Studies; ILEPERUMA, O. 1988. Photofixation of Dinitrogen on Semiconductor Catalysts. Study heterogeneous catalysis with semiconductor particulate systems, emphasizing systems capable of light-driven fixation of dinitrogen to ammonia in order to develop nitrogen-fixing solar cells. 8.269

SRI LANKA. Oregon State U.; MORRIS, R. 1990. Cycles of Phosphorus and Other Nutrients in Alley Crops on Alfisols. Determine the long-term requirements of phosphorus and other nutrients in alley cropping, a promising agroforestry system, and how these requirements can be efficiently sustained on agriculturally important soils (Alfisols) in the semiarid tropics. 10.229

SRI LANKA. U. Colombo; TILLEKERATNE, L. 1988. Studies on the Allelopathic Potential of Selected Plant Species and Characterization of Allelochemicals. Select plants with high potential allelopathic interactions to explore their potential uses in agriculture. 8.254

SUDAN. Old Dominion U.; DAY, F. 1987. Nitrogen Dynamics of the Acacia Senegal Agroforestry System in Sudan. Develop a more efficient microbial symbiont/legume tree relationship that would yield a higher amount of N_2 and increase agricultural production. Evaluate ecological and genetic variability of populations on two main soil types for N_2 input. 7.136

SUDAN. Purdue U.; JUDGE, M. 1988. Extended Shelf-Life of Unrefrigerated Pre-rigor Cooked Meat. Develop a processing method combining aerobic packaging, meat surface acidification treatment, pre-rigor cooking and rapid cooking rates to improve microbial, flavor and textural quality of unrefrigerated meat. 6.474

SUDAN. U. Khartoum; KHALID, S. 1985. Biochemical Aspects Unique to Parasite (Striga)/Host (Sorghum) System. Investigate possible means to block development of first contact with the host by understanding the mechanisms governing chemical interaction between iridoids and nitrogen fertilizers. 5.362

THAILAND. Battelle-Kettering Lab.; BAKER, D. 1987. Molecular Identification of Frankiae Using Cross Inoculation Group-Specific DNA Sequences. Develop techniques to isolate symbiotic frankia from root nodules and soil as well as molecular probes to identify and discriminate among various host specificity groups of symbiotic frankia. 7.202

THAILAND. BNF Resource Center, Dept. Ag.; BOONKERD, N. 1990. Ecologically Based Models for Prediction of Legume Inoculation Requirement. Develop a method to predict where, when and to what extent legumes will respond to rhizobial inoculation in tropical cropping systems. 9.363

THAILAND. Louisiana State U.; PATRICK, W. 1989. Phosphorus Equilibria and Availability to Rice in Acid Sulfate Soils of Thailand. Study redox chemistry and pH conditions that limit utilization of native soil phosphorus and added fertilizer phosphorus. 9.179

THAILAND. Mahidol U.; CHULAVATNATOL, M. 1986. Changes of Cyanogenic Glycosides and Related Enzymes in Cassava Roots During Storage and Processing. Analyze the biosynthesis, accumulation and degradation of cyanogenic glucosides in cassava roots during storage and sun drying in order to design conditions to prevent deterioration of the roots. 6.404

THAILAND. Prince of Songkla U.; WIRIYACHITRA, P. 1985. Natural Insecticides for *Spodoptera litura* Fabr. Identify antifeedants and substances toxic to *S. litura* found in plants in order to develop insecticides with low mammalian toxicity. 5.240

THAILAND. U. Georgia; JORDAN, C. 1988. Soil Phosphorus Mobilization and Increased Crop Productivity With Agroforestry in Thailand. Test the feasibility of incorporating fast-growing tree species in the taungya system and the effects of mulching with organic residues from these cultivars on crop productivity and soil phosphorus availability. 7.109

U.S.A. Battelle-Kettering Lab.; FLEISCHMAN, D. 1987. Study of Nodulation of *Aeschynomene* by an Unusual Endophyte. Determine whether symbiotic associations occur between purple photosynthetic bacteria and green plants, specifically *Aeschynomene indica.* (With Indian collaborator who is a visiting scientist in the U.S.) 6.300

WEST INDIES. Fruit Experiment Station for the Caribbean; MICHELINI, S. 1987. Forced Flower Expression of Barbados Cherry. Investigate varying watering regimens, cultural manipulations and interactions between vitamin C, anthocyanin and sugars as functions of harvest timing, post-harvest handling and processing to determine efficient crop management. 6.609

WESTERN SAMOA. U. Hawaii, Manoa; HUE, N. 1990. Increasing Soil Productivity Through Organic Matter Management for South Pacific Countries. Increase soil productivity and food production in resource-poor countries through proper utilization of locally available organic materials as a substitute for commercial lime and fertilizers. 8.098

WESTERN SAMOA. U. South Pacific; ASGHAR, M. 1989. Increasing Nutrient Retention and Fertilizer Efficiency in Variable-Charge Soils by Using Locally Available Liming. Increase the nutrient-retention capacity of variable-charge soils and the efficiency of plant nutrient uptake and decrease the aluminum and manganese toxicities through use of locally available liming materials. 8.097

ZIMBABWE. Ministry of Ag.; MUGWIRA, L. 1988. Mapping Crop and Soil and Plant Nutrient Status for Improved Fertilizer Recommendations. Develop a combination of soil and plant tissue analyses for use in assessing spatial variability of soil. Evaluate effects of fertilizer in order to modify existing blanket fertilizer recommendations. 7.088

Diversity of Biological Resources

BRAZIL. Centro Nacional de Recursos Geneticos; CORADIN, L. 1985. Development of Germ Plasm Sampling Strategy for the *Macauba* and *Mbocaya* Palms and Related *Acrocomia* Species. Develop reliable, nonbiased sampling techniques for collecting tropical perennials oriented to breeding and conservation. 5.197

BRAZIL. N.Y. Botanical Gardens; BALICK, M. 1988. Improving Management Practices for Biomass Production From Native Stands of Babassu Palm. Improve the use of the babassu palm resource through a series of initiatives, including developing trials outside its native range to promote its enhanced utilization in reforestation and fuel/food production on degraded tropical sites. (Work also in Ecuador; collection in Bolivia, Colombia and Mexico.) 7.077

COSTA RICA. North Carolina State U.; DVORAK, W. 1988. Maintaining Biological Diversity of Threatened Multipurpose Species in Central America by Vegetable Propagation. Collect seeds of threatened populations of commercially important multipurpose species. Establish gene conservation banks and provenance/progeny tests to identify and develop more productive genetic combinations. 8.106

COSTA RICA. U. California, Davis; GEPTS, P. 1989. Establishment of a "Core Collection" for Common Bean (*Phaseolus vulgaris* L.) Genetic Resources Conservation. Evaluate a selection of 500 accessions of common bean from the world *Phaseolus* collection for morphoagronomic traits. Study a subset of 100 accessions for molecular markers. 9.241

HAITI. Texas A&I U.; FELKER, P. 1989. Genetic Improvement of Cactus (*Opuntia*) for Fruit, Vegetable and Fodder on Semiarid Lands. Quantitatively compare the performance of local cultivars under local climatic conditions and determine statistical interactions in their fruit, fodder and vegetable production. 7.187

HONDURAS. Fundación Hondureña; TABORA, P. 1989. High Density Techniques in Palm Hearts Production. Develop palm heart species with higher densities and nitrogen levels and evaluate them for precocity, yield and quality. 9.396

INDONESIA. Pattimura U.; TURUKAY, B. 1986. Crop Potential of Underexploited Tuberous Plants: Diverse Germ Plasm for Evaluation as Food Crops in Indo-Pacific Islands. Propagate clones from source of germ plasm of *Xanthosoma, Colocacia* and *Dioscorea* to promote their adaptation to the Indo-Pacific region. 6.054

JAMAICA. U. West Indies; BACON, P. 1989. Development of a Wetland Evaluation Model for the Caribbean. Develop and test a computer model for wetlands management, prepare an operations manual for its use and train personnel for its operation. 9.088

KENYA. Virginia Polytechnic Inst. and State U.; HILU, K. 1987. Breeding of Finger Millet: Phase I Molecular Genetic Study. Use chloroplast and nuclear DNA to determine gene pools of finger millet, to examine their cytoplasmic diversity and to single out potential species and accessions for breeding use. 7.242

MALAWI. U. Maryland; MCKAYE, K. 1990. Genetic Analysis and Stock Identification of Commercially Important Fishes From Lake Malawi (Lake Nyasa), Africa. Identify and distinguish between sibling species of the commercially important fishes. 10.069

MALAYSIA. Dept. Veterinary Service; NGAH, N. 1986. Growth Parameters and Reproductive Status Study of Malayan Gaur and Cross-Bred Cattle Hybrids. Study growth rate, carcass yield and chromosomes of gaur cattle. Conserve gaur gene pool in order to explore its potential as a meat resource. 6.550

MALAYSIA. Harvard U.; TOMLINSON, P. 1988. Increasing the Exploitability of the Nypa Palm for Fuel and Wood. Increase sap productivity by improving tapping methods and identifying high-yielding varieties for cultivation purposes, as well as investigate diversification of leaf utilization and analyze rhizomes for biomass and starch content. 8.129

MEXICO. U. Nacional Autónoma de Mexico; BYE, R. 1988. Molecular, Cultural and Ecological Markers of Genetic Diversity in Mexican Species of Beans (*Phaseolus*). Determine correlation of genetic, ethnobotanic and ecogeographic factors of *Phaseolus* diversity in three cultural-geographic areas in Mexico. 8.085

NEPAL. BioSystems Analysis, Inc.; JACKSON, R. 1990. Reducing Livestock Depredation Losses in the Nepalese Himalaya. Identify and recommend ways to improve animal husbandry and rangelands management in order to reduce wildlife/livestock/people conflicts and enhance protection of wildlands and rare species such as the snow leopard. 9.256

NEPAL. Tribhuvan U.; RAJBHANDARI, B. 1990. Exploitation of Genetic Yield Potential of Common Buckwheat Ecotypes in Different Ecological Regions of Nepal. Raise and sustain the production and productivity of common buckwheat, a neglected hill crop in Nepal. 10.614

NEPAL. Tribhuvan U.; SHARMA, K. 1990. Exploitation of Genetic Yield Potentiality of Ua (*Hordeum* spp.) Germ Plasm in the High Altitude Himalaya. Collect, screen, identify, evaluate and introduce naked barley germ plasm to exploit its genetic variability for higher yield and augmentation of food supply. 9.397

PERU. Princeton U.; GORCHOV, D. 1987. Seed Dispersal in a Tropical Forest Managed for Sustained Yield. Study effects of vegetation structure and species composition on dispersal of seeds into clearings in order to design alternative management methods to enhance natural reseeding. 7.228

PERU. U. California, Davis; QUIROS, C. 1988. Use of Molecular Markers for Measuring Genetic Erosion in Potato in Andean Farms. Identify genetic markers in cultivars of potato population to study genetic diversity among different farm types and agroclimatic zones. Information will be used to quantify genetic erosion and determine extent of outcrossing, interploidy and hybridization. 7.112

PERU. U. New Mexico; MORAIN, S. 1988. Analysis of Declining Traditional Crops, Using Satellite Remote Sensing and GIS. Develop a cost-effective and efficient method for use in critical germ plasm collection and in situ conservation efforts for quinoa (*Chenopodium quinoa*), kiwicha (*Amaranthus caudatus*, grain amaranth), oca (*Oxalis tuberosa*), añu (*Tropacolum tuberosum*), olluco (*Ollucus tuberosa*) and tarwi (*Lupinus mutabilus*). 7.258

PERU. U. Peruana Cayetano Heredia; LEON-BARUA, R. 1986. The Usefulness of Traditional Peruvian Remedies for Diarrhea and Parasites.... Evaluation in In Vitro and Animal Models. Study the action mechanisms of bacterial enteropathogens and pathogenicity in order to examine the ability of herbal remedies to decrease intestinal secretion. 6.345

PERU. U. Peruana Cayetano Heredia; VAISBERG, A. 1989. Characterization of the Active Principle, Mechanism of Action and Possible Mutagenic Activity of Wound Healing Materials From Sangre de Grado. Investigate the cicatrizant activity of plant extracts in animal models in order to characterize their active principles, study their mechanisms of action and determine whether they have mutagenic activity. 8.068

PHILIPPINES. Washington State U.; LUMPKIN, T. 1986. Fingerprinting of Azolla Germ Plasm. Identify azolla accessions at intraspecific and interspecific levels under conditions in phytotron where azolla germ plasm is maintained and at various growth stages and diverse environmental conditions in order to overcome cultivation constraints. 6.446

RWANDA. U. Wisconsin; MOERMOND, T. 1989. Animal Seed-Dispersers as Key Elements for Conservation of Tropical Forests. Determine which tree species depend on animals to disperse their seeds, which animal species are needed as dispersers and which fruiting trees need to be maintained as food sources for the dispersers. 9.259

SRI LANKA. Harvard U.; ASHTON, P. 1988. Understanding the Maintenance of Tree Species Richness for Silviculture and Conservation Management. Combine taxonomic, population genetic (isozyme analysis) and ecological data to determine whether a complete monophyletic group shares the same ecology. 8.245

SRI LANKA. U. Ruhuna; PATHIRANA, R. 1986. Collection and Evaluation of Sesame Germ Plasm for Breeding Adapted, High-Yielding Cultivars. Provide a genetic base for substantially increasing the yield and production of sesame by breeding genotypes that could be included in the intensive cropping systems in dry and intermediate zones. 6.106

THAILAND. Chitralda Palace; CHUTHAMAS, P. 1988. In Vitro Conservation and Propagation of Three Economic Species of Rattans. Use tissue culture techniques for conservation and mass propagation of three species of rattan: *Calamus* sp., *C. caesius*, and *C. pandanosmus*. 8.196

THAILAND. Kasetsart U.; GAVINLERTVATANA, P. 1985. In Vitro Conservation and Germ Plasm Exchange of Bamboo. Develop new tissue culture techniques for bamboo conservation and propagation. Develop in vitro conservation techniques, conserve bamboo varieties from Thailand and Sri Lanka and develop techniques for mass propagation and for germ plasm exchange. 5.247

THAILAND. Khon Kaen U.; FEUNGCHAN, S. 1985. Collection and Utilization of Tamarind Germ Plasm. Establish which sweet and sour tamarind types bear exceptionally large pods, well filled with pulp. Study the growth potential in relation to rootstock selection. Develop techniques for harvesting, preservation and utilization. Investigate growth. 5.243

THAILAND. Mahidol U.; BHAMARAPRAVATI, N. 1985. Fiber Farming Through Weed Utilization. Collect and study germ plasm of *Calotropis gigantea*, study its spinning and weaving floss fiber and study the economic feasibility of its use. 4.525

THAILAND. Smithsonian Institution; WILDT, D. 1990. Enhancement of Cattle Productivity While Conserving Wild Cattle Species. Develop data base on the general reproductive physiology of wild cattle species indigenous to Southeast Asia and determine the effectiveness of artificial breeding and cryobiological techniques for conserving this diverse genetic resource. 10.310

U.S.A. National Zoological Park; WEMMER, C. 1990. Population Biology and Genetics of the Asian Elephant. Provide the scientific basis for the development of coordinated, multinational programs for the demographic and genetic management of captive Asian elephants. (With collaborators in Myanmar (formerly Burma), India, Indonesia, Malaysia, Nepal, Sri Lanka and Thailand.) 10.073

VANUATU. U. South Pacific; MANSHARDT, R. 1988. Study of the Genetic Resources of the Plant Species *Piper methysticum* Forst, or "Kava." Study effects of geography and environmental variation on the kavalactone composition of *P. methysticum*. Analyze interspecific and intraspecific polymorphism of *P. methysticum*, *P. wichmannii* and *P. grandispicum* and identify kava wilt resistant clones. 7.039

ZAIRE. U. Wisconsin; MBAKULIRAHI, M. 1990. Study of the Factors Improving the Cricetoma Reproduction in Captivity—Toward a New Breed of Microlivestock. Determine the suitability of *Cricetomys gambianus* and *C. emini* as microlivestock in Zaire. 7.081

ZIMBABWE. Frostburg State U.; HOWARD, J. 1990. Identification and Conservation of Indigenous Tilapiine Genetic Resources in Zimbabwe. Characterize genetic variation within and among the tilapiine species of Zimbabwe and assess threat to their integrity from hybridization with introduced cichlid fishes. 10.197

Engineering Technology (premodule)

BOLIVIA. Inst. Boliviano de Biología de Altura; DEDET, J.-P. 1990. Computer-Aided Identification of American Sandflies. Create a computerized program that will permit the collection of descriptions of phlebotomine species of French Guiana in a knowledge base. 10.135

BOLIVIA. U. Arizona; GERBA, C. 1987. Water Disinfection by Material Surface Contact. Develop a water treatment device containing high – isoelectric – point clays, zeolites, AL203 or other earthen low-cost materials in order to inactivate rotavirus, hepatitis A and enteric bacteria and study its effectiveness. 6.354

CAMEROON. U. Yaounde; KWANKAM, S. 1985. Digital Information Transmission on Electric Power Lines. Combine baseband and amplitude modulation techniques to fully exploit power lines as a source of communications. 5.204

CHILE. U. Católica de Chile; AGUILERA, J. 1988. Bases for the Separation of Light and Dark Tissue From Pelagic Fish. Develop separation procedures through study of softening mechanisms of the interfibrillar matrix by thermal and biochemical means and assess ways to physically disrupt softened tissue. 7.334

GUATEMALA. Inst. Ciencia y Tecnología Agricolas; MASSAYA, P. 1989. Construction and Application of Biologically Based Whole Farm Simulation Models in Guatemala. Develop and use a computer simulation model to efficiently identify the most promising genetic types, to investigate biological and socio-economic effects of early maturing bean varieties and to develop agricultural production alternatives. 9.245

INDONESIA. U. Indonesia; SISWANTO, M. 1985. Materials Research and Electrical Resistance Relaxation in Carbon Black-Filled Rubber. Investigate the chemical interaction between carbon black and rubber and the feasibility of using electron spin resonance, x-ray diffractometer and scanning electron micrograph with electrical resistance relaxation measurements to determine free radical processes. 5.028

MEXICO. Colegio de Postgraduados; PALACIOS-VELEZ, O. 1986. Development of an Interactive Computer Graphic System for the Design of Agricultural Drainage. Develop a methodology to facilitate and improve the calculations needed for the topographical, hydrological and hydraulic design of agricultural drainage. 6.255

MEXICO. Inst. Investigaciones Eléctricas; VILAR PEDROCHE, J. 1985. Electrical Energy Supply to Rural Communities Directly From Transmission Lines. Develop a capacitive voltage divider circuit to supply electricity to rural communities of 500 or fewer inhabitants near transmission lines, for which a conventional high voltage substation is not economically feasible. 4.210

MOROCCO. Inst. Agronomique et Veterinaire Hassan II; HOUSSINE, B. 1987. Investigation of Plastic Liners for Indigenous Underground Grain Storage Structures. Compare traditional and improved pit storage by measuring physical aspects of grains (water activity, interkernel levels of carbon dioxide, oxygen and fat acidity), biological aspects (mycotoxins, damaged seeds and urine) and consumer interests. 7.336

PERU. Inst. Investigación Nutricional; FREUNDT-THURNE, J. 1986. A Novel Method Using Bioelectrical Impedance to Measure Malnutrition and Acute Dehydration in Hospitalized and Village Children. Develop a measurement of body water that, together with a hydration coefficient of fat-free body mass

and body weight, can be used to predict caloric reserves in children. 6.344

SRI LANKA. Virginia Polytechnic Inst.; GOONASEKERE, K. 1986. Design, Development and Evaluation of Low-Cost Electronic Flow Sensor and Its Application for Microcomputer-Aided Irrigation System. Design, develop and test a low-cost water-stage sensor for monitoring water stage in open channels. 6.075

THAILAND. Asian Inst. Technology; BERGADO, D. 1987. Welded Wire Reinforced Mechanically Stabilized Earth Embankments With Cohesive Backfill. Develop design and construction guidelines for using local cohesive clays and silts as reinforced backfill material in areas where granular soils are not readily available. 7.051

THAILAND. Energy Concepts; ERICKSON, D. 1988. Intermittent Solar Ammonia Absorption Cycle (ISAAC) Refrigeration for Lesser Developed Countries. Develop and test a solar-powered ice maker that is simple and reliable, uses low-cost materials and does not require advanced maintenance or manufacturing skills. 6.454

THAILAND. Kasetsart U.; NOOMHORN, C. 1990. Preparation and Evaluation of Condensation Polymers for Membrane Application. Study the chemical modification of condensation polymers that could be used in specialty membrane applications. 9.367

THAILAND. Cukurova U.; ERBATUR, O. 1988. Upgrading Lignites via Thermal Reduction With Coke-Oven Gases for Possible Utilization in Metallurgical Coke Production. Upgrade lignites and noncoking coals to a state in which they can be utilized in metallurgical coke production by preblending them with various coking coals. 8.344

TURKEY. Cukurova U.; MENGI, Y. 1989. Improvement of the Earthquake Resistance of Low-Strength Masonry by Means of Bamboo Reinforcement. Reinforce and prestress LSM (adobe) structures by bamboo. Test this method in shaking-table experiments. 9.089

Global Climate Change

BRAZIL. U. Federal; MEZA-MONTALVO, M. 1989. Effects of Cultural Practices on Potential Soil and Water Losses From Deforested Land in Humid Tropic Regions. Use a portable rainfall simulator to make measurements on site and to predict the extent and severity of erosion for benchmark soils. 9.311

COSTA RICA. U. Costa Rica; RADULOVICH, R. 1988. Water Optimization of Rainfed Tropical Cropping. Develop and test a water-use model based on deterministic components of the soil-crop-atmosphere continuum and on probabilistic rainfall analysis in order to optimize rainfed crop production. 8.337

DOMINICAN REPUBLIC. U. Florida; ANTONINI, G. 1989. Assessment of the Impact of Land Use Change on Tropical Steepland Hydrology. Use a realistic tropical steepland watershed model to conduct sensitivity studies on the impact of land-use change on flooding, deposition, transport and export. 8.369

ECUADOR. U. Montana; STOP, T. 1990. Cangahua in Ecuador; Its Strength, Classification and Delineation. Build and test a predictive model for mapping exposed cangahua (volcanic ash materials). Classify cangahua strength and hydraulic conductivity with remote sensing and geographic information system techniques to facilitate land reclamation efforts. 10.288

ECUADOR. U. Southwestern Louisiana; TWILLEY, R. 1988. Importance of Mangrove in Sustaining Fisheries and Controlling Water Quality in Tropical Coastal Ecosystems. Study production, storage, transport and utilization of organic detritus and nutrients in mangroves with contrasting tidal and fertility gradients to determine if function of mangroves depends on local environment's hydrology and fertility. 8.333

GHANA. U. Sciences and Technology School of Mines, Tarkwa; APPIAH, H. 1990. Geology, Mining, Ecology and Potential of Small-Scale Mining, Ghana. Determine the source and occurrence of gold and diamond placer deposits in West Africa and thereby supply needed technological knowledge for small-scale miners. 10.241

JAMAICA. Florida International U.; THORHAUG, A. 1987. The Toxicity of Oil Spill Clean-Up Using Various Dispersants on Critical Tropical Habitat: Seagrasses, Mangroves, Corals. Establish field data for comparative toxicity. Establish toxicity concentration limits for selected dispersants. Monitor long-term toxicity or recuperation of seagrasses, mangroves and corals after exposure. 7.103

JAMAICA. U. Georgia; WIEBE, W. 1989. Mangrove Forests and Seagrass Meadows as Biological Water Quality Filters Along Tropical Coasts. Determine whether mangrove forests and seagrass meadows serve as sequential biological water quality filters for terrestrially derived sediments and nutrients. 9.393

KENYA. Duke U.; JOHNSON, T. 1986. African Lake Sediments Analysis: Short-Term Climatic Fluctuations. Analyze the salinity indicators of 12-meter piston cores from Lake Turkana to determine its historic variations in salinity and predict the direction and extent of climatic change in the coming 100 years. 6.599

MALAYSIA. U. Maryland; NEWELL, R. 1988. Contribution of Mangrove Detritus to the Production of Commercially Important Shrimp Species. Conduct feeding studies with ^{14}C-labelled mangrove leaf material and stable isotope tracer techniques to determine rate at which shrimp utilize mangroves as a source of nutrition and reasons for their apparent low levels of assimilation of mangrove carbon. 8.054

MOROCCO. Ministère de l'Energie et des Mines; SAADI, M. 1985. Block Structure of the Lithosphere and Its Role in the Genesis and Distribution of Metallic Ore Deposits. Test a model of block structure of deeper parts of the lithosphere using Bouguer gravity maps with wavelength filtering. 5.346

PAKISTAN. New Mexico State U.; NI, J. 1990. Seismotectonics of the Western Himalaya: Applications to Earthquake Prediction in Pakistan and Plate Tectonics. Investigate the seismic hazard and seismotectonics of northern Pakistan. 9.038

PERU. U. Nacional Mayor de San Marcos; PAREDES C. 1985. Ecologic Evaluation and Benthonic Resources Management in the Peruvian Littoral System. Compare and study mechanisms and processes that control colonization of benthic organisms and post-catastrophic recuperation of shallow water benthic subsystems. 3.F42

Other Projects

NEPAL. Royal Nepal Academy of Science and Technology; JHA, J. 1988. Scientific Instrumentation Unit: A Unit for Repair, Maintenance and Innovation of Scientific Equipment. Develop a list of scientific equipment requiring frequent repair and maintenance, a plan for training technicians for its upkeep, and low-cost, locally produced equipment to meet developing-country needs. 8.020

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(Number is PSTC file reference. If principal investigator is in United States, country refers to collaborator.)

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BAMBOO (conservation and propagation using tissue culture), 5.247. Thailand; p. 15.

CLIMATE CHANGE (monsoon prediction models), 2.E15. India; pp. 16-17.

CLIMATE CHANGE (studies at Lake Turkana, East Africa), 6.599. Kenya; pp. 16, 17.

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MANGROVES (contribution of detritus to shrimp production), 8.054. Malaysia; p. 15.

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